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2023 INTERNATIONAL CONFERENCE
E-BUSINESS TECHNOLOGIES

Table of Contents

SESSION: DIGITAL MARKETING AND SOCIAL MEDIA

SESSION: BIG DATA AND ARTIFICIAL INTELLIGENCE

SESSION: SMART ENVIRONMENTS

SESSION: VR, AR AND COMPUTER SIMULATION

SESSION: BLOCKCHAIN

SESSION: DIGITAL PROJECT-BASED LEARNING

Foreword to the EBT 2023 conference

Dear colleagues, dear friends,

We are glad to welcome you to the third E-business technologies conference, at FON, University of Belgrade. The goal of the conference is to gather leading professors, scientists, researches and experts in practice, well-established IT companies and PhD students in order to share ideas and use cases from practice in area of e-business.

Interactions and convergence of the advanced information technologies and e-business ecosystems have redefined methods modern business entities and ecosystems generate value, shape roles and activities, while opening new directions, challenges and environments for both academia and practitioners. Digital e-business ecosystems bring plethora of possibilities, opportunities and challenges in different contexts. We see E-business technologies conference as a kind of a platform or environment for strategic networking on both national and international level. In addition, the idea is to foster scientific potentials, skill and knowledge and promote and empower the ideas of digital society, competencies, citizen science, crowds, etc.

EBT 2023 accepted 45 regular papers from 10 countries. In addition to a large number of researchers and experts from Serbia, the conference will include researchers from abroad: USA, Russia, India, Indonesia, Portugal, Bosnia and Herzegovina, South Africa, Eritrea and Rwanda. Keynote lectures will be given by two eminent experts: prof.dr Vladimir Brusić, Li Dak Sum Chair Professor in Computing and Data science and Head of Smart Medicine Laboratory, University of Nottingham Ningbo China, and prof.dr Aleksandar Kavčić, Ph.D. scientist and professor at Carnegie Mellon University and founder of Alek Kavčić Foundation, USA.

Further, the conference includes sessions and a workshop for students on the topic of Digital project based learning organized within the Erasmus+ project “D-PBL: advancing project-based learning into the Digital Era”, KA2 programme for cooperation partnerships in higher education.

We thank all the volunteers and other members of the organizational team for the huge effort, help and support

Welcome to EBT 2023 in Belgrade

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Zorica Bogdanović
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EBT 2023 Keynote speakers

Prof. dr Vladimir Brusić
Li Dak Sum Chair Professor in Computing and Data science and Head of Smart Medicine Laboratory
University of Nottingham Ningbo China

Prof.dr Aleksandar Kavčić
Ph.D. scientist and professor at Carnegie Mellon University and founder of Alek Kavčić Foundation, USA

Scott Spiegel
Blockcahain specialist, founder and CEO at BitBasel, Florida, USA.

EBT 2023 - Open ceremony speakears

Prof. dr Milan Martić
Dean, Faculty of Organizational Science, University of Belgrade

Prof. dr Zorica Bogdanović
Department of e-business, Faculty of Organizational Science, University of Belgrade

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EBT 2023

KEYNOTE LECTURE

Smart Health Home

Vladimir Brusić

Li Dak Sum Chair Professor in Computing and Data science and
Head of Smart Medicine Laboratory
University of Nottingham
Ningbo China

Abstract: Smart Health Home combines the Internet of Health Things (IoHT) and data communication technologies with health-related applications, to deliver healthcare services at home. SHH offers clear advantages for healthcare delivery: the available sensors are reliable, it enables for 24-hours health status monitoring, the IoHT devices are context-aware, and SHH can learn from acquired data through data analytics and machine learning methodologies. The barriers to adoption of SHH include the deficit of medically meaningful and interpretable reporting; limited accuracy, reliability, and trustworthiness of measurements; lack of compliance to recommended or mandated medical procedures, device standards, and software standards; concerns about data privacy, safety, security; and limited compliance with laws and ethical norms. These barriers can be overcome by innovative solutions developed through the adoption of standardized procedures, application of software engineering principles, and multi-layer information fusion. Multiple SHH connected through community data exchange center offers promise for deploying of recent technologies of Federated Learning, and Smart Contracts to enhance community health monitoring and rapid response to address individual health needs.

EBT 2023

KEYNOTE LECTURE

THE STATE OF THE SERBIAN PUBLIC EDUCATION SYSTEM

Aleksandar Kavčić

Ph.D. scientist and professor at
Carnegie Mellon University
founder of Alek Kavčić Foundation
USA

Abstract: Chaos. In physics, it is described as the property of a complex system whose behavior is so unpredictable as to appear random. Colloquially, it is described as complete disorder and confusion. Either description applies. The Serbian education system hosts institutions of unimaginable extremes. On the one hand, there are completely dysfunctional schools, yet on the other, Serbia hosts institutions that are the envy of much better funded education systems. So, how did we come to this point? In this talk, we will consider the decline of the education system in the three decades since the collapse of Yugoslavia. From an orderly self-sufficient education system, we have come to a chaotic state in which "outsourcing" seems to be the universal paradigm. Major indicators show that the paradigm is flawed, and we will propose a way forward that can be summarized in two words "value system".

EBT 2023

KEYNOTE LECTURE

From Fringe to Mainstream: The Evolution of Blockchain Adoption

Scott Spiegel

Blockchain specialist
founder and CEO at BitBasel

Miami, Florida, USA.

Abstract: This talk examines the progression of blockchain technology from its origins as a fringe internet currency to its widespread adoption in various industries and the public sector, highlighting key milestones and real-world applications.

EBT 2023

DIGITAL BUSINESS ECOSYSTEMS

Digital Business system of sharing economy: How can European countries be segmented?

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Abstract—Sharing economy, sometimes called collaborative consumption, is a concept, business model, and market in which individuals offer or rent their own assets which are not in use. Different types of sharing economy emerged from shared accommodation to sharing fashion items. No matter what is shared, the agreement on what is shared and under what circumstances is usually made via a website or platform within a digital ecosystem. The research question is how European countries can be segmented based on the characteristics of users of shared accommodation. The analysis was done on the Eurostat data from the ICT usage in households survey for 2019, while the applied segmentation (clustering) algorithm was k-means. The obtained results can be helpful in shedding light on how European countries can be grouped based on the characteristics of users of shared accommodation. It is believed that the research conducted in this study could act as a driver of further research on the topic of segmentation analysis of individuals and countries based on sharing economy activities.

Keywords: Sharing economy, Shared accommodation, segmentation analysis, clustering, Digital business ecosystem.

I. INTRODUCTION

New communication tools (primarily Web 2.0 technologies) have opened up the possibility of mass sharing and dissemination of information and introduced the practice of contacting unknown and physically distant people [1]. The given ability inspired people to offer, share and use other person's resources, especially as the new technologies allowed for a simple and secure arrangement. Therefore, peer-to-peer activity through which access to goods and services can be given, obtained, and shared by coordinating the acquisition and distribution of a resource is defined as sharing economy [2].

The idea of "sharing" is nothing new, but how the "sharing" is organised and perceived is new. Literature suggests that the first forms of what we now call sharing economy appeared in the 2010s when companies like Uber and Airbnb started operating [1], [3]. What makes sharing in the sharing economy different from usual sharing is the presence of a platform and the Internet as mediators [4].

The main participants in the sharing economy are the platform provider, the service provider, and the customer [5]. In addition, it is essential to mention that politicians, local governments, and NGOs are also part of the sharing economy ecosystem and that their impact on the way sharing economy is organised and regulated is omnipresent [6].

The available data on the level of the European Union (hereinafter referred to as EU) on the level of usage of shared accommodation provided by Eurostat indicates that at the EU-27 level, there are visible differences [7]. According to the data for 2019, the country that had the lowest percentage of individuals who used any website or application for booking accommodation from another person is Cyprus (5%), while this type of hospitality is most represented in Luxembourg (46%). The average usage at the EU-27 level is 21%. Intercountry differences at the EU level related to the openness and proneness to using shared accommodation visibly exist.

The main research question of this study is how European countries can be segmented based on the characteristics of users of shared accommodation. The analysis was done on the Eurostat data from the ICT usage in households survey for the year 2019, while the applied segmentation (clustering) algorithm was k-means.

The obtained results can be helpful in shedding light on two aspects. First, the results could unveil how European countries can be grouped based on the characteristics of users of shared accommodation. Second, the results could indicate consumer behaviour patterns when using any website or application to arrange accommodation from another individual. Policy-makers at the micro and macro level could be provided with valuable insights which can assist them in developing new policies or modifying current ones, which will act as an impetus towards individuals to share their accommodation and for others to turn to shared accommodation. Also, the segmentation analysis results could be used for benchmarking purposes as well.

The paper has the following structure. After the introductory part, we will provide insights into the digital business system of sharing economy. In section three, the indicators provided by Eurostat, which were used for segmentation, are presented. Besides presenting the indicators, the methodological aspects of the data collection process are outlined as well. In the next section, we outline the methodological aspects of the conducted research as well as the research results. Discussion and concluding remarks are given in the last section.

II. DIGITAL BUSINESS SYSTEM OF SHARING ECONOMY

Digital sharing economy (DSE) is defined as "*A class of resource allocation systems based on sharing practices which are coordinated by digital online platforms and performed by individuals and possibly (non)commercial organisations with the aim to provide access to material and immaterial resources. Digital sharing systems operate in the space between traditional sharing and the formal economy*" [8].

According to the report of the PANACEA project related to setting foundation for capacity building of sharing community in Serbia, there are two main business models in sharing economy [1].

The first model encompasses the model in which a company (provider) owns the specific resources and "shares" them via platform. Using the platform the provider achieves a bilateral relationship with the customer [9]. In this case, the provider provides the user with a resource for a limited amount of time for a predetermined price. This model is a B2C model, a business-to-consumer model. Examples of companies operating on this model are Car2Go and ZipCar.

The other model, a more decentralised one, is the model in which the transaction happens between two individuals, thus creating a peer-to-peer (P2P) (or even customer-to-customer C2C) sharing network [10]. Again, all communication and transactions take place on the platform. Examples of companies operating on this model are AirBnb and BlaBlaCar.

As we can see in both models, one of the prerequisites is the technology. Technologies which enable the function of sharing economy are digital platforms, mobile applications, big data, cloud solutions, Internet of Things (IoT), artificial intelligence (AI), machine learning (ML) and blockchain [11].

According to Wirtz et al. [12], sharing economy platforms are a specific type of platform alongside platforms for communication, content and review, social media, booking aggregator, retail, payment, and others. The platforms act as matchmakers, enabling interaction between service seekers and providers. Mobile applications allow providers to offer assets and customers to search for assets 24/7 from every corner of the world. Using big data and cloud solutions, the number of participants in the sharing economy and the number of transactions is unlimited. Internet of Things (IoT) allows to constantly monitor asset location, among other parameters, while AI and ML assist in predictions and personalisation. Finally, blockchain technology is used to build trust in the sharing economy system [11].

III. INDICATORS OF SHARING ECONOMY AVAILABLE FROM EUROSTAT

The data available in the Eurostat database, which refers to the sharing economy, is the data collected within the cycle of surveys on the use of information and communication technologies (ICT) in households and by individuals (ICT usage in households and by individuals (isoc_i)). This survey was conducted for the first time in 2002, and every year it is improved, modified, and new questions and groups of questions are included in the questionnaire to describe the use of ICT [7] more precisely.

The statistical unit of the survey are households and individuals. Households are defined as all private households having at least one member in the age group 16 to 74 years, while individuals are those aged 16 to 74. In some countries there are data for participants who are younger than 16 and older than 74, but that does not account for the majority of EU countries.

Regarding the country coverage, the annual ICT survey is conducted in all EU member states, United Kingdom (UK), Iceland, Norway, Switzerland, candidate countries and potential candidate countries. Here we should point out that for candidate countries and potential candidate countries, there are missing or imputed data for multiple indicators. Therefore, in our analysis, we observed the EU member states, UK, Iceland, Norway, and Switzerland.

In order to better understand and interpret the results, it is important to present how was the question related to shared accommodation defined and what was the precondition to answering it.

The precondition for the respondent to answer the question related to the usage of the shared accommodation is that he/she has used the Internet in the last year. In the question related to the usage of shared accommodation, the respondents were asked to indicate whether they had used a website or application to purchase accommodation services from another individual in the past twelve months. In order to include only P2P and exclude the B2P segment, the use of websites and applications of hotels, motels, campsites, travel agencies, tour operators and alike was not taken into account. The focus was on the accommodation reserved for vacations, as well as private purposes trips. It is important to note that the transaction and contracting are supposed to have been made through a website or application, while the payment methods were not the focus [13].

The question is defined as a multiple-choice question. The three answers offered were: a) Yes, through a specific website or application that allows the purchase of accommodation services from others, b) Yes, through any website or application that allows the purchase of accommodation services from others (e.g. social networks) and c) No, I have not [13]. The first answer offered involves the use of a specific website or application that allows booking and renting accommodation. An example of a company mentioned in this question to help respondents understand the question is Airbnb or examples of similar companies operating nationally. The second answer offered is about using any website or application. An example would be that through a certain Facebook group, an individual found accommodation and made a reservation.

An aspect important for the conducted study is the format in which the data is available. The main indicator provided is the percentage of individuals that used shared accommodation. However, Eurostat provides categorised data as it provides the percentage of individuals that used shared accommodation per gender, educational attainment, age group, income group, and their combinations.

IV. CONDUCTED RESEARCH

A. Research methodology

To answer the research question which is how European countries can be segmented based on the characteristics of users of shared accommodation, we first collected the data on sharing accommodation available from the Eurostat. We collected the data for the year 2019 for the following 13 indicators: All Individuals [all_individ], Individuals 16 to 24 years old [age16-24], Individuals 25 to 34 years old [age25-34], Individuals 35 to 44 years old [age35-44], Individuals 45 to 54 years old [age45-54], Individuals with no or low formal education [no_low_edu], Individuals with medium formal education [med_edu], Individuals with high formal education [high_edu], Individual living in a household with income in first quartile [LHW_1Q], Individual living in a household with income in second quartile [LHW_2Q], Individual living in a household with income in third quartile [LHW_3Q], Individual living in a household with income in fourth quartile [LHW_4Q], and Students [students]. We considered the effect of age, educational attainment, and household income. The data used in this research is publicly available on user demand. We collected the data for EU-27, Norway, Iceland, Switzerland, and the UK. The link to the dataset is provided in the reference list [14].

After the data was collected, in the next step, a clustering algorithm was applied. We opted for k-means clustering [15]. Literature suggests that k-means clustering effectively produces good clustering results in various fields of study [16], [17]. This clustering algorithm partitions the observed entities into a predefined k number of clusters. Each observation belongs to the cluster with the nearest mean, serving as the centre of the cluster [18]. The objective function is to minimise the sum of squares between the entities and the cluster centre. Although the algorithm has many benefits, one of its drawbacks is that the number of clusters should be predefined and that the presence of outliers can distort its results [18]. Clustering has been previously applied with success in segmenting users of shared transport [19], shared accommodation [20], micro-mobility and shared scooters [21], so we as well applied it in our study.

B. Descriptive analysis results

The first step in the analysis was the descriptive analysis of the collected data. The results are presented in Table I.

Table I. Descriptive statistics of the collected data

Indicator	Min	Max	Mean	Std	IQR
all_individ	5.250	33.890	18.524	7.453	10.677
age16_24	5.730	42.990	20.711	9.196	14.435
age25_34	9.350	45.400	28.232	9.867	17.535
age35_44	6.140	41.530	23.861	9.216	13.566
age45_54	3.560	33.880	18.441	8.232	15.122
no_low_edu	0.480	16.840	7.468	5.096	9.050
med_edu	3.130	35.630	16.375	7.999	13.525
high_edu	9.110	56.880	31.637	11.537	18.650
LHW_1Q	1.680	20.440	10.243	5.653	9.852
LHW_2Q	2.820	20.410	11.548	5.024	9.428
LHW_3Q	5.440	35.620	16.697	7.500	12.910
LHW_4Q	6.440	47.210	24.240	10.153	16.775
students	6.060	37.000	20.750	8.670	15.345

To perform the descriptive analysis, we obtained the minimum (Min), maximum (Max), mean (Mean), standard deviation (Std), and interquartile range (IQR) for each of the 13 indicators. Observing the means, we can say that they range from 7.468% (no_low_edu) to 31.637% (high_edu). Interestingly, the indicators with the highest and the lowest mean are those related to the usage of shared accommodation based on educational attainment. Standard deviations are high and range from 5.024% (LHW_2Q) to 11.537% (high_edu). High standard deviation and high mean of the indicator high_edu indicate that in some countries, the usage of shared accommodation among those with higher education is high, while in some, it is extremely low. The results of the IQR point out that there is a visible level of variability in the usage of shared accommodation among European countries according to different socio-demographic groups and characteristics.

The next step in the descriptive analysis was to explore whether there are multivariate outliers, as it is known that they can distort the results of clustering algorithms [22]. The presence of outliers was inspected using Mahalanobis distance [23]. This analysis was done in SPSS 29. The procedure is such that if a value of Mahalanobis distance has a p-value less than 0.001 for the Chi-square distribution with, in our case, 12 degrees of freedom, a country would be considered an outlier. Our initial analysis pointed out that Luxembourg was the closest to be an outlier with the p value of 0.025. According to the suggested threshold, Luxembourg is not an outlier, but as further clustering results indicated it distorted the results, we decided to exclude Luxembourg from further analysis.

C. Segmentation results

The k-means clustering was performed in R using the "cluster" package [24]. As mentioned above, when conducting k-means clustering, the number of clusters should be predefined. To decide on the number of clusters to retain, we used the between sum of squares and total sum of squares ratio. We calculated the ratio for four cluster structures; for two, three, four, and five retained clusters and noted the cluster structures (Table II). The ratio ranges from 56.8% to 79.4%. The increase in the number of clusters retained leads to a higher ratio, which is expected. However, the cluster structure should be taken into account. We opted for a three-cluster structure as the ratio is 67.4% and the three clusters are relatively similar in size.

Table II. Evaluation of different cluster structures

No. of clusters retained	2	3	4	5
between_SS / total_SS	56.8%	67.4%	75.3 %	79.4 %
Cluster sizes	17, 13	13, 10, 7	8, 7, 3, 12	6, 7, 7, 3, 7

The list of countries within each of the three retained clusters is provided in Table III. The first cluster is named *Advanced users* and within it we can find countries like France, Belgium, Italy, and Spain. The second cluster is named *Intermediate users* and countries like Greece, Norway, and the UK are in it. The final cluster is named *Beginners* and encompasses countries like Slovenia, Bulgaria, Denmark and the Czech Republic.

Table III. Segmentation of european countries based on the users of shared accommodation

Cluster 1 – Advanced users	Cluster 2 – Intermediate	Cluster 3 - Beginners
Belgium	users	Bulgaria
Croatia	Austria	Cyprus
Estonia	Finland	Czech Republic
France	Greece	Denmark
Germany	Hungary	Latvia
Ireland	Iceland	Romania
Italy	Lithuania	Slovenia
Malta	Norway	
Netherlands	Poland	
Slovakia	Portugal	
Spain	United Kingdom	
Sweden		
Switzerland		

To better understand the cluster structures and the behaviour of consumers in them, in Table IV, we present the mean values of each indicator per cluster.

cluster	**all_individ**	**age 16_24**	**age 25_34**	**age 35_44**	**age 45_54**
1	24.658	28.374	36.819	31.218	24.767
2	17.816	18.695	26.325	23.343	17.889
3	8.144	9.360	15.010	10.939	7.484
cluster	**no_low_edu**	**med_edu**	**high_edu**	**LH-W_1Q**	**LH-W_2Q**
1	10.498	23.165	40.512	13.633	14.811
2	7.262	14.695	29.901	10.344	11.895
3	2.139	6.164	17.637	3.713	4.993
cluster	**LH-W_3Q**	**LH-W_4Q**	**students**		
1	21.979	31.615	28.451		
2	16.218	22.830	18.341		
3	7.573	12.559	9.893		

Considering the coordinates of cluster centres, which are the mean values per cluster, visible differences could be noticed among the clusters. Firstly, cluster number one, *Advanced users*, is the cluster with the highest centre scores per each variable. Therefore, it is notable that countries within it are the ones where citizens with different socio-economical backgrounds are engaged in using shared accommodation. Particularly, this cluster excels mostly in the population aged 16-24, 35-44 and through medium level of education. Cluster two pointed out countries in which citizens are using shared accommodation in a certain percentage, but that percentage can be improved. For example, in these countries, only 18.341% of students, on average, use shared accommodation. The third cluster, the *Beginners*, showed in which countries the concept of shared accommodation is or not popularised or is slowly emerging or countries in which the citizens do not trust or do not have sufficient knowledge to use sharing accommodation platforms.

The four non-EU countries (Iceland, UK, Norway and Switzerland) have found their places in the first and second clusters, respectively. This means that non-EU countries are on the advanced and intermediate level of shared accommodation usage even if not in the EU.

Additional visualisation of the clustering results is given in Fig. 1. Countries within Cluster 1 are marked in red, those in Cluster 2 in green, and those in Cluster 3 in blue.

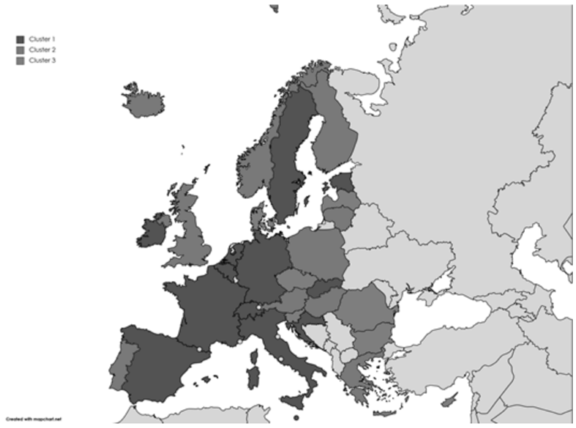

Fig. 1. Visualisation of clustering results on the map of Europe

V. DISCUSSION AND CONCLUSION

The level of participation in the sharing economy is expected to flourish as it provides personalised customer experiences [25]. Nevertheless, significant differences between european countries exist related to the usage of shared accommodation.

The survey conducted by Eurobarometer in 2016 showed that the majority of Europeans are aware of the sharing platforms, whereas only 17% of them actually use them [26]. The same survey indicated that there are visible country-level differences. According to the results, respondents in Greece and Portugal are more trustworthy towards the provider compared to respondents in Slovenia. Expectations of respondents from Latvia and Bulgaria who used sharing economy have not been mostly met, while the respondents in Romania, the Czech Republic and Cyprus need more information on the provider than it is currently offered [26].

The results from the newer wave of Eurobarometer survey are from 2018. The updated results indicate that 23% of Europeans use sharing economy platforms, pointing out an increase from 2016 [27]. However, the report also states that the differences in usage among countries are still significant.

According to Munkøe [28] by who states that "differences in the use of and the rules governing sharing economy services may well result in different approaches by national regulators". It is clearly evident that the signals from policy-makers and governing bodies are detrimental for the (non)participation in the sharing economy. To better understand and unlock the results of this study country-level policy analysis should be conducted.

The results of the study indicate that there are differences in consumer behaviour on the European level based on their socio-economic background when it comes to using shared accommodation. Most countries in Western Europe are advanced users of shared accommodation, countries in central Europe are intermediate, while countries in Eastern Europe are discovering shared accommodation services.

Although the presented study is promising, its results should be interpreted in light of its limitations. The first limitation of the study is the data used. The Eurostat data is reliable and reputable, but the latest available data is for the year 2019, which is four years ago from the current moment. Since 2019 COVID pandemic happened, as well as significant economic and political turmoil which have impacted sharing economy and sharing accommodation patterns [29], [30]. It would be interesting to conduct the analysis on more recent data, compare the segmentation results, and inspect how the sharing accommodation patterns changed in the previous period. Again, a limitation to the data can be discussed. The data provided by the Eurostat is on a country level. Data on the country level can provide valuable insights, but city data could be used to detect prominent tourist destinations, point out cities in which tourism is evolving, or tourist destinations which are losing attractiveness among tourists. Data on the individual level would allow us to even better understand the sharing economy user and provider.

Having in mind the type of available data, two future directions of the study emerge. The first is related to the application of more advanced segmentation techniques. In this study, clustering and k-means algorithm was applied. Clustering groups entities which behave in the same way taking into account all chosen variables. However, it would be interesting to go further and segment entities based on the specific pattern behaviours [31]. The analysis that allows for creating more coherent and precise segments is biclustering first emerged with the study of J.A. Hartigan, a professor of statistics at Yale University [32]. Since then, the application of biclustering has expanded. Biclustering is now used in different fields, such as marketing [33] and tourism research [34]. The second future direction of the study might be a longitudinal study. At the moment, Eurostat provides data for 2017, 2018, and 2019. It would be of interest to conduct related samples analysis [35] and simulation analysis [36]. Related samples analysis would reveal did and how the usage of shared accommodation changed in the three-year period. This analysis could be done for different types of data available and could reveal whether the behaviour of a particular socio-demographic group changed. These results could be beneficial to various stakeholders involved in the sharing economy.

Having in mind the presented results, observed limitations and defined future directions of the study, we can conclude that the ecosystem of sharing economy is developing, that there is interest in participating in the sharing economy, but that more research should be done to better understand the motivation, drivers, and perception of all the participants in the business model. It is believed that this research might trigger more in-depth segmentation analysis on the users of shared accommodation not only on the level of EU area, whereas on the national level as well.

ACKNOWLEDGEMENT

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REFERENCES

[1] Project PANACEA, "Ekonomija deljenja Karakteristike, poslovni modeli, primeri platformi i razvojni izazovi," Belgrade, 2022.

[2] X. Cheng, J. Mou, and X. Yan, "Sharing economy enabled digital platforms for development," Inf. Technol. Dev., vol. 27, no. 4, pp. 635–644, Oct. 2021.

[3] C. J. Martin, "The sharing economy: A pathway to sustainability or a nightmarish form of neoliberal capitalism?," Ecol. Econ., vol. 121, pp. 149–159, Jan. 2016.

[4] R. Belk, "You are what you can access: Sharing and collaborative consumption online," J. Bus. Res., vol. 67, no. 8, pp. 1595–1600, Aug. 2014.

[5] S. Benoit, T. L. Baker, R. N. Bolton, T. Gruber, and J. Kandampully, "A triadic framework for collaborative consumption (CC): Motives, activities and resources & capabilities of actors," J. Bus. Res., vol. 79, pp. 219–227, Oct. 2017.

[6] M. Hossain, "Sharing economy: A comprehensive literature review," Int. J. Hosp. Manag., vol. 87, p. 102470, May 2020.

[7] Eurostat, "ICT usage in households and by individuals (isoc_i). Reference Metadata in Euro SDMX Metadata Structure (ESMS)," 2023. [Online]. Available: https://ec.europa.eu/eurostat/cache/metadata/en/isoc_i_esms.htm.

[8] M. J. Pouri and L. M. Hilty, "The digital sharing economy: A confluence of technical and social sharing," Environ. Innov. Soc. Transitions, vol. 38, pp. 127–139, Mar. 2021.

[9] A. Acquier, V. Carbone, and D. Massé, "How to Create Value(s) in the Sharing Economy: Business Models, Scalability, and Sustainability," Technol. Innov. Manag. Rev., vol. 9, no. 2, pp. 5–24, Feb. 2019.

[10] D. E. Rauch and D. Schleicher, "Like Uber, but for local government law: the future of local regulation of the sharing economy," Ohio St. LJ, vol. 76, p. 901, 2015.

[11] A. Balachandran, "The Sharing Economy: Technology Platforms which shape the next big economic revolution," 2018. [Online]. Available: https://www.linkedin.com/pulse/sharing-economy-technology-platforms-which-shape-next-balachandran/.

[12] J. Wirtz, K. K. F. So, M. A. Mody, S. Q. Liu, and H. H. Chun, "Platforms in the peer-to-peer sharing economy," J. Serv. Manag., vol. 30, no. 4, pp. 452–483, Oct. 2019.

[13] CIRCABC, "Methodological Annex," 2019.

[14] Eurostat, "Individuals - use of collaborative economy (until 2019)," 2023. [Online]. Available: https://ec.europa.eu/eurostat/databrowser/bookmark/9aafa074-6a40-4706-a2d0-e6d37f-3303b9?lang=en.

[15] J. A. Hartigan and M. A. Wong, "Algorithm AS 136: A K-Means Clustering Algorithm," Appl. Stat., vol. 28, no. 1, p. 100, 1979.

[16] M. E. Celebi, H. A. Kingravi, and P. A. Vela, "A comparative study of efficient initialisation methods for the k-means clustering algorithm," Expert Syst. Appl., vol. 40, no. 1, pp. 200–210, Jan. 2013.

[17] M. Maricic, M. Bulajic, Z. Radojicic, and V. Jeremic, "Shedding light on the Doing Business Index: Machine learning approach," Bus. Syst. Res., vol. 10, no. 2, pp. 73–84, 2019.

[18] E. F. Škrabuľáková, M. Ivanova, and E. Michaeli, "Usage of clustering methods in mathematics, geoinformatics and related fields of university study," in Carpathian Control Conference (ICCC), 2016, pp. 723–728.

[19] N. Bojković, V. Jeremić, M. Petrović, and S. Tica, "Preferences for car sharing service attributes among university students: Evidence from an emerging market," J. East Eur. Manag. Stud., vol. 24, no. 4, pp. 636–653, 2019.

[20] D. Guttentag, S. Smith, L. Potwarka, and M. Havitz, "Why tourists choose Airbnb: A motivation-based segmentation study," J. Travel Res., vol. 57, no. 3, pp. 342–359, 2018.

[21] D. Lo, C. Mintrom, K. Robinson, and R. Thomas, "Shared micromobility: The influence of regulation on travel mode choice," N. Z. Geog., vol. 76, no. 2, pp. 135–146, 2020.

[22] G. D. S. Jayakumar and B. J. Thomas, "A new procedure of clustering based on multivariate outlier detection," J. Data Sci., vol. 11, no. 1, pp. 69–84, 2013.

[23] R. De Maesschalck, D. Jouan-Rimbaud, and D. L. Massart, "The Mahalanobis distance," Chemom. Intell. Lab. Syst., vol. 50, no. 1, pp. 1–18, Jan. 2000.

[24] M. Maechler and E. Al., "Package 'cluster,'" 2022. [Online]. Available: https://cran.r-project.org/web/packages/cluster/cluster.pdf.

[25] Huawei, "How the Sharing Economy Will Shape National Digital Transformation," 2020. [Online]. Available: https://e.huawei.com/en/blogs/industries/insights/2020/the-sharing-economy-digital-transformation.

[26] Eurobarometer, "Flash Eurobarometer 438 The use of collaborative platforms," 2016.

[27] Eurobarometer, "Collaborative economy in the EU," 2018.

[28] M. M. Munkøe, "Regulating the European Sharing Economy: State of Play and Challenges," Intereconomics, vol. 52, no. 1, pp. 38–44, 2017.

[29] S. Ye, S. I. Lei, X. Zhao, L. Zhu, and R. Law, "Modeling tourists' preference between hotels and peer-to-peer (P2P) sharing accommodation: a pre- and post-COVID-19 comparison," Int. J. Contemp. Hosp. Manag., no. In press, Oct. 2022.

[30] D. Stylidis and M. Terzidou, "Exploring how perceived tourism impacts evolve over time (2009–2019) in an era of uncertainty: economic crisis, host-guest interactions, and Airbnb," J. Sustain. Tour., vol. 31, no. 2, pp. 615–638, Feb. 2023.

[31] S. Dolničar, "Beyond 'Commonsense Segmentation': A Systematics of Segmentation Approaches in Tourism," J. Travel Res., vol. 42, no. 3, pp. 244–250, Feb. 2004.

[32] J. A. Hartigan, "Direct clustering of a data matrix," J. Am. Stat. Assoc., vol. 67, no. 337, pp. 109–137, 1972.

[33] D. Nikolic, M. Kostic-Stankovic, and V. Jeremic, "Market Segmentation in the Film Industry Based on Genre Preference: The Case of Millennials," Eng. Econ., vol. 33, no. 2, pp. 215–228, Apr. 2022.

[34] S. Dolnicar, S. Kaiser, K. Lazarevski, and F. Leisch, "Biclustering: Overcoming Data Dimensionality Problems in Market Segmentation," J. Travel Res., vol. 51, no. 1, pp. 41–49, Jan. 2012.

[35] M. S. Shabbir and O. Wisdom, "The relationship between corporate social responsibility, environmental investments and financial performance: evidence from manufacturing companies," Environ. Sci. Pollut. Res., vol. 27, no. 32, pp. 39946–39957, Nov. 2020.

[36] T. Parezanovic and N. Zornic, "Anticipating the impact of sharing economy drivers on consumer intention for using a sharing economy service," JEEMS J. East Eur. Manag. Stud., vol. 27, no. 2, pp. 233–258, 2022.

Digital Ecosystem Model for Workplace Transition in Post-COVID Era

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Abstract—Industry 4.0 is a period of rapid technological advancement and development that has had a profound impact on society, the environment, and business. Unquestionably, COVID-19 has accelerated the adoption of digital technologies and fundamentally altered the workplace and style of working. Employees and businesses have accepted new working practices that include using digital tools but also accepting more agile and flexible procedures and norms. The workplace has transitioned to being digital or at least hybrid. The broad adoption of Industry 4.0 technology and the critical role that innovation plays in scaling-up processes will have a major, even disruptive, impact on the workforce, workplace ecosystems, and labor market. The purpose of this paper is to look into the underlying mechanisms and dynamics that support the digital environment and ecosystems and propose a digital ecosystem model for transition and improvement of workplace in the post-COVID period.

Keywords—Digital Ecosystem, Workplace, HRM, Transition, Industry 4.0, Post-COVID

I. INTRODUCTION

The COVID-19 pandemic has dramatically impacted the market by significantly increasing the number of employees working from home. We can say that remote work in the organizational sense is the biggest change that the pandemic has brought us. As evidence of the speed of this change, we bring information that, before the pandemic, companies needed (on average) more than a year to implement a feasible solution for working from home. On the other hand, in the pandemic, they needed only 11 days to implement a satisfactory model of homework [1]. A study by the McKinsey Global Institute shows that the hybrid model (which is a combination of working from home and working in the office) could become a permanent characteristic of the labor market in the future. In the future, 20 to 25% of employees in developed economies and 10% of employees in developing economies could work from home three or more days a week without affecting work productivity. This represents a four to five times higher level of working from home than before the pandemic [2]. Also, the Gensler Research Institute survey shows that 52% of employees in the post-pandemic future would prefer a hybrid work model. This represents a significantly different opinion of employees compared to the time of the pandemic when they predominantly preferred working from home. At the same time, younger employees prefer the hybrid model more than older employees [3]. The hybrid work model is preferred by 75% of respondents in the 2022 McKinsey & Company survey. Even 85% of the employees currently working on a hybrid model chose to make that model even in the future. A distinct tendency for a hybrid labor model appears in all sectors of industry, geographic areas and demographic groups involved in research. It is an interesting fact that the hybrid model is very acceptable to different marginalized groups and can be a good basis for their easier integration into the company [4]. The post-pandemic period is characterized by attempts by companies to return employees to their offices. Other companies make changes, and they try to find the best hybrid solution, going so far as to talk about personalization of the model for each employee. Management of hybrid teams, successful inclusion, and training, ensuring employee visibility and the possibility of advancement in the company's hierarchy, creating an inclusive organizational culture of the company, and recruiting new employees, will be some of the biggest challenges for management and employees in the future.

The development of digital technologies has created the conditions to talk about work-from-home models. According to this, digital technologies and digital interface are key for productive work based on homework models.

The purpose of this paper is to look into the underlying mechanisms and dynamics that support the digital environment and propose a digital ecosystem model for companies whose employees work partially or fully from home, which can help in dealing with the aforementioned challenges.

II. DIGITAL ECOSYSTEMS

As a fresh perspective on the evolving, complex, and interrelated systems, the idea of digital ecosystems is put out in new millennia [5]. The *Digital Ecosystem* is a new, multidisciplinary term that is challenging to explain. As a result, many definitions of the concept have been proposed from various perspectives such as economics, technology, and ecology, thus making it challenging to comprehend.

The Digital Ecosystem is described [6] as a practical metaphor for comprehending the dynamics of business networks at the sectoral and regional levels, as well as their interaction with and through information and communication technologies (ICT), from an economic point of view. The OPAALS project community [7] defines the term Digital Ecosystem as emerging fresh paradigm for the catalysis of sustainable regional development driven by SMEs, distributed and peer-to-peer functioning in a shared, public worldwide environment enables this technology. A digital version of biological ecosystems, which are thought to be strong, self-organizing, and scalable architectures that can automatically handle complex, dynamic issues, are seen as the Digital Ecosystem from a technology standpoint [8].

Term *Digital Ecosystem* from an ecological viewpoint is defining digital component as any useful idea that is expressed by a language (formal or natural), digitalized, and transported within the ecosystem, and that can be processed by humans or computers [9]. Digital Ecosystems should be viewed holistically and from a multidisciplinary standpoint [10] as a self-organizing digital infrastructure designed to facilitate collaboration, knowledge exchange, the creation of open and adaptable technologies, and the evolution of business models in a digital environment for networked organizations. Therefore, a digital ecosystem is a self-organizing, scalable, and sustainable system made up of disparate digital entities and how they relate to one another. It emphasizes interactions between entities to increase system utility, gain benefits, and encourage information sharing, internal and external cooperation, and system innovation.

A megatrend that fundamentally alters economies, communities, and the environment is technological change. In addition to technology advancements, the COVID-19 has significantly influenced the rate, scope, and priority of digital transformation. Thanks ICT and the tools made available by the Industry 4.0, we now possess amazing power. The Industry 4.0 consists of the interaction of technologies across the physical, digital, and biological domains [11]. Additionally, various advancements, fields, and specialties are combined and harmonized in an intelligent manner to produce new types of intelligence [12]. In addition to employees, who make up the internal and traditional workforce, the term *workforce ecosystem* is now frequently used, and it refers to two other significant participant groups as well: the external workforce such as freelancers (gig workers), service providers, developers, accessory providers, etc., and intelligent technology for workforce augmentation and human-computer interaction [13].

In the era of Industry 4.0, artificial intelligence (AI), augmented reality (AR), virtual reality (VR) and robotics will play a significant role in the workforce ecosystem in addition to internal and external human resources. The digital age's unique ICT developments have led to significant changes in the economy, the labor market, and employment dynamics, including the expansion of the mixed workforce and gig work [13].

Emerging technologies like AI, automation, and sophisticated robotics/intelligent systems, which can replace, help, or work in conjunction with human resources by boosting their skills and capabilities, are a crucial component of talent management. It is clear that the three types of hybrid workforce, internal (employees), external (gig workers and other external workforce), and advanced/intelligent technologies, are interdependent [14].

Another crucial component of the work ecosystem is the workplace. The majority of the internal workforce worked full or part-time in an actual office prior to the COVID-19 epidemic. A disruptive change was influenced by the pandemic and organizations were compelled to have their staff work remotely as a result of the measures that social distance imposed. Since the pre-pandemic era, remote work or teleworking has been a strategy worth thinking about in the context of digital transformation and considering businesses' interest in implementing new policies that encourage human resources. However, only businesses that often worked on projects and had international teams with geographically distributed employees made the transition from the traditional setting to a hybrid model, which combines office time with remote work. However, even in these situations, most of the remote workers also worked from their offices, which could have been in a different city, region, or even another country [14].

The infrastructure and corporate culture were not ready to accept working from home until COVID-19 pandemic became the *black swan* that was required to hasten this process of transition, digitization, and spread of the hybrid workplace. As a result of the pandemic's social isolation, employees are beginning to profit more from flexibility and other advantages of working from home. The workforce is now increasingly favoring a mix of working from anywhere, including from home or the office.

Pre-COVID and post-COVID data used in a study to determine the preferred work models of workers around the world [15] highlight the desire for hybrid work now in so called home and office blended. As a result of the pandemic, preferences have radically altered, with 81 percent supporting the hybrid model, compared to only 29 percent who favored hybrid work choice during the pre-COVID time.

Additionally, even though remote work has been used for a long time before COVID-19 [16], the pandemic has accelerated this change, which may have longer-lasting consequences on management methods [17] and work organization in general [18]. It is evident that, because of COVID-19, most academic studies have been on remote work [19, 20]. To enhance convenience, functionality, and wellbeing, the proposed ecosystem strives to offer adaptable and on-demand spaces. The workplace can be chosen by each person individually based on their present requirements, preferences, workload, job character, etc. According to a previous prediction [15], fifty percent of the workforce will probably split their time between an office, their home, and a third location (such a café or library), creating a *Total Workplace Ecosystem*.

Significant advantages of digital workplace transformation include increased employee engagement, enhanced teamwork, lower operating costs, and it fosters innovation and raises customer satisfaction [21, 22, 23]. Although the literature also highlights some of the difficulties associated with this phenomenon, such as those related to infrastructure, adopting new technology, and personnel management, the benefits of the digital workplace transformation exceed these issues [22, 24].

III. MODEL

The proposed digital ecosystem model (Fig. 1) for working places transition in post-COVID era contains the following key parts: users, infrastructure, technologies, content, and management. The parts of the model are designed to enable the building and maintenance of a strong organizational culture for on-site, hybrid and remote employees.

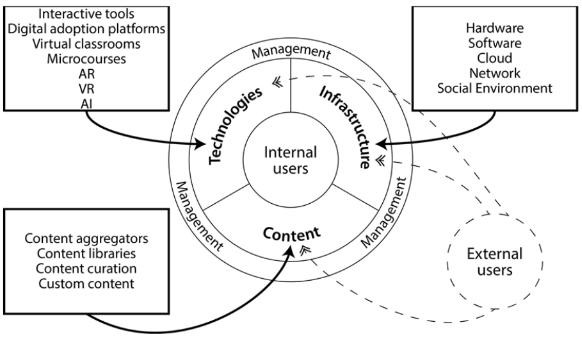

Fig. 1. Proposed Digital Ecosystem Model for Workplace Transition in Post-COVID Era

A. Users

Users present the first part of the digital ecosystem model. Users usually represent anyone who has access to digital technologies because of the ubiquity of computers, smart devices, and their increased use [25]. In the proposed model, the users are considered as internal and external. Internal users are employers, employees, administrators, managers, while external users are represented by those who occasionally interact with certain parts of the model, e.g., external educators, external content creators, technical support and so on. Managers are especially important when looking at hybrid and remote workers because they are the main link between company, employee, and organizational culture. As such, they must have appropriate skills set to meet the demands of today's business environment. Users can access various content that will help not only in gaining new knowledge and skills, but also in communication and cooperation to build a strong organizational culture for different types of employees.

B. Infrastructure

Infrastructure includes all basic services needed for a digital learning ecosystem to work properly. It refers to hardware, software, cloud, network, and social environment (users, designers, and system developers) [26]. Infrastructure is often the crucial foundation for digital transformation in organizations [26].

C. Technologies

Technologies in the proposed model should enable productive work from home (remote work), development, improvement and preservation of organizational culture, and professional development. Professional development in the model refers to the use of different technologies to acquire new knowledge and skills in the post-pandemic business environment.

A strong company culture means that the benefits of the company are expressed in many ways, such as: increased profits, more engaged employees, stronger relationships, and higher productivity rates [27]. Along with the digital transformation, the transformation of the organizational culture is also happening. The following tools are very useful in the transformation of organizational culture [27]: learning management systems (LMS) for cultivation and growth, mentorship platforms for support and growth, online time tracking system for flexibility, engagement platforms for communication and feedback, employee recognition program for reward and recognition and productivity monitoring software for employee autonomy. In addition to the learning purpose, LMS is also important in the organizational culture because it can be adapted to the specific needs of the company. Mentoring platforms are essential for support, growth, and professional development, especially for hybrid and remote employees. There are various types of mentoring online platforms and some of them are: GrowthMentor, MentorPass, Oneday, Sparrow, Mentessa, Pearl, etc. [28]. Since the beginning of the pandemic, time tracking software has become widely used as it provides flexibility in terms of where and when employees work. Some of the examples of time tracking software are Timecamp, TrackingTime, ClickUp etc. Employee engagement platforms can help in achieving a positive emotional connection between employees and the company and they usually include features like employee feedback, survey sentiment analysis, and recognition of top achievements [29]. Some of the platforms for employee engagement are Slack, Jotform, Blink, Kudos, Workvivo, ect. Employee recognition proved to be a significant motivator that has a direct positive impact on the performance and satisfaction of employees, which also has a positive impact on organizational performance [30]. The most popular tools for employee recognition are Nectar, Fond, AwardCo, WorkTango, Blueboard, Bucketlist and Motivosity. Employee monitoring software is used to monitor employee productivity and evaluate their efficiency. The best employee monitoring software overall for 2023 is Teramind according to Forbes advisor [31].

There are many tools that can help build and maintain an organizational culture in the post-COVID era. Such tools can serve a variety of purposes, including [32]:

- Tools for *getting employee feedback,* e.g., 15Five, Bonsly, CultureIQ, BlogIn, Kanjoya.
- Tools for *defining company goals and managing directions*, e.g., Charlie, Emplo, Pinipa, Trello.
- Tools that *improve team communication*, e.g., Atlassian, BlogIn, Workplace by Facebook, Jive Software, SalesForce Chatter, Slack.
- Tools for *improving innovation and team creativity,* e.g., BrightIdea, OI Engine, Speakup, Spigit, Wazoku.
- Tools that help in *taking care of employees*, e.g., Perks at Work, SmartHub, Looop, Headspace, Sleepio, Briq.

"*Learning ecosystem platforms enable easy discovery, collaboration, management, and measurement of learning that is geared to a blend of digital, synchronous, internal, and external content.*" [33] Management and content are separate parts of the model, so they will be discussed later. In the context of learning technologies employers and employees can use a range of technologies and tools including interactive tools, digital adoption platforms, virtual classrooms, microcourses, AR, VR, AI etc. What specific technologies and tools will be used depends on the industry, the nature of the work and the required knowledge and/or skill that needs to be acquired.

Interactive tools that can be used in digital learning ecosystems include [34]:

- *Polls and quizzes* - allow learners to actively participate in different learning activities.
- *Games/gamification* - benefits of gamification include promotion of critical thinking and active participation, as well as creativity of learners.
- *Interactive infographics* - combine diagrams, charts, text, images and more. Interactive infographics are used to enhance understanding of abstract information and to attract learners' attention.
- *Interactive videos and live streaming* - they have certain advantages over asynchronous educational videos. Interactive videos and live streaming promote interaction, active and participatory learning.
- *Jamboard* - this Google tool can be used as an interactive whiteboard or as the tool which promotes collaborative skills, creativity, and critical thinking.

Besides interactive tools, tools as learning record stores, digital adoption platforms and modality-specific tools can be used in learning ecosystems [33]. Learning record stores (LRS) are becoming increasingly important in digital learning systems, and they are used to store learning experiences [35]. LRS is not the replacement for LMS. It is a service in the cloud that deals with learning information storage, as well as its retrieval [36]. Some of the benefits of using a LRS are recording learning experiences, informal learning scenarios, support for different content types, team-based learning, learning monitoring, etc. [36].

"*A digital adoption platform overlays applications (e.g., CRM, HCM, ERP, legacy and external) with in-application guided learning, simulations, analytics and nudging to drive adoption, proficiency and engagement.*" [37] Digital adoption platforms are very beneficial during digital transformation. These platforms help employees to learn new technologies, offer detailed walkthrough of different processes and tasks, increase internal efficiency, decrease the number of technology-related queries and request for technical assistance and they usually result in more digital savvy employees [38]. Some of the products in the digital adoption platforms market include Whatfix, WalkMe, ADOPT, Userlane etc. [37].

Modality-specific tools align with learning styles preferences. The assumption is that individuals will achieve better learning outcomes if their preferred modalities (visual, auditory, or kinesthetic are considered [39].

In addition to the above-mentioned approaches, for the workplace transition in post-COVID era microcourses, augmented and virtual reality, and artificial intelligence can also be used. Micro-courses are limited both in terms of content and duration. Micro-courses are used to structure and design courses in less independent courses and each of them should be defined with specific learning objectives [40]. Some of the advantages of using micro-courses in the workplace are improved learning retention, better satisfaction, faster learning, raised engagement, reduced development time and costs and learning culture support [41].

"*We define Augmented Reality (AR) as a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it*". [42] Benefits of AR training of employees include employee engagement, safety awareness, alleviation of training cost, lowering learning curves [43].

Virtual reality is an advanced human computer interface that simulates a real environment. You can simply move in the virtual world as a participant, see from different angles, and reach for something [44]. Virtual reality can provide us with education as well as entertainment because it is both informative, useful, and entertaining.

"A*rtificial intelligence is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable*." [45] AI tools automate away some of the manager tasks so they can be "free to do more of the creative and strategic work that has a bigger impact on the success of their companies". Some of these tasks that can be done through AI are smarter people analytics, removing biases, identifying employees on the way out, litigation strategy etc. [46].

During the COVID-19 pandemic, tools for online collaboration and communication enabled functioning of all business processes when it comes to management and organizational culture. For there to be no major backlog in the mentioned processes it was necessary to find tools that will completely replace the current way of conducting business. It was necessary to find tools that would enable and facilitate 1:1 meeting, group meetings, event planning, introducing new employees to their tasks and their responsibilities, etc. Some of the most important tools that support communication culture and collaboration are Google Drive, ProofHub, Process Street, Slack, LucidcHart, Zoom, LastPass, Zapier, Shift. These tools can help enhance the remote workforce and boost collaboration. [47]

D. Content

Content can be obtained from content aggregators, content libraries or through curation. [33] Since there is available a large amount of data, the way in which the content is collected and presented is very important. Content aggregators are tools or entities that gather web content from various web sources for reuse. Learning content aggregators are suitable for todays' business environment since their usage can overcome limitations such as team size, learning styles and preferences, budget, etc. Benefits of content aggregation include easier content curation, increased learner engagement, improved learner retention, greater flexibility, and increased ROI [48]. Content libraries usually refer to off-the-shelf learning materials. These types of content mostly include industry knowledge, soft skills development or compliance information and it is beneficial for training of teams/ departments of content that is not company specific [49]. Content curation refers to existing content that will be republished. Benefits of content curation for learning and development programs include focuses on relevant information, saves time and resources, encourages continuous learning, enhances productivity and performance gain [50]. In addition to the mentioned options for content generation, there is also an option for custom content creation. Custom content gives an organization control over the content, and it is suitable for individualized training needs. [49]

E. Management

Management in the digital ecosystem implies specifying the way in which some of the most important managerial tasks will be defined and maintained. Management in the model refers to management of all other components of the model. It can include training of existing and new employees, planning of group and 1:1 meetings, managing digital teams, opportunities for visibility and progress of employees, recruitment of new employees and evaluating them, monitoring, measurement of progress, etc. Some of the digital tools that can help with all of the above are: Asana, Slack, Microsoft Teams, Trello, MeisterTask and Miro [51] The tools should help managers and employees to effectively and efficiently fulfill their tasks. Each tool has certain advantages and disadvantages, and it can be oriented towards communication and collaboration, organization of daily work routine, transparency, management of digital teams, etc. [51]. The tool will be chosen according to the needs of the company and the manager.

A significant part of the digital ecosystem model for working places transition are measurement and metrics for assessment of the effectiveness of the business processes. In addition to financial metrics, in the post-COVID era it is important to monitor non-financial metrics. "*The most common learning and growth metrics that are used to assess non-financial organizational performance are human resources (HR), information capital (IC), and organizational culture and alignment (OCA).*" [52] Monitoring is also part of management and some of the areas that need to be monitored are strategy, development, freedom of thought, superior support, and well-being of employees. Besides the above-mentioned, the proposal is to measure loyalty and satisfaction of employees.

IV. CONCLUSION

The interaction between technology and people will become incredibly complex in the upcoming years and we must be ready for such changes in advance. It is our responsibility to have the skills necessary to control Industry 4.0 tools and technology. A substantial number of issues, hazards, and concerns linked to traditional unemployment, technical unemployment will arise if AI and intelligent automation systems only replace human resources. However, if this combination of people and technology works in harmony, it may result in cost savings and extra benefits for businesses, clients, and other stakeholders.

Industry 4.0 specific new technologies and innovation as a fundamental component of scaling-up processes will soon result in significant and occasionally even disruptive changes to the labor market, as well as changes to the workforce and workplace ecosystems.

The COVID-19 showed numerous flaws and problems that have been in business for a very long time, especially regarding how to conduct daily tasks from the standpoint of physical to virtual contacts. The conflict between returning to work and rethinking work as they accept a new reality is likely to be the largest difficulty companies face during the recovery.

The development of digital technologies created new conditions to implement work-from-home models. Since digital technologies and digital interface are key for productive work based on homework models this paper is proposing a digital ecosystem model for companies whose employees work partially or fully from home, to help them in dealing with the challenges of post-COVID workplace.

To accomplish people's well-being, it is crucial to support a productive and healthy workplace that supports hybrid work from the office, home, and/or other locations. Understanding and meeting the requirements of the workforce is a crucial step in raising satisfaction, motivation, and engagement, which will ultimately improve worker performance. Performance in the workplace today and in the future should take these changes into account. Emerging technologies will be crucial in redefining society, as well as in enhancing corporate performance and rearranging work, workplace, and worker ecosystems.

REFERENCES

[1] McKinsey & Company, "McKinsey Digital and Strategy & Corporate Finance Practices: How COVID-19 has pushed companies over the technology tipping point—and transformed business forever," McKinsey Global Publishing, 2020.

[2] S. Lund, A. Madgavkar, J. Manyika, S. Smit, K. Ellingrud, M. Meaney, and O. Robinson, "The postpandemic economy: The future of work after COVID-19," McKinsey Global Institute, Februrary 2021.

[3] Gensler Research Institute. "U.S. Workplace Survey Winter 2021," 2021.

[4] B. Dowling, D. Goldstein, M. Park, and H. Price, "Hybrid work: Making it fit with your diversity, equity, and inclusion strategy," McKinsey Quarterly, McKinsey & Company, April 2022.

[5] C. Fiorina, "The digital ecosystem," Speech at World Resources Institute Conference, Seattle, Washington, October 2000.

[6] P. Dini, M. Darking, N. Rathbone, M. Vidal, P. Hernández, P. Ferronato, G. Briscoe and S. Hendryx, "The digital ecosystems research vision: 2010 and beyond," Brussels: European Commission, 2005.

[7] Open Philosophies for Associative Autopoietic Digital Ecosystems (OPAALS), Network of Excellence. http://www.opaals.eu/

[8] W. Li, Y. Badr, and F. Biennier, "Digital ecosystems: challenges and prospects," in Proceedings of the International Conference on Management of Emergent Digital EcoSystems, 2012, pp. 117-122.

[9] H. Fu, "Formal Concept Analysis for Digital Ecosystem," in IEEE Proceedings of the 5th International Conference on Machine Learning and Applications (ICMLA'06), 2006, pp. 143–148.

[10] A. Razavi, S. Moschoyiannis, and P. Krause, "An open digital environment to support business ecosystems," Peer-to-Peer Networking and Applications 2, 2009, pp. 367–397.

[11] K. Schwab, "The Fourth Industrial Revolution," World Economic Forum, 2016.

[12] M. Skilton, and F. Hovsepian, "The 4th Industrial Revolution: Responding to the Impact of Artificial Intelligence on Business," Palgrave Macmillan, 2018.

[13] M. Bart, B. Mohammed and S. Tamru, "Emerging Medium-Scale Tenant Farming, Gig Economies, and the COVID-19 Disruption: The case of commercial vegetable clusters in Ethiopia," European Journal of Development Research, no. 32, 2020, pp. 1402–1429.

[14] A. T. Gorski, I. Gligorea, H. Gorski, and R. Oancea, "Workforce and Workplace Ecosystem–Challenges and Opportunities in the Age of Digital Transformation and 4IR," in International conference KNOWLEDGE-BASED ORGANIZATION, vol. 28, no. 1, 2022, pp. 187-194.

[15] Cushman & Wakefield, "The Future of Workplace: How Will COVID-19 and Data Shape the New Workplace Ecosystem?" Available online: https://www.cushmanwakefield.com/en/insights/ covid-19/the-future-of-workplace.

[16] M.H. Olson, "Remote office work: Changing work patterns in space and time," Communications of the ACM, 26(3), 1983, pp. 182–187.

[17] E. Brynjolfsson, J. J. Horton, A. Ozimek, D. Rock, G. Sharma, and H.-Y. TuYe, "COVID-19 and RemoteWork: An Early Look at US Data," National Bureau of Economic Research, Working Paper, June 2020.

[18] B. Z. Larson, S. R. Vroman and E. E. Makarius, "A Guide to Managing Your (Newly) Remote Workers," Harvard Business Review, 18(2), 2020, pp. 27-35.

[19] M. Angelucci, M. Angrisani, D. M. Bennett, A. Kapteyn, and S. G. Schaner, "RemoteWork and the Heterogeneous Impact of COVID-19 on Employment and Health," no. w27749. National Bureau of Economic Research, 2020.

[20] G. Gallacher, and I. Hossain, "Remote Work and Employment Dynamics under COVID-19: Evidence from Canada,". Canadian Public Policy, 2021.

[21] C. Meske, and I. Junglas, "Investigating the elicitation of employees' support towards digital workplace transformation," Behaviour and Information Technology 40, no. 11., 2021, pp. 1120–1136.

[22] M. Attaran, S. Attaran, and D. Kirkland, "The need for digital workplace: Increasing workforce productivity in the information age," International Journal of Enterprise Information Systems (IJEIS), 15(1), 2019, pp. 1-23.

[23] S. Köffer, "Designing the digital workplace of the future-what scholars recommend to practitioners," 2015 International Conference on Information Systems: Exploring the Information Frontier, 2015 pp. 1-21.

[24] K. Dery, I. M. Sebastian, and N. V. Meulen, "The Digital Workplace Is Key to Digital Innovation," MIS Quarterly Executive, 16(2), 2017.

[25] F. Sussan and J. Zoltan, "The digital entrepreneurial ecosystem," Small Bus Econ 49, 2017, pp. 55–73.

[26] Y. Chen, Z. Wang and J. Ortiz, "A sustainable digital ecosystem: digital servitization transformation and digital infrastructure support," Sustainability, vol. 15, 1530, 2023.

[27] K. Graffin, "Build a better company with these tools," May 2022, https://www.insightful.io/blog/build-a-better-company-culture-with-these-tools

[28] F. Panagiotakopoulos, "26 Top Online Mentoring Platforms," April 2023, https://www.growthmentor.com/blog/online-mentoring-platfor ms-software/

[29] T. Reitsma, "10 Best Employee Engagement Software of 2023," April 2023, https://peoplemanagingpeople.com/tools/best-employee-engage ment-software/

[30] A. S. Amoatemaa and D. D. Kyeremeh, "Making Employee Recognition a Tool for Achieving Improved Performance: Implication for Ghanaian Universities," Journal of Education and Practice, Vol.7, No.34, 2016.

[31] J. Simonson, “Best employee monitoring software of 2023,” April 2023, https://www.forbes.com/advisor/business/software/best-emplo yee-monitoring-software/

[32] Blogin, “25 Online Tools for Building Company Culture”, https://blogin.co/blog/25-online-tools-for-building-company-culture-56/

[33] B. Willis, “A Tech Guide to Learning Ecosystems,” Alexandria, VA: Association for Talent Development, 2021.

[34] T. Meepung, S. Pratsri and P. Nilsook, “Interactive tool in digital learning ecosystem for adaptive online learning performance,” Higher Education Studies, vol. 11, 2021, pp. 70–77.

[35] C. Labba, A. Roussnaly and A. Boyer, “An operational framework for evaluating the performance of learning record stores,” European Conference on Technology Enhanced Learning, Sep 2020, Heidelberg, Germany, 2020, pp.45-59.

[36] P. Berking, “Choosing a learning record store (LRS),” Advanced Distributed Learning (ADL) Initiative, 2015.

[37] Gartner, “Digital adoption platform reviews and ratings,” https://www.gartner.com/reviews/market/digital-adoption-platforms

[38] U. Jha, “How digital adoption platforms enable digital transformation”, Sptember 2022, https://www.grazitti.com/blog/how-digital-adoption-platforms-enable-digital-transformation/

[39] K. Aslaksen and H. Loras, “The modality-specific learning style hypothesis: a mini-review,” Front. Psychol., vol. 9, 1538, 2018.

[40] S. Combefis, “A COVID 19 Teaching Experiment: Combining competency-Based assessment and Micro-Courses to teach technical and non technical skills,” in 2021 IEEE Frontiers in Education Conference (FIE), 2021, pp. 1-5.

[41] H. Colman, “7 benefits of microlearning you need to know,” January 2023, www.ispringsolutions.com/blog/benefits-of-microlearning

[42] J. Carmigniani and B. Furth, “Augmented reality: an overview,” Handbook of augmented reality, 2011, pp. 3-46.

[43] L. Fade, “The benefits of augmented reality for employee training,” February 2021, https://www.forbes.com/sites/forbes-businesscouncil/ 2021/02/12/the-benefits-of-augmented-reality-for-employee-training/ ?sh=15958cfe66d6

[44] J. M. Zheng, K. W. Chan and I. Gibson, “Virtual reality, A real world review on a somewhat touchy subject,” IEEE Potentials,1998.

[45] J. McCarthy, “What is AI?,” Computer Science Department, Stanford University, 2007.

[46] A. Owais, “Artificial Intelligence in HR,” Lecturer at Department of Management Studies, North Campus, University of Kashmir, JK, 2018.

[47] J. Hall, “9 tools that can help remote teams communicate better,” July 2022, https://www.forbes.com/sites/johnhall/2022/07/10/9-tools-that-can-help-remote-teams-communicate-better/?sh=-2f5a5803b2ff

[48] eSoftSkills, “What are the benefits of learning content aggregation?,” https://esoftskills.com/what-are-the-benefits-of-learning-content-aggregation/#2_Easier_content_curation

[49] K. Matyas, “The best places to find off-the-shelf elearning content,” June 2022 https://maestrolearning.com/blogs/7-of-the-best-places-to-find-off-the-shelf-elearning-content-2/

[50] Easygenerator, “What is content curation in L&D and how to use it?,” July 2022, https://www.easygenerator.com/en/blog/e-learning/content -curation-learning-and-development/

[51] P. Forster, “8 digital tools for the management of remote teams,” January 2021, https://morethandigital.info/en/8-digital-tools-for-the-management-of-remote-teams/

[52] R. K. Dahal, “Effectiveness of learning and growth performance metrics in the Nepalese telecommunications industry for organizational success,”. Problems and Perspectives in Management”, 20(4), 2022, pp. 238-249.

The Role of Healthy e-Business in Society 5.0: The Empowerment of the Human-centric Era

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Abstract—The article is brain waved to simultaneously style healthy e-business and enlighten its role in the new world order that moves forward towards the worldwide innovative human-centric phenomenon designed for long-term prosperity and well-being of all. The research method adopted in the study is founded on secondary data collection using a selected literature review approach, considering the conceptual nature of the study. The research results reveal the definition of healthy e-business and signify the role of e-business in shaping society aimed at empowering human-centricity. The concluding remarks depict the contribution, limitations and future research required to be carried out before the entire implementation into practice.

Keywords - healthy e-business, human-centricity, prosperity, well-being, innovation

I. DEFINING A RESEARCH PROBLEM

The world nowadays is characterised by the pronounced ever-present changes that fly on the wings of a promising new world order at high speed.

A sharp transformation that was:

- initiated by the birth of Industry 4.0 in Germany in 2011.,
- accelerated by the COVID-19 pandemic phenomenon, which spread from China worldwide at the beginning of 2020.,
- reshaped by the Russia-Ukraine war that boomed at the beginning of 2022., and
- outlined by the early signals of the banking crisis that took place at the beginning of 2023.,

strongly indicates a long wave of a significant shift in science, policies, societies, civilisations, economies, businesses, and organisations [1-17, 23].

Recent global research results referring to capitalism and extreme poverty—an analysis that has taken into account human height, real wages, and mortality since the long 16th century [18] on the one hand, and the Kondratieff cycles, a popular method used to analyse war and financial crises [17, 19] on the other—imply a call for scientists to rethink capitalism as a sustainable solution for the future. In other words, lessons learnt from history, accumulated challenges at a global scale [2], recent events, and researches strongly indicate a need for a transformational shift from capitalism to a new system that may satisfy the well-being and prosperity of all in the long run, taking into account all related human-centric aspects. Human-centricity is outlined by Society 5.0 and shaped by collective (hybrid) intelligence ecosystem concepts [1, 8].

Society 5.0 was developed in Japan by Keidanren – Japan Business Federation as a holistic and effective response to all global challenges, representing a future for the world, founded on a human-centric approach, and designed for all [1-3, 6-13]. Society 5.0 is defined as: "*A human-centred society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space*" [1, 8], [12, p. 415], [23, p. 64]. The Government of Japan acknowledged Society 5.0's vision, concept, and strategy in 2016 and broadly boosted its visibility outside the country's borders [1-3, 6-13, 15, 23, 27, 28].

Four years later, i.e. in 2020., a group of authors from Serbia have shaped a human-centric approach by putting a sustainable future at the centre of an innovative conceptualisation that strengthens the collective (hybrid) intelligence ecosystem viewed in an integrated manner. The concept is defined as: "*an innovative approach that encompasses and encourages simultaneous development and growth of both, economies and societies by introducing a concept of deep integration of humans' and smart machines' cognitive and emotional intelligence and open innovation, thus by empowering collective intelligence for the long-term well-being and prosperity of different stakeholder groups in the ecosystem*" [8, p. 134], [12, p. 415], [23, p. 65]. The model is founded on three main building blocks [8, 11, 12, 23]:

- open innovation,
- human beings' cognitive and emotional intelligence,
- artificial cognitive and emotional intelligence;

The transformative journey towards the collective (hybrid) intelligence ecosystem with the vision of a sustainable, noble, and human-centric future implies a significant shift from challenges to opportunities, a set of aligned changes viewed in a multidisciplinary manner, and holistic and smart management of change to maximise the potential for sustainable economies and societies in the long run [8, 23].

E-business has a significant role in empowering a human-centric era. E-business represents the business that employs the internet to network to empower e-commerce, e-business processes, e-collaboration, and e-communication with all stakeholders. In other words, e-business utilises the internet, intranets, extranets, and other networks to support commercial processes effectively. During its evolutionary journey driven by innovations, e-business has played a notable role in developing the new economy [20]. The development of a new economy can be grounded on key e-business models that determine a business path. For example: "Business to Business (B2B), Business to Consumer (B2C), Consumer to Business (C2B), Business to Government (B2G), Consumer to Consumer (C2C), Pear to Pear (P2P), Government to Citizen (G2C), Citizen to Government (C2G) and Business to Employee (B2E)" [24].

The energetic and high-speed development of information and communication technologies and the birth of Industry 4.0 have fostered the adoption of e-business on a global scale, simultaneously creating various benefits and opportunities on the one hand and costs and risks on the other. Recent research has depicted a growth of financial and non-financial costs and risks as a result of the exponential growth of cyber-attacks on governments, organisations, and individuals. The costs and risks include losses of revenue, sensitive data and reputation that influenced around 49% of organisations worldwide. In 2017, an evidenced loss amounted to more than $5 billion [10, 25, 26]. To create a sustainable future for all, the key concerns of the study arose:

- What would represent a healthy e-business?
- What is the role of healthy e-business in shaping a human-centric society?

The purpose of the article is to enlighten the reader on the definition of healthy e-business and its role in the new world order that moves forward towards the human-centric era conceptualised by Society 5.0 and collective (hybrid) intelligence ecosystem, a worldwide phenomenon designed for the long-term prosperity and well-being of all.

The paper is structured as follows: The introduction fashions a research problem. The research method sheds more light on the most appropriate method that fits the research problem based on the maturity level and research scope. Research results bring to the table key aspects needed to be considered as an effective response to the research problem. Finally, the paper ends with concluding remarks that contain key limitations, contributions, and future research towards a noble, human-centric era conceptualised for all.

II.RESEARCH METHOD

The overall research study is founded on the analogy of the building blocks of Beckhard and Harris's change model [4, 5, 46-48] where:

- Dissatisfaction with the status quo equals the research problem definition;
- Vision is equivalent to sustainable human-centric concepts of Society 5.0 and Collective Intelligence (Hybrid) Ecosystem [1, 8];
- First steps towards the preferred future state correspond to research results shown in Section 3.

When the research method is in question, the article opted for secondary data collection, considering that the existing theoretical fund has no evidence on the definition of healthy e-business and its role in empowering a human-centric era. In other words, the conceptual nature of the study and the research subject shown in this study for the first time have established a convenient research method grounded on the literature review approach. The review process consists of five stages, i.e. [10, 21, 23]:

- Definition of research criteria,
- Inquiry of relevant literature using reliable databases,
- Selection of the most suitable articles that fit the purpose and scope of the study, including published articles of the authors of this paper followed by Saaty's example of theory development [e.g. 49],
- Examination of selected articles,
- Derivation of results and conclusions.

The research results emanated according to the efforts viewed from two perspectives.

The narrow perspective comprehends a holistic view on:

- Dimensions definition,
- Healthy e-business requirements definition and categorisation in the corresponding dimension,

The broad perspective apprehends a healthy e-business as an entity in the ecosystem, harmonious to satisfy a human-centric vision. With that in mind, the role of healthy e-business is analysed and shown in the section hereafter.

The opted research method aims to maximise reliable research results for the research problem according to the research purpose and scope [21, 22, 10].

III. RESEARCH RESULTS

In order to design a healthy e-business concept that empowers a human-centric era, the study reveals building blocks that outline the phenomenon, based on which definition may be derived. Table 1 shows the holistic overview of aspects that constitute a healthy e-business concept introduced in this article [4, 5, 7, 8, 10, 11-14, 17, 23, 29, 30, 31, 32, 33, 34, 35, 36, 37-44].

Table I. A holistic overview of dimensions that constitute healthy e-business concept

Dimension	Healthy e-business requirements
Political, legal and policy	▪ Strong and secured telecommunications infrastructure at the country level with well-established resilience and risks frameworks through business continuity management, ▪ Legal and policies harmonisation of elements required for reliable healthy e-business at country, regional, and global level aimed at creating values for all: □ healthy e-business governance, □ industry standards and performance evaluation, □ clear rules at the market, □ intellectual property rights, □ copyrights, □ security and privacy requirements, □ strict rules for fraud prevention, detection and response. ▪ Effective healthy e-business strategies and change management, ▪ Efficient and effective government and governmental support to all stakeholders, ▪ Effective education governance regarding healthy e-business to all involved parties.
Economic	▪ Healthy growth based on simple, comfortable, cost-efficient, human-oriented and secured doing business in a healthy e-business ecosystem empowered by integrated technologies from Industry 4.0, ▪ Empowerment of a knowledge-based economy.
Organisation and management	▪ Establishment of clear healthy e-business strategies, ▪ Healthy e-business ecosystem development, ▪ Open innovation utilisation in healthy e-business models, ▪ Resilience development and utilisation in healthy e-business models, ▪ Trust development and empowerment in an ecosystem, ▪ Customer-centric orientation in the e-commerce business model, ▪ The shift from shareholders to stakeholders value creation, ▪ Effective change, project and innovation management, ▪ Effective education to all stakeholders, ▪ Effective leadership and trust-based collaboration development, ▪ Development of soft skills that fit the context of Society 5.0.
Technology	▪ High quality of infrastructure, ▪ Strong cybersecurity, information security and privacy, ▪ Emerging technologies integration with healthy e-business models and technologies (e.g. blockchain, AI), ▪ Interoperability, ▪ Resilience utilisation in business continuity management, ▪ Emotional intelligence utilisation in healthy e-business models and technologies, ▪ Dynamic, agile and responsive technology development and effective interactions with humans.
Process	▪ A well-defined, secured, resilient, easy-to-use, efficient process that strongly supports cyber and physical space integration and orientation to human-centric needs.
Social ethics	▪ High morals, integrity and fairness in a healthy e-business ecosystem, ▪ Development of security culture and trustworthy collaboration, ▪ Taking care of mental health in humans, ▪ Respectiveness of human rights and human needs.
Individuals / Humans	▪ Emotional intelligence development in humans, ▪ Empowerment of cognitive intelligence in humans, ▪ Effective decision-making based on fairness and integrated emerging technologies (e.g. AI, big data), ▪ Social and economic equity, ▪ Empowerment of quality of living, ▪ Inclusion into development and further evolution of healthy e-business concept.

Taking into account the holistic overview of healthy e-business requirements that constitute the healthy e-business concept introduced in this article, depicted in Table 1, the healthy e-business represents: *a holistic, multidisciplinary driven and innovative approach of simple, comfortable, resilient, secured, trusted, fair and human-oriented e-business, empowered by an effective support of integrated innovative technologies in a healthy e-business ecosystem with the purpose to ensure prosperity, well-being, and healthy growth of economies and societies in the long run suitable to fit noble sustainable future designed for all*.

Based on the vision and holistic overview of dimensions that build, in an integrated manner, healthy e-business, the role of such a notion in shaping a human-centric society is viewed in two key aspects.

First, when a socio-economic aspect is in question, healthy e-business contributes to the new emerging human-centric era in two fundamental ways:

- Development of healthy growth of economies and societies by integrating all requirements into the healthy e-business ecosystem, depicted in Table 1;
- Development of a new political and economic system, considering that capitalism cannot fit into the new human-centric era. For example, new GDP calculation may take into account the measurement of responsiveness and evolution of government, social and economic equity, resilience level, quality of living, intellectual property, copyrights, human rights, knowledge-based economy results, emotional intelligence development and adoption, mental health, quality of infrastructure, cybersecurity, information security, privacy, and other related aspects that do not constitute the healthy e-business concept [45].

Second, when humans are in question, healthy e-business may ensure a noble, resilient, comfortable, fair, secured, trusted, and high-quality environment that perfectly satisfies the needs of people, enabling perfect work-health-private life balance [11, 23].

From a strategic perspective, the key preferences of the healthy e-business concept lie in empowering a sustainable society and economy based on the development of efficient and effective e-businesses with incorporated hard and soft components, implying a beneficial supply of safe, trusted, resilient and healthy growth of all in the perfect integration of the vision of super-smart and human-centric society drawn by Society 5.0 or Collective Intelligence (Hybrid) Ecosystem [1, 8].

Research results imply significant changes in all related aspects, i.e. in science, societies and economies to satisfy the desired effects. The research results also emphasise the development of a new political-economic system as part of needed changes to align all corresponding components in the human-centric vision.

However, this transformative voyage conveys some challenges needed to be addressed. The main challenge refers to understanding the vision of a human-centric society, the concept of healthy e-business and its role in the human-centric society. Next, unalignment of all required aspects at all levels, inadequate strategic change management and lack of knowledge in the implementation process may end up with poor short-term results and low long-term outcomes.

Accordingly, the transformative journey of healthy e-business towards the Society 5.0 or Collective (Hybrid) Intelligence Ecosystem with the vision of a sustainable and people-oriented future suggests a strong wave shift from challenges to possibilities, with the primary principle on development and alignment of all described building blocks, considered and managed holistically, wised and in a multidisciplinary mode to maximise the prospect of sustainability to humans, economies and societies [8, 23].

IV. CONCLUDING REMARKS

The article is conceptualised with the purpose to simultaneously fashions healthy e-business and shed more light on its role in the new world order that moves forward towards the worldwide innovative human-centric phenomenon designed for long-term prosperity and well-being of all. Human-centricity is outlined by Society 5.0 and shaped by collective (hybrid) intelligence ecosystem concepts [1, 8].

E-business plays a vital role in strengthening a human-centric society and developing a new economy. However, the rapid growth of information and communication technologies and the origins of Industry 4.0 have accelerated the adoption of e-business, simultaneously bringing benefits and opportunities on the one hand and costs and risks on the other. Moreover, the exponential growth of cyber-attacks on governments, organisations, and individuals as a result of poor resilience have initiated new concerns at a global scale regarding costs and risks that encompass losses of revenue, sensitive data and reputation of all. In 2017, an evidenced loss at a global level amounted to more than $5 billion [10, 25, 26].

Taking into account that the existing theoretical fund has no evidence on the definition of healthy e-business and the role of healthy e-business in empowering a human-centric era, the paper opted for a secondary data collection using a selected literature review approach that fits the research problem according to the research scope.

Having all in mind, a healthy e-business reveals the holistic overview of dimensions and requirements that constitute a healthy e-business concept introduced in this article for the first time. The results are shown in Table 1, based on which the definition of a healthy e-business is carried out. Besides, the research results depict the role of healthy e-business in shaping a human-centric era, focusing on two key aspects: socio-economic and human beings.

The paper may contribute to the further development of e-business theory, a new political and economic system that measures healthy e-business requirements into the GDP calculation, and a human-centric future. However, despite the contribution, the key limitation of the article lies in the maturity level in the initial phase of conceptualisation. Accordingly, before the implementation into practice, future research should include qualitative and quantitative research analysis [15], simulations and deep test that considers the integration of all requirements enlighten in the study to maximise potential towards the desired outcome according to the vision of the human-centric era.

REFERENCES

[1] Keidanren - Japan Business Federation, "Toward realization of the New Economy and Society. Reform of the Economy and Society by the Deepening of Society 5.0", Keidanren, Tokyo, Japan, 2016. Available at: http://www.keidanren.or.jp/en/policy/2016/029_outline.pdf.

[2] M. Fukuyama, "Society 5.0: Aiming for a new human-centered society", Japan Spotlight, vol. 1, pp. 47-50, 2018.

[3] C. M. Ferreira, and S. Serpa, "Society 5.0 and social development", Management and Organizational Studies, vol. 5, no. 4, pp. 26-31, 2018.

[4] M. Čudanov, V. Tornjanski, and O. Jaško, "Change equation effectiveness: Empirical evidence from South-East Europe", Business Administration and Management, vol. 22, no. 1, pp. 99-114, 2019.

[5] V. Tornjanski, "Predviđanje uspešnosti organizacionih promena kvantitativnim Bekard i Harisovim modelom", doktorska disertacija. Beograd: Fakultet organizacionih nauka, 2019.

[6] K. Grunwitz, "The future is Society 5.0", Computer Fraud & Security, vol. 20, 2019.

[7] V. Tornjanski, S. Knežević, and S. Milojević, "Synergetic effects of integrated collaboration between humans and smart systems in banking: An overview", in XVII International Symposium SYMORG, Zlatibor, 2020.

[8] V. Tornjanski, M. Čudanov, and S. Marinković, "Shaping a new business landscape by empowering collective intelligence: Synergetic effects of open innovation, human and artificial cognitive and emotional intelligence", in 2nd Virtual International Conference: Path to a Knowledge Society-Managing Risks and Innovation - PaKSoM 2020, Niš, 2020.

[9] Japan Government – JG, "Abenomics", 2020. Available at: https://www.japan.go.jp/abenomics/

[10] V. Tornjanski, S. Knežević, D. Ljubanić, V. Glišić, D. Žižić, and J. Travica, "Towards secured digital business ecosystems: From threats to opportunities" in E-Business Technologies Conference Proceedings, vol. 1, no. 1, pp. 1–14, 2021.

[11] V. Tornjanski, S. Knežević and B. Vulević, "TOWARDS SUSTAINABILITY: SHAPING THE PROJECT MANAGEMENT LANDSCAPE IN THE CONTEXT OF THE SOCIETY 5.0", In Proceedings of the XXV MEĐUNARODNI KONGRES IZ UPRAVLJANJA PROJEKTIMA "ODGOVORNO I FLEKSIBILNO UPRAVLJANJE PROJEKTIMA", Belgrade, Serbia, pp. 173-184, 2021.

[12] V. Tornjanski, and M. Čudanov, "Towards Society 5.0 Era: Organisational Empowerment of the Sustainable Future", In Proceedings of the 3rd Virtual International Conference: Path to a Knowledge Society - Managing Risks and Innovation, Niš, Serbia, pp. 413-422, 2021.

[13] European Commisssion – EC, "Industry 5.0. - Towards a sustainable, human-centric and resilient European industry", European Commission Directorate-General for Communication, 2021. Available at: https://ec.europa.eu/info/publications/industry-50_en.

[14] D. Fasnacht, "Banking 4.0: Digital Ecosystems and Super-Apps", Theories of Change: Change Leadership Tools, Models and Applications for Investing in Sustainable Development, pp. 235-256, 2021.

[15] G. Săvoiu, M. Čudanov, and V. Tornjanski, "DOES THE HOLISTIC APPROACH CONSTITUTE A REALISTIC AND POSSIBLE OPTION FOR A FUTURE OF PROFOUND HUMAN KNOWLEDGE AND FOR A MODERN SCIENTIFIC RESEARCH?" Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ), vol. 12, no. 1, pp. 3-10, 2023.

[16] M. Ray, "Russia-Ukraine War", Encyclopedia Britannica, 13 Apr. 2023. Available at: https://www.britannica.com/event/2022-Russian-invasion-of-Ukraine.

[17] D. Fasnacht, and C. Straube, "Quantum computing as an enabling technology for the next business cycle", HMD Praxis der Wirtschaftsinformatik, Springer Nature, 2023. https://doi.org/10.1365/s40702-023-00969-x

[18] D. Sullivan and J. Hickel, "Capitalism and extreme poverty: A global analysis of real wages, human height, and mortality since the long 16th century", World development, 161, 106026, 2023. https://doi.org/10.1016/j.worlddev.2022.106026

[19] N. Kondratieff, "Die langen wellen der konjunktur", Archiv für Sozialwissenschaft und Sozialpolitik, vol. 56, no. 3, pp. 573-609, 1926.

[20] C. Combe, "Introduction to E-business", Routledge, 2012.

[21] P. K. Senyo, K. Liu, and J. Effah, "Digital business ecosystem: Literature review and a framework for future research", International journal of information management, vol. 47, pp. 52-64, 2019.

[22] H. Snyder, "Literature review as a research methodology: An overview and guidelines", Journal of business research, vol. 104, pp. 333-339, 2019.

[23] V. Tornjanski, S. Knežević, and B. Vulević, "Perspectives of Project Management Sustainability in the Society 5.0 Context: Moving Forward Towards Human-Centricity", European Project Management Journal, vol. 13, no. 1, pp. 61-73, 2023. DOI: 10.56889/qxqq4024.

[24] J.A. Pires, J. A., and R. Gonçalves, "Constrains associated to e-business evolution", In E-business issues, challenges and opportunities for SMEs: driving Competitiveness (pp. 335-349). IGI Global, 2011.

[25] FBI, "Ransomeware Prevention and Response for CISOs.," Federal Bureau of Investigation, 2017.

[26] S. Hasan, M. Ali, S. Kurnia, and R. Thurasamy, "Evaluating the cyber security readiness of organizations and its influence on performance," Journal of Information Security and Applications, vol. 58, no. 102726, pp. 1-16, 2021.

[27] M. C. Tavares, G. Azevedo, and R.P. Marques, "The Challenges and Opportunities of Era 5.0 for a More Humanistic and Sustainable Society—A Literature Review", Societies, vol. 12, no. 6, pp. 149, 2022. https://doi.org/10.3390/soc12060149

[28] V. A. Murcia, J.F. Palacios, and G. Barbieri, "Farmbot simulator: Towards a virtual environment for scaled precision agriculture", In Service Oriented, Holonic and Multi-Agent Manufacturing Systems for Industry of the Future: Proceedings of SOHOMA LATIN AMERICA 2021 (pp. 234-246). Springer International Publishing, 2021.

[29] J.E. Lawrence, and U.A. Tar, "Barriers to e-commerce in developing countries", Information, society and justice journal, vol. 3, no. 1, pp. 23-35, 2010.

[30] L. COLLINI, V. B. D. P. HAUSEMER, V. B. I. B. CHEN, V. B. J. VITIC, V. B. J. S. MARCUS, B. M. LE MOUEL, ... and P. S. L. ZAMPORI, "E-commerce and the EU Green Deal-Analysis of the environmental footprint of online sales in the context of the circular economy", Policy Department for Economic, Scientific and Quality of Life Policies Directorate-General for Internal Policies, 2022. doi:10.2861/538992

[31] V. Tornjanski, "Blok-lanac i sektor finansijskih usluga", U Čudan, A. i drugi. Forenzičko računovodstvo, istražne radnje, ljudski faktor i primenjeni alati (prvo izdanje, br. str. 1055-1079), Fakultet organizacionih nauka, Beograd, Srbija, 2021.

[32] V. Obradović, and M. Todorović, "Responsible Value Chain", In De Gruyter Handbook of Responsible Project Management, Walter de Gruyter GmbH & Co KG 267, 2023. https://doi.org/10.1515/9783110724783

[33] A. M. Corrales-Estrada, L. L. Gómez-Santos, C. A. Bernal-Torres, and J. E. Rodriguez-López, "Sustainability and resilience organizational capabilities to enhance business continuity management: A literature review", Sustainability, vol. 13, no. 15, 8196, 2021.

[34] V. Tornjanski, and M. Cudanov, "Are customers ready for evolving digital disruption?: Empirical evidence from banking

sector of Serbia", Innovation Management, Entrepreneurship and Sustainability (IMES), pp. 1024-1033, 2017.

[35] B. Radenković, M. Despotović-Zrakić, Z. Bogdanović, D. Barać, and A. Labus, "Elektronsko poslovanje", Beograd: Fakultet organizacionih nauka, 2015.

[36] D. Fasnacht, "Open Innovation in the financial services: Growing through openness, flexibility and customer integration", Verlag Berlin Heidelberg: Springer, 2009.

[37] H.W. Chesbrough, "The era of open innovation", MIT Sloan Management Review, vol. 44, no. 3, pp. 35-41, 2003.

[38] U.-i. Chung, Y. Tei, S. Mitsuyoshi and S. Tokuno, "How to reconcile morality and diversity in globalization and multidisciplinary integration," Econophysics, Sociophysics & Other Multidisciplinary Sciences Journal (ESMSJ), vol. 6, no. 1, pp. 4-7, 2016.

[39] I. Adizes, "Organizational passages—diagnosing and treating lifecycle problems of organizations," Organizational Dynamics, vol. 8, no. 1, pp. 3-25, 1979.

[40] Deloitte, "The future of cyber survey 2019 - Cyber everywhere. Succeed anywhere.," Deloitte, 2019.

[41] B. Delibašic, J. E. Hernández, J. Papathanasiou, F. Dargam, P. Zaraté, R. Ribeiro, S. Liu and I. Linden, "Decision Support Systems V–Big Data Analytics for Decision Making," in First International Conference, ICDSST, Belgrade, 2015.

[42] D. Fasnacht, "Open Innovation Ecosystem: The Winner Takes It All", Fasnacht D.(2018) Open Innovation Ecosystems. In: Open Innovation Ecosystems. Management for Professionals. Springer, Cham, 2019. DOI, 10, 978-3.

[43] S. Marinkovic, S. B. Rakocevic, and V. Tornjanski, "ENHANCING INNOVATION MANAGEMENT COMPETENCES IN BANKING", In Proceedings of the 25th EISIC - Excellence in Services International Conference, Universita di Verona, Italy (pp. 1-15), 2022.

[44] D. Cvijanović, V. Mirčetić, and S. Vukotić, "THE INFLUENCE OF LEADERSHIP STYLE ON ORGANISATIONAL PERFORMANCES AND CHALLENGES IN COVID-19 PANDEMIC AND SIMILAR CIRCUMSTANCES", THEMATIC PROCEEDINGS, 11, 2021.

[45] A. Yang, "Humanity is more important than money — it's time for capitalism to get an upgrade", ideas.ted.com. https://ideas.ted.com/humanity-is-more-important-than-money-its-time-for-capitalism-to-get-an-upgrade/amp

[46] R. Beckhard, "Strategies for large system change", Sloan Management Review, vol. 16, no. 2, pp. 43-55, 1975.

[47] R.F. Beckhard, and R.T. Harris, "Organizational Transitions: Managing complex change", MA: Addison Wesley Publishing Company, 1977.

[48] R.F. Beckhard, and R.T. Harris, "Organizational Transitions: Managing complex change", Reading, MA: Addison-Wesley, 1987.

[49] T.L. Saaty, "Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP)", J. Syst. Sci. Syst. Eng., Vol. 13, pp. 1–35, 2004. https://doi.org/10.1007/s11518-006-0151-5

Costs and Benefits of the Implementation of Smart Grids in the European Union

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Abstract— This paper discusses the costs and benefits of implementing smart grids in EU member states. Only six EU member states have achieved full coverage with smart meters. Smart grids contribute to increasing energy efficiency, balancing demand and supply for electricity and reducing harmful impacts on the environment. There are four regulatory incentives for Distribution System Operators cost efficiency and productivity. The treatment of costs in the functioning of energy distributors differs between countries. According to the capacities of Distribution System Operators for the application of smart grids, countries can be grouped into three clusters. EU member states are divided into two groups according to the net benefit from the application of smart meters. Although the capacities for integrating a smart grids into the energy system are the largest in Germany and the Czech Republic, in these two countries the cost benefit analysis of smart meters gives negative results..

Keywords - smart grid, smart meters, cost, benefit, European Union

I. INTRODUCTION

Due to the current conflict in Ukraine, the energy stability of the European Union is at risk. Despite the energy sector development strategies, the current situation has shown all the disadvantages of energy dependence on the Russian Federation. An effort made more urgent by the need to discover other sources of economic and industrial advantage outside of Russian gas would result in a 20% reduction in the EU's natural gas and oil demand this decade and a 50% reduction in coal demand [1].

The European Green deal can help the EU accomplish its revised 55% emissions reduction objective. In addition to the pre-pandemic baseline and the 40% objective, half of the deficit may be closed in the electricity sector, followed by transportation decarbonization. However, investments as part of the EU's green recovery can only support around half of this effort on a conditional basis. Additional investments and financial mechanisms are necessary to provide a route to 55% by 2030, particularly given the consequences of the newly announced REPowerEU initiative. Plans such as the REPowerEU, as well as other investment schemes that may follow in the near future, must be well prepared to prevent the danger of probable fossil fuel rebounds following COVID-19, despite the fact that the epidemic itself has been determined to have little influence on long-term emission trajectories [2].

Smart grids are particularly useful for integrating increasing amounts of variable renewable energy sources (RES), storage of energy, and electric car charging while retaining the system's efficiency and reliability. Smart grid provide data on supply and demand. Additionally, smart grids give users who generate their own energy the opportunity to react to pricing by returning any excess to the grid. With the help of smart grids, new market participants may supply customers with new kinds of services, allowing them to adapt their consumption and profit from the flexibility the grid has access to [3].

European Union provides a comprehensive framework for the integration of energy policies throughout its member states. Smart grids are intended to help to the EU's long-term goals, which include increasing energy efficiency and share of RES by 27% by 2030, and lowering greenhouse gas emissions. The European commission has placed a special priority on the large-scale roll-out of smart metering throughout all member countries, as envisaged by Electricity Directive from 2009, in order to include consumers in their active participation in the energy supply market [4]. Through a variety of features, smart meters should enable customers to take benefits from the gradual digitalization of the energy industry. Additionally, consumers should have quick access to contracts with dynamic power prices and data on their energy use. Nearly 77% of European users are anticipated to have a smart meter for electrical energy by 2024, and 44% will have a smart meter for gas [5].

II. THEORETICAL BACKGROUND

The first project, which installed 45 million smart meters throughout the EU's 12 member states, launched European smart grid initiatives in 2001. The implementation of smart meters decreased energy use by up to 10%. The development of smart grid technology and policies should go hand in hand. Energy security, supply dependability, economic opportunities, and impact mitigation are all advantages of smart grids. Future grid success depends on political and regulatory support, attention, and the restructuring of energy production, market, and consumption. Significant expenditures will be needed to make the transition to a smarter electrical grid [6].

Study [7] demonstrate that DSOs invest significantly more on average in markets with low market concentration ratios than in those with high ratios. The average investment in SG in the first group of countries was €206 per million of GDP, compared to €104 per million of GDP in the second group. Regulation with incentives may encourage the development of the smart grid and related investments. Investments averaged €130 per million of GDP in states with incentive-based regulation, compared to €78.6 per million of GDP in states with cost-based regulation. Similar to how an incentive-based scheme would be more successful than a hybrid model, a hybrid approach might also be beneficial in delivering investment incentives for smart grid [7].

Study by [8] shown that when incorporating RES, the adoption of a smart grid may considerably increase the dependability and stability of the energy system. The same study also discovered that using smart grid technologies can decrease the need for additional transmission and distribution equipment, thereby saving grid operators money [8].

The entire power consumption of communication networks and data centers, in particular, is equivalent to that of big countries. As a result, with rising power prices and looming carbon restrictions and taxes, the operational expenditures (OPEX) of communication networks and data centers are increasing. As a result, significant efforts have lately been made to improve the energy-efficiency of ICTs. Smart grid-driven strategies, in addition to traditional ways, have found their way to give OPEX savings. The smart grid has introduced new concepts including as dynamic pricing systems, distributed generation, demand management, and fine-tuned monitoring of faults and disturbances, which may be efficiently used to minimize ICT costs, consumption, and emissions [9], [10]. Faruqui et al [11] estimates the cost of installing smart meters in the EU and suggests that dynamic pricing enabled by smart meters can reduce peak demand and lower the need for expensive peaking power plants, resulting in operational savings.

According to a research [12], the integration of RES presents certain difficulties, including weather unpredictability, noise pollution, and high transportation costs. The utility may be able to minimize the peak power consumption during on-peak hours with the penetration of Plug-in Electric Vehicles (PEVs) and Energy Storage System, which has advantages for the environment and the economy. Integration of RES with PEVs has a great deal of potential to reduce CO_2 emissions, resulting in more environmentally friendly electricity. The smart grid idea is present across the whole power system with the goal of delivering more dependable, affordable, and sustainable electrical networks. When RESs, battery storage systems, and PEVs are integrated, however, it necessitates new control strategies. Smart grids can help with environmental preservation, the promotion of green energy, and improving grid stability [12].

Given the current environment of growing power demand, smart meters are essential for the seamless functioning and management of the future smart grid. With such a capability, load forecasting should be easier and more precise in order to deal with the future energy market. Furthermore, authentic datasets created by smart meters will be able to be sent directly to a server for more accurate analysis. The obtained data can be used for parametric and non-parametric predictive models. Non-parametric approaches employ non-linear data and are based on AI, whereas parametric methods use linear data. It is also noticed that, in addition to historical data from smart meters, several algorithms incorporate meteorological data and time period as inputs to their models. Key metrics of energy performance are utilized for each model to determine system correctness [13], [14]. On a sample of 64 European DSOs, the study [15] shows that traditional financial indicators are not good enough to show the profitability of investing in new digital technologies in the energy sector, such as smart grids and smart meters.

Study by [16] emphasizes the importance of conducting a comprehensive cost-benefit analysis of smart grid projects due to their large investment and delayed benefits. In study by [17] researchers models a smart municipal energy grid and finds that it can decrease total yearly community energy costs and reduce CO_2 emissions. According to [18] researchers builds a model to evaluate the costs and benefits of each system in the smart distribution network and finds that it is more secure, efficient, economic, and environmentally friendly compared to traditional distribution networks. Overall, the model suggest that while there are costs associated with implementing smart grids in the EU, the benefits include operational savings, decreased energy costs, and reduced CO_2 emissions [18].

The potential for the application of smart grids also exists in Serbia. The Republic of Serbia has a large energy potential for the use of renewable energy sources. Because of the incentive system in the form of feed-in tariffs, there is a growth in investments in the energy sector [19]. In study by [20] developed a BI model for the needs of the main electricity distributor in Serbia. The model is adapted to developing energy markets and includes three main components: balance responsibility, balance mechanism and allocation of cross-border capacities. According to the study [21] conducted in Serbia, consumers' views toward environmental preservation and green energy drive them to engage in new smart grid services. Furthermore, attitudes regarding these incentives fluctuate among age groups. Participants in the age ranges 31-50 may be more interested since they are more aware of environmental challenges [21].

III. IMPLEMENTATION OF SMART GRIDS

A. Research questions

Based on the review of the literature and available data from the publications of international institutions, several research questions were formulated that were attempted to be answered in this paper:

- Is it possible to measure the effects of the implementation of smart grids with financial indicators?
- What are DSO's capacities for the integration of smart grids and smart meters?
- What are the costs and benefits of implementing smart meters in EU countries?
- Is it possible to group EU member states according to the level of smart grid implementation?

B. Cost efficiency and productivity

The calculation of the WACC (Weighted Average Cost of Capital) is a critical component of the used regulatory procedures. Sectoral regulators determine the WACC in regulated contexts, such as the energy distribution industry, and the DSOs are reimbursed for the opportunity costs of capital through the WACC. Both the cost of debt and the cost of equity are taken into account by the WACC.

Consumers will pay a high price if the WACC is set above the future opportunity costs of capital, while network operators may not be able to cover expenditures that would improve the quality of network services if the WACC is set below those costs. Recent increases in EU inflation have brought it to levels not seen in more than 20 years. If the inflation anticipation is different from the actual inflation, DSOs who borrow in nominal terms are at danger. The more unclear real inflation outcomes are, the greater the danger. With rising loan rates brought on by higher capital costs due to growing inflation, DSOs may find it more difficult to invest in network assets and grid modernisation [22].

To group European countries by regulatory schemes, use various criteria. Group European countries by regulatory schemes using various criteria. In study [23] discusses about regulatory incentives for DSOs' cost efficiency and productivity. This study categorizes models into four types: price-cap, revenue-cap, cost-plus, and hybrid. In the study sample of 22 member states of the EU, 59% use revenue-cap systems, 14% use price-cap schemes, 14% use hybrid schemes, and 14% use cost-plus schemes. The Dutch price-cap regulatory scheme is an often cited example. Price-cap regulation has been used in the Netherlands since the first price control in 2002. The revenues that DSOs are permitted to generate during a regulation period are fixed and established using a mathematical formula under this framework. This strategy incentivizes network operators to reduce expenses in order to maintain or enhance profitability. Similarly, the main premise of price control in Slovakia employs a price-cap as a technique, which assures profit only under truly efficient company operations and encourages network providers to lower their own losses. Quite unexpectedly, in Slovakia, the price cap is established independently for each voltage level [24].

Currently, only Belgium, Croatia, and Estonia use cost-based regulatory frameworks. Typically, significant quality of service or other types of incentives are integrated with cost-plus regulatory frameworks in countries where they are used. As an illustration, the regulator in Belgium uses a sophisticated cost-plus model that combines a profit-sharing (PS) and a quality-of-service (QoS) mechanism. As part of the PS cost-reduction mechanism, the operator is rewarded for keeping real expenditure under budget by retrieving 50% of the difference (up to a cap of 10% of the budget). A few European regulatory authorities have created and put into place hybrid models that integrate rate-of-return, price-cap, and/or revenue-cap regulatory regimes. Italy, Portugal, and Hungary are among these countries that employ hybrid regulatory frameworks [24], [25].

Many hybrid models address capital costs (CAPEX) using a cost based approach and OPEX using an incentive based approach. The hybrid system in Portugal uses a price-cap model for the treatment of OPEX and a rate-of-return model for the handling of CAPEX for activities at the medium voltage network level. Another example is the Italian regulatory framework, where the regulator has encouraged DSOs to reduce OPEX while paying out the invested capital at a predetermined rate over four years. The Hungarian incentive regulation resembles a price-cap system in theory, but in reality, it mixes elements of quality regulation, revenue caps, and price caps [25].

The regulatory authorities in most EU members have a non-TOTEX approach, handling CAPEX and OPEX differently. Almost 80% of countries and DSOs use the non-TOTEX approach, while the other approach is present only in Croatia, Denmark, Portugal, Germany, and the Netherlands.

C. Capacities of Distribution System Operators

In order to be able to see the possibilities for the implementation of smart grids in the existing energy sectors of the EU member states, it is necessary to see the capacities of DSOs. Within the European Union, there are over 2.5 thousand DSOs, of which each of the 182 DSOs meets the needs of over 100 thousand customers. Fig. 1 shows the total number of DSOs by country and the number of DSOs that meet the needs of over 100 thousand users for each member country. The most DSOs are present in Germany (882), which also has the largest number of DSOs serving over 100,000 customers (80 DSOs). It is followed by: Spain with 354 DSOs, the Czech Republic (290), Poland (180) and Sweden (170).

Based on the number of DSOs serving more than 100 thousand customers, countries can be grouped into several clusters: countries with 8-12 DSOs, countries with 2-7 DSOs and countries with one DSO. Germany is not included in the clusters because the number of DSOs serving over 100,000 users is much higher compared to all member countries, and neither is Malta due to the number of consumers. The first cluster of countries consists of: Austria, Belgium, Denmark, Finland, Italy, and Romania. The second cluster of countries consists of Bulgaria, Czech Republic, France, Hungary, Netherlands, Poland, Slovakia, Spain, and Sweden. The third cluster of countries consists of Estonia, Croatia, Cyprus, Greece, Ireland, Latvia, Lithuania, Luxembourg, Portugal, and Slovenia [26].

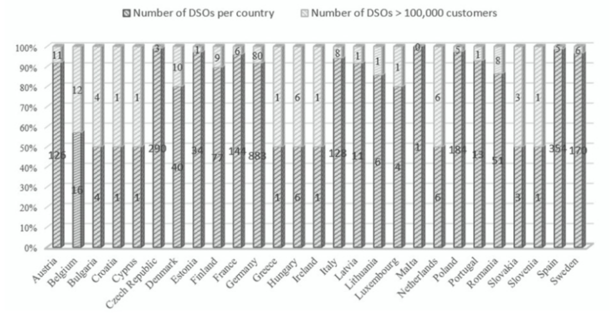

Fig. 1. DSOs in the EU member states in 2020, adapted from [26]

D. Smart meters

The coverage rate is calculated as the proportion of end users who have smart meters compared to all other end users in the DSO region covered. These statistics allow to identify five distinct degrees of coverage: There are five different roll-out stages: 1) Completed roll-out; 2) Nearing completion, 3) In process, 4) Early stage (pilot project), and 5) No roll-out.

On the one hand, DSOs who have finished a roll-out program and achieved an average of 97% coverage are those that have done so with full coverage throughout their service region. These DSOs have been included in group 1. On the other side, fourth group is given to DSOs that have installed smart meters for less than 20% of their consumers, attaining an average customer coverage of 10%.

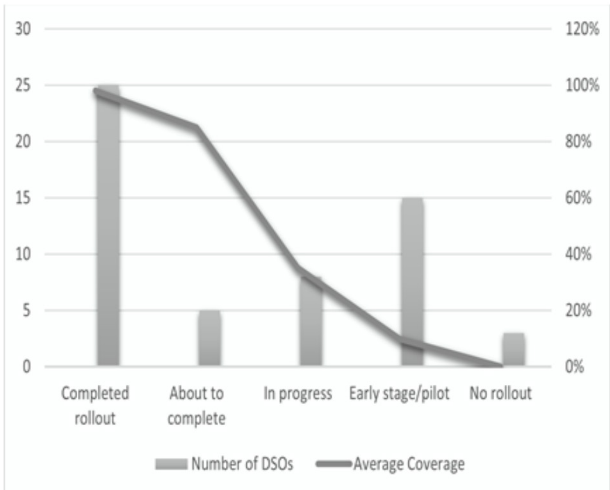

Fig. 2. The coverage rate of DSOs by smart meters in 2022, adapted from [24]

By the end of 2022, a few Member States will have achieved the Directive's criteria (80% coverage by 2020), while others will have fallen short or given up entirely. DSOs were grouped together in first group because, as was predicted, the degree of smart meter penetration is near to 100% in Member States where a nationwide roll-out has been completed. Italy, Sweden, Finland, Spain, Denmark, and Estonia are a few of the top EU nations for the implementation of smart meters [24].

Table 1 shows data for 22 member countries for which data were available. For Finland, France and Malta, there is no data on the benefits of smart meters, so the net benefit cannot be measured. In terms of costs, smart meters are the most expensive in the Czech Republic, followed by Austria, Germany and Ireland. The lowest costs of smart meters are in Portugal, Romania, Italy, and Malta.

If the net benefit is considered as the difference between benefits and costs per unit for smart meters, EU member states can be divided into two groups. The countries that realize a net benefit are: Greece, Estonia, Portugal, Italy, Ireland, Austria, Netherlands, Sweden, Luxembourg, Poland, Denmark, and Slovak Republic. The largest net benefit per meter point was achieved by Greece and Estonia. The second group of countries consists of those countries that realize a net loss according to this criterion: Romania, Lithuania, Germany, Czech Republic, and Latvia. These results are not expected since the second group of countries includes countries that have low unit costs of smart meters [25].

In order to improve the level of coherence across European, national, and regional activities addressing smart grids, the Smart Grids European Technology Platform was founded in 2004. This platform's collaboration with other nations, particularly North America and Japan, played a crucial role in ensuring that the development of commercial goods and the global expansion of smart grids are complimentary. The British government has created a number of organizations and platforms to boost donations towards the construction of smart grids. The Energy Technologies Institute, a collaboration between the UK government and business sectors, is a good example. It permits the accelerated development of green technologies, such as energy storage, building energy management, and DSOs, with a flexible mix of public and private finance [27]. The countries of the Western Balkans have adapted the regulatory framework for energy to the directives of the European Union. In these countries, especially due to their potential in the field of RES and geographical proximity to the EU, there is a possibility for the application of smart grids and inclusion in already existing EU transnational projects of smart grids. However, due to insufficient investment in the energy sectors of the countries of the Western Balkans, the implementation of smart grids significantly lags behind the countries of the European Union [28].

Table I. Cost and benefit per metering point

Country	Cost per metering point in euros	Benefit per metering point in euros	Net benefit in euros
Austria	590	654	64
Czech Republic	766	499	-267
Denmark	225	233	8
Estonia	155	269	114
Finland	210	n/a	n/a
France	135	n/a	n/a
Germany	546	493	-53
Greece	309	436	127
Ireland	473	551	78
Italy	94	176	82
Latvia	302	18	-284
Lithuania	123	82	-41
Luxembourg	142	162	20
Malta	77	n/a	n/a
Netherlands	220	270	50
Poland	167	177	10
Portugal	99	202	103
Romania	99	77	-22
Slovak Republic	114	118	4
Sweden	288	323	35

IV. CONCLUSION

The integration of the smart grid into the existing energy system leads to benefits that can be qualitatively and quantitatively expressed. Demand response is one way smart grids enhance energy efficiency. Consumers are encouraged to limit their energy use during peak hours, when power demand is highest. Smart grids can help these initiatives by giving users with real-time data on their energy consumption and allowing them to alter their consumption accordingly. This can assist decrease the need for extra power plants to be brought up during peak hours, which can be costly and polluting, as well as gather enough information to provide customised demand response services. The main advantage is in increasing the stability and efficiency of the energy sector. This is especially pronounced when it comes to RES, primarily due to seasonal variations in the production of energy from different renewable sources. Smart grid can to enhance economic growth, create new green jobs, and improve environmental protection.

However, consumer awareness and education about the smart grid is needed to improve consumer acceptance and protection. Data protection is one of the possible problems in the operation of smart grids.

Implementing smart grids in the EU can bring benefits, but requires careful planning and analysis to ensure economic viability and optimize the energy system. In terms of monitoring the costs of operating DSOs, there is no uniform methodology in all member countries. Due to the different models for evaluating the efficiency and productivity of the energy sector, it is difficult to make comparisons between countries. Although DSOs capacities are the largest in Germany and the Czech Republic, in these two countries the cost benefit analysis of smart meters gives negative results. Future directions of research can be oriented towards the construction of indicators that will enable a more precise comparison between member countries in which smart grids are implemented.

REFERENCES

[1] International Energy Agency, "World energy outlook 2022," 2022. [Online]. Available: https://www.iea.org/reports/world-energy-outlook-2022.

[2] K. Hainsch., K. Löffler, T. Burandt, H. Auer, P.C. del Granado, P. Pisciella, and S. Zwickl-Bernhard, "Energy transition scenarios: What policies, societal attitudes, and technology developments will realize the EU Green Deal?," Energy, vol. 239, 122067, January 2022.

[3] L. Morten, I. Røpke, and E. Heiskanen, "Smart grid: hope or hype?." Energy Efficiency, vol. 9, pp. 545-562, April 2016.

[4] N. IqtiyaniIlham, M. Hasanuzzaman, and M. Hosenuzzaman, "European smart grid prospects, policies, and challenges," Renewable and Sustainable Energy Reviews, vol. 67, pp. 776-790, Januaru 2017.

[5] European Commission, "Smart grids and meters," 2023. [Online]. Available:https://energy.ec.europa.eu/topics/markets-and-consumers/smart-grids-and-meters_en.

[6] M. Kochański, K. Korczak, and T. Skoczkowski, "Technology innovation system analysis of electricity smart metering in the European Union," Energies, vol 13 (4), 916, February 2020.

[7] C. Cambini, A. Meletiou, E. Bompard, and M. Masera, M., "Market and regulatory factors influencing smart-grid investment in Europe: Evidence from pilot projects and implications for reform," Utilities Policy, vol. 40, pp. 36-47, June 2016.

[8] A.Q, Huang, "Power semiconductor devices for smart grid and renewable energy systems,"Power electronics in renewable energy systems and smart grid: Technology and applications, pp. 85-152, June 2019.

[9] M. Erol-Kantarci and H.T Mouftah, "Energy-efficient information and communication infrastructures in the smart grid: A survey on interactions and open issues," IEEE Communications Surveys & Tutorials, vol. 17(1), pp. 179-197, July 2014.

[10] D. Ruilong, "Smart grid and demand side management, " in Handbook of Real-Time Computing. Singapore: Springer Nature Singapore, pp. 681-703, August 2022.

[11] A. Faruqui, D. Harris and R. Hledik, "Unlocking the €53 billion savings from smart meters in the EU: How increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment," Energy Policy vol. 38 (10), pp. 6222-6231, October 2010.

[12] M. A. Judge, A. Khan, A. Manzoor and H.A. Khattak, "Overview of smart grid implementation: Frameworks, impact, performance and challenges," Journal of Energy Storage, vol. 49, 104056, May 2022.

[13] F. Dewangan, A. Y. Abdelaziz, and M. Biswal, "Load Forecasting Models in Smart Grid Using Smart Meter Information: A Review." Energies vol. 16 (3), 1404, January 2023.

[14] L. Diahovchenko, M. Kolcun, Z. Čonka, V. Savkiv and R.

Mykhailyshyn, R, “Progress and challenges in smart grids: distributed generation, smart metering, energy storage and smart loads,” Iranian Journal of Science and Technology, Transactions of Electrical Engineering, vol. 44, pp. 1319-1333, February 2020.

[15] G. Prettico, A. Marinopoulos and S. Vitiello, "Guiding electricity distribution system investments to improve service quality: A European study," Utilities Policy, vol. 77, 101381, August 2022.

[16] M. Pongrašić and Tomšić, “Cost-benefit analysis of smart grid projects implementation,” Journal of Energy, vol. 66, 2017.

[17] I. Batas-Bjelic, N. Rajakovic and N. Duic, "Smart municipal energy grid within electricity market," Energy vol. 137, pp. 1277-1285, October 2017.

[18] X. Yu, J. Li, S. Zhang, J. Liu, Y. Niu and D. Wang, “Comprehensive costs and benefits evaluation of smart distribution network,” October 2015 [4th International Conference on Information Technology and Management Innovation, pp. 500-504, 2015].

[19] M. Parežanin, "Strane direktne investicije u energetskom sektoru Republike Srbije," Ekonomske ideje i praksa, vol. 23, pp. 85-95, December 2016.

[20] M. Radenković, J. Lukić, M. Despotović-Zrakić, A. Labus and Z. Bogdanović, “Harnessing business intelligence in smart grids: A case of the electricity market,” Computers in industry, vol. 96, pp. 40-53, April 2018

[21] M. Radenković, Z. Bogdanović, M. Despotović-Zrakić, A. Labus, D. Barać and T. Naumović, “An IoT approach to consumer involvement in smart grid services: A green perspective,” In Trends and Innovations in Information Systems and Technologies, Springer International Publishing, vol. 1 8, pp. 539-548, May 2020.

[22] W. Romeijnders and M. Mulder, “Optimal WACC in tariff regulation under uncertainty,” Journal of Regulatory Economics, vol. 61(2), pp. 89-107, March 2022.

[23] A. Meletiou, C. Cambini and M. Masera, “Regulatory and ownership determinants of unbundling regime choice for European electricity transmission utilities,” Utilities Policy, vol. 50, pp. 13-25, Februarz 2018

[24] A. Meletiou, J. Vasiljevska, G. Prettico and S. Vitiello, “Distribution System Operator Observatory 2022,” 2023, [Online]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC132379

[25] Council of European Energy Regulators, “Report on regulatory frameworks for European energy networks 2022,” CEER, 2023, [Online]. Available: https://www.ceer.eu/documents/104400/-/-/2a8f3739-f371-b84f-639e-697903e54acb

[26] Euroletric, “Distribution Grids in Europe: Facts and Figures 2020,” 2021, [Online]. Available: https://cdn.eurelectric.org/media/5089/dso-facts-and-figures-11122020-compressed-2020-030-0721-01-e-h-6BF237D8.pdf

[27] M. A. Brown and S. Zhou, "Smart-grid policies: an international review," in Advances in Energy Systems: The Large-scale renewable energy integration challenge, pp. 127-147, 2019.

[28] I. Batas-Bjelic and N. Rajakovic, "National energy and climate planning approach for the Western Balkans: between the carrot and the stick of the EU Green Agenda," International Journal of Global Environmental Issues vol. 20 (2-4), pp. 123-134, February 2022.

Geospatial Data - Platform, Products and Applications

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Abstract—Geospatial and location-based information is increasingly becoming a key part of the pervasive digital world of transformation and innovation trends, changing many business practices, providing new technological applications, and bringing about a data revolution that is having a positive influence on social and economic systems. The connection of geospatial data and new technologies is the direction to be pursued at the global world level. Part of this connection is a digital platform of investment locations. The author presents the main goal of this paper ¬— to build a register of investment locations. The sub-goals are: collecting data for the register of investment locations and raising the capacity of human resources. The project itself is an innovative solution that contributes to the new platform to consolidate the existing state of pilot investment locations, affect the development of geospatial data, and to turn data into digital form. The paper describes the research and the achieved results of the project.

Keywords - geospatial data, investment location, platform

I. INTRODUCTION

Geospatial and location-based information is increasingly becoming a key part of the pervasive digital world of transformation and innovation trends, changing many business practices, providing new technological applications, and bringing about a data revolution that is having a positive influence on social and economic systems. [1]. Geospatial data is a critical component in policy making, resource planning, land surveying, disaster mitigation, and monitoring infrastructure. It is also crucial in defense, security, and agriculture operations among other things. Geospatial data plays a fundamental role in driving the development goals of nations, the growth of the economies, navigating the response to natural disasters and climate change, etc. [1].

The connection of geospatial data and new technologies is the direction to be pursued at the global world level. Part of this connection is the digital platform of investment locations. Such a platform has been developed in the Republic of Serbia. The applied methodology is the construction of a model that includes the analysis of potentials of investment locations, determining significant data on the location, as well as raising the capacity of human resources.

II. GEOSPATIAL DATA

Geospatial data is any information with a reference of location. Today, most companies have a spatial reference and combine their data with other market data. It is certain that information technologies have led to the digitization of geospatial data, which contributes to a significant context for informed decision-making based on data [2,3].

Collection and analysis of geospatial data requires the use of information and communication technologies and mapping of 3D geodata. Such an approach is based on a commitment to integrated, multidisciplinary projects that emphasize science and research based on data handling and access to information about location, its parameters, society, and the environment. With the help of new technologies, trends and correlations between data can be displayed in order to gain insight into target groups, locations, and markets.

Spatial information, combined in a common infrastructure, provides many opportunities to improve public services, contribute to better planning and decision-making, and reduce costs by avoiding duplication and inconsistencies in data [4].

III. DIGITAL PLATFORM OF INVESTMENT LOCATIONS

The increased value of capital investments cannot be separated from the investment attractiveness that attracts domestic or foreign investors. Some factors that can create investment attractiveness are labor, infrastructure, price, economy, market size, political, social, and cultural regulations [5].

Along with the development of technology, the investor's decision to invest is also influenced by information, communication and technological capabilities, and e-government services. The benefits of e-government implementation are bureaucracy reform, corruption reduction, transparency, and improved accountability [6]. For better understanding, investment locations have a multidisciplinary approach from the aspects of architecture, urbanism, construction, economy, finance, law, but often also the protection of the human environment.

The digital platform of investment locations helps to visualize location data. This gives a deep insight into locations, markets, and operations. The features of this digital platform are as follows:

- Up-to-date and accurate - Regular updates ensure high accuracy of investment locations;
- Highly detailed - View location details in one place;
- Possibility of visual inspection of locations;
- Linking to other data related to the investment location.

The Republic Geodetic Authority has also recognized the importance and investment in the digital platform of investment locations in Serbia. This is the bearer of the realization of the idea that all potential investment locations are published in digital form. The idea was implemented through the project "Improving the business environment in the Republic of Serbia", which is supported by the Swedish International Development Cooperation Agency (SIDA) and the Swedish Agency for Cartography, Cadastre and Land Registration - Lantmateriet, which began in early 2019 [7].

This project is one in a series of activities in the process of developing the e-space of the Republic of Serbia, and should contribute strengthening the economy based on knowledge and innovation. The goal of the project is to contribute to achieving sustainable and inclusive economic growth in the Republic of Serbia, improving the business environment, increasing investment and innovation of the private sector, improving the transparency of the investment process, and improving the climate for investment inflows. Also, the project contributes to the process of European integration of the Republic of Serbia and improves activities on the implementation of the 2030 Sustainable Development Agenda of the United Nations and as such is extremely important for the Government of the Republic of Serbia.

IV. METHODOLOGY

The realization of the basic goal implies several basic questions:

- What are the benefits from the digital transformation of the investment location community building process?
- Do stakeholders agree with changes in the Law, organizational behavior?
- How will locations be managed in the digital age? What are the possible overcoming obstacles?
- Planning and possible creation of a continuous process of building a digital community of investment locations.

Based on these issues, the main hypothesis is defined in the project:

- Implementation of the digital platform of investment locations will contribute to the formation of the register of investment locations.

Special hypotheses set:

- The formation of the digital platform of investment locations is influenced by data obtained from local self-government units.
- The formation of the digital platform of investment locations is influenced by mutual cooperation and communication between the implementer and the representatives of the local self-government unit.

Building a digital platform implies conducting research related to the type of data to be collected from local governments, but also to determine the significance of each data for the investor.

V. RESEARCH

The research was conducted among 11 units of local self-government: Arilje, Bor, Valjevo, Vranje, Knjaževac, Požarevac, Pirot, Sombor, Ćuprija, Čačak, Zrenjanin. It lasted for several months, which, in addition to the basic questionnaire, also included trainings in order to achieve the results of the research.

The research addressed the following questions:

- What are the capacities of human resources in local self-government units?
- For legal restrictions, investors are mainly interested in type of land ownership. What types of investments are allowed? What planning documents do exist?
- Is the transport infrastructure related to the distance of locations from road, railway, river, and air traffic important for a potential investor?
- Under the location significance data, the significance is reflected in the following elements: Where is the location? Cadastral municipality, Number of cadastral parcels, Number of real estate lists, Communal equipment, Planned purpose, Planning basis, Area, Area for alienation…
- How significant is the energy potential of the location?
- Is the potential of wind, biomass, gas, solar energy, geothermal energy source significant?

VI. RESULTS

In order to achieve the goal of the project, we start by collecting data for the register of investment locations, the formation one of the obligatory elements according to the Law on Planning and Construction [8]. Based on the research conducted in the pilot units of the local self-government, it was realized that potential investors are primarily interested in legal restrictions, and then the traffic infrastructure. Location-related data are in third place on a scale of 1 to 10.

Based on these results, it was concluded that certain attributes with a lower significance score will not be presented on the future digital platform. In addition, it was pointed out that important attributes are incentives for local self-government units, as well as contacting in order to achieve possible cooperation and communication between investors and representatives of local self-government units.

Raising human resource capacity is an important element — the sustainability of the project depends on it, and it is necessary to consider internal and external resources.

Internal resources represent human resources within local self-government units. It is necessary to develop appropriate competencies among employees in local self-government units who are ready to respond to the needs of the project. It should be kept in mind that adequate human resource management can have an impact on corporate culture and organizational climate, information and knowledge management, etc. [9, 10]. The principles and desired contribution of employees are incorporated into human resources policy at the organizational level. In this way, a direct impact on the capacity of local self-government units can be achieved through increasing the competencies of employees and their mutual interaction [11].

The availability of external resources is also needed for the smooth implementation of the project. These are stakeholders who identify as partners. Among them are: the Development Agency of Serbia, the Ministry of Construction, Transport and Infrastructure, the Republic Bureau of Statistics, the National Employment Service, the Standing Conference of Towns and Municipalities, and many other institutions. Connection with stakeholders in terms of external resources is the systems and protocols that are defined and with which electronic communication is realized.

For the needs of good cooperation and communication, the project implementer organized a series of trainings for representatives of local self-government units. Due to the advent of the COVID-19 virus, the trainings were mostly online.

Having in mind human resources, internal and external, there is a connection of several actors in one place: investors, local self-government units, state, and other institutions. Between them, electronic communication is realized, which includes several models of communication: G2B, G2C, B2B, B2C, and B2E. The two most common models of communication are G2C and G2B [12,13]:

- The Governance-to-Consumer (G2C) model is used by potential investors to obtain information about investment locations. The G2C model is primarily concerned with obtaining information about the location by local governments. The G2C principle has caused a visible adjustment of the representatives of local self-government units, who have the opportunity to make an offer, in order to attract investors and thus survive in a selective and strong market. It is imperative on a digital platform where the investor can get detailed information about the location.
- The Government-to-Business (G2B) model is represented in communication between local governments and other institutions. This communication includes information between individual legal entities. The basis of the G2B model concerns the provision of information, which aims to increase efficiency, reduce transaction costs, and provide real-time information for all participants in the chain [13]. Reduction of transaction costs is achieved by reducing the cost of paying for services and using the Internet to obtain and compare the latest information related to investment locations. Providing real-time information involves creating accurate reports on the location and its attributes.

A. Data visualization on a digital platform

Based on the data collected so far, the Republic Geodetic Authority has started publishing investment locations on the digital platform Geosrbija. All local self-government units submitted data on at least one location located within their local self-government unit. The following figures show the data visualization on a digital platform.

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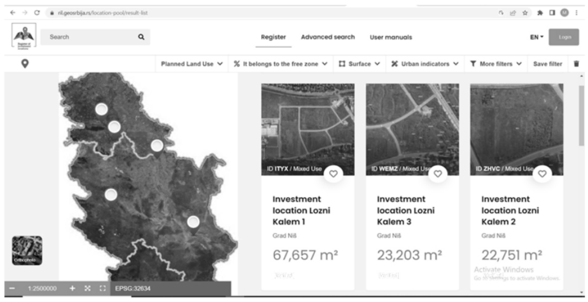

Fig 1. Investment locations in the register of investment locations [14]

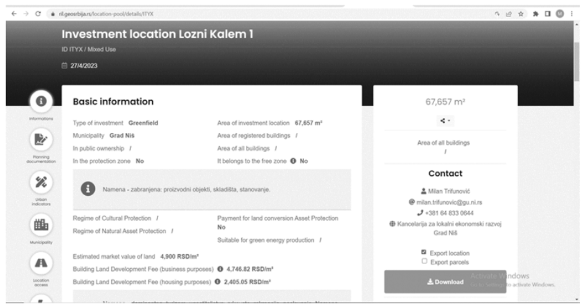

Fig 2. Investment location Lozni Kalem 1, Nis [14]

In that way, the current realization of the project is monitored, until a platform is established, that will be used exclusively for monitoring investment locations. This achieves full visibility of the project's results so far.

The results of the project is the standardization of data, the regular updating of which leads to the establishment of the National Register of Investment Locations.

The planned model is designed to [7]:

- Enable unique identification of each investment location;
- Establish a unified classification of locations at the state level;
- Provide relevant information to potential investors;
- Provide transparent insight to citizens, the state, and other stakeholders;
- Have the possibility of connecting with other national registers;
- Ensure that all information is defined in accordance with ISO 19100 standards and the INSPIRE directive;
- Ensure that all changes to the data can be monitored and updated.

The Register of Investment Locations is structured to ensure its sustainability and development during and after the establishment of the register. This is achieved by a Web application that contains data from the field. The primary role of the Web application is to provide a mechanism for collecting and maintaining data on investment locations in the field that will be automatically stored in the database of the National Geospatial Data Infrastructure. The Web application will be an interface for tracking investment locations, a map and a channel of communication between investors and representatives of the local self-government unit.

Eleven local self-government units in Serbia participated in the implementation of the project. The project itself is an innovative solution that contributes to the new platform to consolidate the existing state of pilot investment locations and to turn data into digital form. Data collection and exchange is done with official institutions, and all participants have the possibility of electronic monitoring of investment locations [17]. In this way, it is possible to find data on investment locations in one place, view existing human resource capacities and improve their quality, as well as to achieve multiple advantages in business, organization, and system efficiency [18]. The main goal of this project is to build a national model of investment locations. Hypotheses have been confirmed, the construction of this model enables the formation of a register of investment locations based on research conducted with representatives of local governments. Within the implementation of the project, mutual cooperation was achieved between implementers and representatives of the local self-government unit.

VII. CONCLUSION

The digital platform of investment locations represents the register of investment locations as part of the future e-space. This platform strives to lead a responsible and optimized system solution in a built environment, which offers advanced tools for modeling, recommending strategies and solutions that will provide architects, engineers, developers, investors, and all stakeholders greater reliability of all resources in the country. In this way, information is the most important resource that changes perceptions, the concept of space and time, affects social relations, creating social justice, economic equality and moral and political boundaries that are interconnected and represent modern technological development.

Therefore, it influences the formation of a better organizational and business climate. The effect of local economic development is achieved, which improves the quality of life of residents by increasing the number of employees, their real income, quality of infrastructure and local services, growth of property and living standards, and the like [15, 16].

This project builds a national register of investment locations through the collection of data for the register of investment locations, raising the capacity of human resources and monitoring the implementation of tasks and their visibility.

REFERENCES

[1] Geospatial World Forum, available https://geospatialworldforum.org/geo4sdgs.php ,2023

[2] Radenković B., Despotović-Zrakić M., Bogdanović Z., Barać D., Labus A., Bojović Ž.,, "Internet inteligentnih uređaja – Prvi udžbenik na srpskom jeziku iz oblasti Internet of things", Fakultet organizacionih nauka, 2017

[3] Tahirović T., Naumović T., Živojinović L., Bogdanović Z. & Despotović-Zrakić M.,, "Designing augmented reality services for e-business: a project management perspective", European Project Management Journal, 8 (2) 2, 2018, pp. 9-16,

[4] Tajudeen, F.P., Nadarajah, D., Jaafar, N.I., Sulaiman, A., "The impact of digitalisation vision and information technology on organisations' innovation", European Journal of Innovation Management, 25(2), 2021

[5] Khan S., Khan S., Aftab M.,"Digitization and its impact on economy", International Journal of Digital Library Services, 5(22), 2015, pp. 138-149

[6] Prasetyo B., Susanto T.W., "The Relationship Analysis of e-Government Implementation on Increasing Capital Investment in the Region" (Case Study: Banyuwangi City), IPTEK, Journal of Engineering, 3(1), 2017

[7] Republički geodetski zavod, The Project Proposal for Improvement of Investment environment in Serbia, Serbia, 2018

[8] Law on Planning and Construction ("Sl. Glasnik RS" br. 72/2009, 81/2009 - ispr., 64/2010 - odluka US, 24/2011, 121/2012, 42/2013 - odluka US, 50/2013 - odluka US, 98/2013 - odluka US, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - dr. zakon i 9/2020) 2020

[9] Kourtit, K., Nijkamp, P. and Steenbruggen, J., "The significance of digital data systems for smart city policy". Socio-Economic Planning Sciences, 58, , 2017, pp. 13-21

[10] Kuhlmann S., Heuberger M., "Digital transformation going local: implementation, impacts and constraints from a German perspective", Public Money & Management, doi: 10.1080/09540962.2021.1939584, 2021

[11] Sheffi,Y., ,"Supply Chain management under the threat of international terrorism". Internal Journal of Logistics Management. 12(2), 2001, pp. 1-11

[12] Jovanović-Milenković M., Radojičić, Z., Milenković, D., Vukmirović, D., "Applying electronic documents in development of the healthcare information system in the Republic of Serbia". Computer Science and Information Systems, 6 (2), 2009, pp.

111-126

[13] Jovanović-Milenković M., "Elektronski zdravstveni sistem i metode unapređenja zdravstvenog stanja stanovništva u Republici Srbiji", Univerzitet u Beogradu, Fakultet organizacionih nauka, doktorska disertacija, Beograd, 2011

[14] Republički geodetski zavod, geoportal Geosrbija, available https://a3.geosrbija.rs/, 2023

[15] Aničić D., "Uloga lokalne samouprave u privrednom razvoju Republike Srbije – mogućnosti i ograničenja", Univerzitet "Union - Nikola Tesla", Fakultet za graditeljski menadžment doktorska disertacija, Beograd, 2018.

[16] Kuhlmann S., Wayenberg E., Bergström T., Franzke J. "The Essence and Transformation of Local Self-Government in Western Europe". In Franzke J.,. Kuhlmann S, Bergström T., Wayenberg E. (Eds.), The future of local self-government. Challenges for local democracy and administration, 1-14, 2021.

[17] Gis and data, available: https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6, 2020

[18] Jagwan P., Sharma G., "Georeferencing and Digitization of Walkways: A GIS Case Study", International Journal of Engineering Research & Technology, 4(5), 2015, pp.1150-1152

Digitalization of Factoring Services: A Quick Scoping Review

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Abstract— Factoring is a financial service that involves the purchase of a company's accounts receivable (invoices) by a third-party financial company known as a factor. Alongside the other financial services, factoring has witnessed major technological disruptionc in the last few decades. The aim of this paper is to review the literature on the digitalization of factoring services. For this purpose, a quick scoping review of the literature has been conducted. The results show that the main technologies disrupting this industry are blockchain and artificial intelligence.

Keywords - factoring, digitalization, value chain, technology disruption

I. INTRODUCTION

In general, factoring as a service belongs to a greater family of Supply Chain Finance services [1]. In specific, factoring is a financial service that involves the purchase of a company's accounts receivable (invoices) by a third-party financial company known as a factor. Usually, supplier sells accounts receivable to the factor against a premium and receives cash for immediate working capital needs [2]. The factor then assumes responsibility for collecting payment from the customer on those invoices. The factor earns a fee on the purchase amount, and the company receives immediate cash flow to fund its operations.

Digitalization of the factoring industry refers to the process of using digital technologies to automate and streamline the entire factoring process, from invoice creation to payment collection. This includes the use of electronic invoicing, online payment processing, automated credit checks, and digital document management. A lot of individual elements of the value process in the past have been conducted with a lot of manual work and subjective assessments. New technologies, however, have changed the landscape of financial industry and increased the importance of supply chain finance [3].

The factoring sector has various advantages as a result of going digital, including better productivity, less paperwork, quicker transaction processing, increased accuracy, and lower prices. Additionally, it enables the provision of more flexible and specialized factoring services, such as selective invoice factoring, in which a business can decide which invoices to sell to the factor rather than all of them. This can be particularly supportive for the SME sector, since the digitalization of factoring can improve efficiency and transparency of their financial operations [4]. Digitalization also enables factors to offer their services to a broader range of businesses, including smaller companies that may not have been able to access factoring services in the past due to high costs or a lack of resources.

The aim of this paper is to review the literature on the digitalization of the factoring industry. Literature reviews are seldom used in the realm of supply chain finance in general [5]. Nonetheless, specific financial services, such as factoring services have been put of the research radars. The specific aim of this paper is to analyze technologies with the highest impact of disruption of particular elements of the factoring value chain. Similar methodology was used in other financial industries, such as banking [6] or insurance [7].

The remainder of this paper is structured as follows. Section II briefly explains the background to factoring value chain and potential disruptive technologies. Section III explains the methodology of this study. Section IV delineates the results and contextualizes the findings. Section V is reserved for the concluding remarks.

II. BACKGROUND

A. Factoring service value chain

Parties involved in factoring are (i) the assignor (supplier), (ii) the lender (factor) who buys the accounts receivable from supplier and (iii) and the debtor (buyer) who is obliged to pay the legitimate holder of the collection rights at the maturity. In the case of factoring without recourse the factor purchases the receivables assuming the credit risk for the buyer's ability to pay. The other option is factoring with recourse which means that factor has the right to request receivables payment from supplier when buyer defaults on payment at due date of receivables.

The process of factoring without recourse may be described as follows:

1. The supplier submits a credit request to factor for purchase of receivables from customers (i.e. factoring limit for specific customers). The factor performs credit risk analysis of the customers. Credit risk analysis is similar to any other banking product, and it is based on qualitative (e.g. company description, market position, competition, business model) and quantitative data (e.g. financial statements). If the creditworthiness of the buyers is acceptable the factor will support the transaction and a factoring contract will be signed.
2. The supplier sells the goods or services to the customers. Payment instructions in sales invoice direct customer's payment straight to the factor at the invoice due date. Typical maturity of short-term factoring financing is between 30 and 90 days, depending on the credit quality of the customer but it is also possible to repurchase receivables with maturity longer than 90 days.
3. In accordance with factoring contracts, trade receivables are transferred to the factor who pays the supplier immediately upon receipt.
4. At receivables due date, the customer pays receivables on bank account of the factor.

Accordingly, the value chain of the factor is represented in Fig. 1.

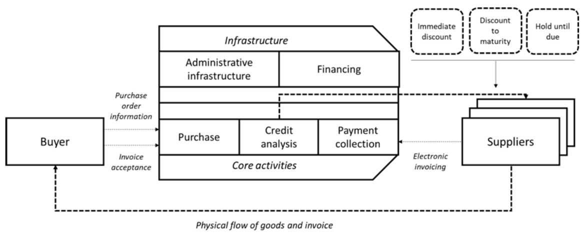

Fig. 1. Value chain model for factoring services (authors' own representation partially based on [8])

The factoring industry in Europe has been developing in the last few decades. Table 1 shows the size of the factoring market for selected European countries.

Table 1 Size of factoring market in European countries

	%GDP		%GDP		%GDP
BE	21,20%	ES	11,20%	DK	6,60%
EE	19,20%	DE	9,80%	SE	4,90%
PT	17,80%	IE	9,30%	SI	4,30%
NL	16,30%	AT	8,50%	CZ	3,80%
IT	15,90%	GR	8,30%	LV	3,50%
FR	15,70%	HU	7,20%	RO	3,00%
CY	14,30%	BG	7,20%	HR	2,40%
FI	14,00%	LT	7,00%	SK	1,90%
PL	12,90%	MT	6,80%	LU	0,70%
UK	12,00%	NO	6,80%	CH	0,10%

Source of data [9]

As shown in Table 1, the size of the total factoring services market is huge. In some countries, such as Belgium, it occupies more than a fifth of the total GDP of a country. Nonetheless, the figures in Table 1 clearly depict that the European economies significantly differ in market size. This provides excellent background for the digitalization and further improvement and growth in the industry.

An additional argument for the importance of the digitalization process in the factoring industry is the ever growing need to make supply chains more efficient and cost effective. Ever since the outbreak of the COVID-19 pandemics, supply chains have witnessed major disruptions [10]. This risk can partially be mitigated with the improvements in supply chain finance in general and factoring in particular [11].

B. Disruptive technologies in financial services

In the last few decades, technology has dramatically reshaped the landscape of conventional financial institutions and services. Scholars and practitioners are very active in discussing which novel technology will have the most disruptive effects on financial services. Consequent lack of consensus is partly expected since the financial industry itself is evidently multifaceted.

Several technologies are particularly important for the disruption of the factoring value chain. Most of them are still underexplored [12]. Concurrent literature usually focuses on electronic invoicing and blockchain technologies [13], machine learning (artificial intelligence) [14], big data and the internet of things [15]. In this paper, we will focus on two technologies – blockchain and artificial intelligence.

In this paper we focused on the two most important elements of the factoring value chain. First, as inferred by [14], credit analysis in the supply chain finance will be at the forefront of the technology influence. Second, document flow and decentralization of payments becomes important, particularly from a global point of view. Accordingly, our main focus will be put on credit analysis and document management within the supply chain.

III. METHODOLOGY

To analyze the possible future direction of the digitalization of factoring services, we conducted a quick scoping review. Contrary to the large scale literature review, such as the bibliometric study [16], this method aims to identify nature and extent of research evidence for the fast-developing research streams [16].

The steps undertaken in our study are given in Table 2.

Table 2 Framework of the quick scoping review

Step	Explanation	Process	Output (No of Papers)
1	Search through Scopus and Web of Sciences databases	Boolean search*	349
2	Abstract/Key words screening	Manual inspection	79
3	Full text screening of the papers	Manual inspection	64
4	Authors judgement on the quality	Manual inspection	11
Factoring service AND blockchain OR artificial intelligence			

A total of 11 papers have been thoroughly analyzed to generate findings on the possible trajectories of the development of the factoring services in the future. Two technologies have been isolated as the most important for the industry transformation – blockchain and artificial intelligence (machine learning).

IV. RESULTS & DISCUSSION

Digitalization is a paramount driver of the transformation in a number of sectors and industries [18]. In this section, we present the main findings for the future of digitalization in the factoring industry by two technologies: (i) blockchain and (ii) artificial intelligence.

A. Blockchain and the transformation of the factoring industry

In particular, as explained in [19], "[b]lockchain Technology (BCT), featuring decentralization, tamper-proofing, traceability, which is usually paired with the Internet of Things (IoT) in real-world contexts, has been widely adopted in the field of finance and is perfectly positioned to facilitate innovative collaborations among participants in supply chain networks." Blockchain enabled supply chain financing firms had even shown greater resilience during the COVID-19 pandemics [20]. Blockchain technology in particular can contribute to (i) improved transparency, (ii) faster payments, (iii) reduced fraud, (iv) enhanced traceability, and (v) increased efficiency:

Blockchain allows for a shared, immutable ledger that all parties in a supply chain can access. This increases transparency and reduces the likelihood of errors or fraudulent activities. Some studies find that the use of blockchain increases the documentation efficiency by 75% [21].

Blockchain can enable faster and more efficient payments between suppliers and buyers, reducing the time and cost associated with traditional payment methods. Smart contracts, in particular, allow for easy and fast transaction in document processing [22]. Accordingly, factors can use blockchain to expedite document reconciliations during factoring. It even creates a positive signaling effect, since "by opening a window of transparency into a firm's supply chain, blockchain technology furnishes the ability to secure favorable financing terms at lower signaling costs" [23].

Fraud in supply chain finance is very serious [24]. Blockchain's immutability makes it difficult to tamper with transaction records. This reduces the risk of fraud, such as invoice fraud or double-spending.

Blockchain can provide a record of every transaction in a supply chain, from the initial supplier to the end customer. This makes it easier to trace products and ensure compliance with regulations and thusly enhances traceability and increases trust [25].

Increased efficiency: Blockchain can automate many of the processes involved in supply chain finance, such as verifying transactions and updating records. This, in turn, reduced financial costs and improves cash flow performance [26].

B. Artificial intelligence and the transformation of the factoring industry

Financial institutions all over the world are investing heavily in artificial intelligence, even though its benefits are yet nascent. This is mostly because of the influence AI is already having on the financial markets and the potential disruption it could have on the whole banking sector [27]. Use cases for AI:

AI can disrupt the credit analysis since "big data makes it possible to base credit score predictions on a broader range of variables than those traditionally included in the classic statistical models (typically, payment history and income)" [28]. AI can also automate the collection of data from a variety of sources, including credit reports, financial statements, and social media. This allows for a more comprehensive and accurate analysis of creditworthiness.

AI can be used to analyze historical data and predict future credit risk. A number of reviews have been focused on the use of AI for predicting financial soundness of a client [29]. Such predictions are vital for any financial industry since credit decisions can stimulate immense financial losses generated from defaulters [30].

AI can use NLP to analyze unstructured data such as social media posts, allowing lenders to assess the behavior of the customer. This can utterly improve financial inclusiveness [31].

Two disruptive technologies elaborated in this paper have a large impact on the digitalization of factoring services in general. However, other digitization enablers should also be taken into consideration when approaching the full-scale performance improvement of both supply chains and individual business. Some of the examples for the digitization include customer acceptance [32], organizational readiness [33], or digital skills of service providers [34].

V. CONCLUSIONS

In this paper, we studied the main activities within the factoring value chain and the main disruptive technologies that have the potential to substantially change the factoring service in the near future. We identified two main activities within the factoring value chain that are prone to the high degree of digitalization – document flow and within the supply chain and the credit analysis. Additionally, two technologies that are considerably changing the paradigm of factoring are blockchain and artificial intelligence.

This study provides twofold implications – for researchers, and for practitioners. As for the researchers, this study identified the main future agenda for the technology-induced changes in the factoring industry, having in mind the fast development of supply chain finance in the last few decades and the growing body of research around it, this might be useful paths for future research. As for the practitioners, this study might be useful for the management of factoring companies (factors). It can help them to understand how they can reduce costs, increase efficiency, and reach a wider customer base by implementing novel technologies in their operations. This study can be beneficial to other stakeholders – buyers and sellers, regulators, and financial analysts.

Although this study provides fresh evidence on the development of factoring services, there are several limitations related to the methodology used. By using the quick scoping review, we might have excluded some publications with important findings. Accordingly, further research should include other databases (e.g. Scopus, GoogleScholar, and CrossRef), other more specific search phrases, and non/scholarly reports (e.g. reports from the major consulting agencies, international organizations, and regulators).

REFERENCES

[1] B. Liu, T. Ju, and H. K. Chan, "The diverse impact of heterogeneous customer characteristics on supply chain finance: Empirical evidence from Chinese factoring," International Journal of Production Economics, vol. 243, p. 108321, Jan. 2022, doi: 10.1016/j.ijpe.2021.108321.

[2] P. Kouvelis and F. Xu, "A Supply Chain Theory of Factoring and Reverse Factoring," Management Science, vol. 67, no. 10, pp. 6071–6088, Oct. 2021, doi: 10.1287/mnsc.2020.3788.

[3] J. Chen, M. Wu, S. Xu, and C. Zhao, "Empirical Analysis of Supply Chain Finance Innovation Model Based on Blockchain Technology," Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, pp. 296–312, 2021, doi: 10.1007/978-3-030-72792-5_26.

[4] Z. Ali, B. Gongbing, and A. Mehreen, "Does supply chain finance improve SMEs performance? The moderating role of trade digitization," Business Process Management Journal, vol. 26, no. 1, pp. 150–167, Oct. 2018, doi: 10.1108/bpmj-05-2018-0133.

[5] Z. Liu, "Literature Review of Supply Chain Finance Based on Blockchain Perspective," Open Journal of Business and Management, vol. 09, no. 01, pp. 419–429, 2021, doi: 10.4236/ojbm.2021.91022.

[6] A. Naimi-Sadigh, T. Asgari, and M. Rabiei, "Digital Transformation in the Value Chain Disruption of Banking Services," Journal of the Knowledge Economy, vol. 13, no. 2, pp. 1212–1242, Mar. 2021, doi: 10.1007/s13132-021-00759-0.

[7] M. Eling, D. Nuessle, and J. Staubli, "The impact of artificial intelligence along the insurance value chain and on the insurability of risks," The Geneva Papers on Risk and Insurance - Issues and Practice, vol. 47, no. 2, pp. 205–241, Feb. 2021, doi: 10.1057/s41288-020-00201-7.

[8] J.-F. Lamoureux and T. A. Evans, "Supply Chain Finance: A New Means to Support the Competitiveness and Resilience of Global Value Chains," SSRN Electronic Journal, 2011, doi: 10.2139/ssrn.2179944.

[9] "The Report on the Factoring Industry in 2021." The Serbian Chamber of Commerce. https://pks.rs/udruzenje/udruzenje-za-bankarstvo-osiguranje-i-druge-finansijske-institucije (accessed Apr. 4, 2023).

[10] L. Li, Z. Wang, and X. Zhao, "Configurations of financing instruments for supply chain cost reduction: evidence from Chinese manufacturing companies," International Journal of Operations & Production Management, vol. 42, no. 9, pp. 1384–1406, Jun. 2022, doi: 10.1108/ijopm-12-2021-0755.

[11] A. Moretto and F. Caniato, "Can Supply Chain Finance help mitigate the financial disruption brought by Covid-19?," Journal of Purchasing and Supply Management, vol. 27, no. 4, p. 100713, Oct. 2021, doi: 10.1016/j.pursup.2021.100713.

[12] F. Caniato, M. Henke, and G. A. Zsidisin, "Supply chain finance: Historical foundations, current research, future developments," Journal of Purchasing and Supply Management, vol. 25, no. 2, pp. 99–104, Mar. 2019, doi: 10.1016/j.pursup.2019.02.002.

[13] Nienhuis, J. J., Cortet, M., & Lycklama, D. (2013). Real-time financing: Extending e-invoicing to real-time SME financing. Journal of Payments Strategy & Systems, 7(3), 232-245.

[14] A. Moretto, L. Grassi, F. Caniato, M. Giorgino, and S. Ronchi, "Supply chain finance: From traditional to supply chain credit rating," Journal of Purchasing and Supply Management, vol. 25, no. 2, pp. 197–217, Mar. 2019, doi: 10.1016/j.pursup.2018.06.004.

[15] W. A. Abbasi, Z. Wang, Y. Zhou, and S. Hassan, "Research on measurement of supply chain finance credit risk based on Internet of Things," International Journal of Distributed Sensor Networks, vol. 15, no. 9, p. 155014771987400, Sep. 2019, doi: 10.1177/1550147719874002.

[16] M. Milosavljević, Ž. Spasenić, and V. Damnjanović, "Bibliometric Survey on Microfinance for the SMEE Sector," Lecture Notes in Networks and Systems, pp. 430–444, Nov. 2022, doi: 10.1007/978-3-031-18645-5_27.

[17] C. Hamel et al., "Defining Rapid Reviews: a systematic scoping review and thematic analysis of definitions and defining characteristics of rapid reviews," Journal of Clinical Epidemiology, vol. 129, pp. 74–85, Jan. 2021, doi: 10.1016/j.jclinepi.2020.09.041.

[18] M. Milosavljević, S. Radovanović, and B. Delibašić, "What drives the performance of tax administrations? Evidence from selected european countries," Economic Modelling, vol. 121, p. 106217, Apr. 2023, doi: 10.1016/j.econmod.2023.106217.

[19] L. Guo, J. Chen, S. Li, Y. Li, and J. Lu, "A blockchain and IoT-based lightweight framework for enabling information transparency in supply chain finance," Digital Communications and Networks, vol. 8, no. 4, pp. 576–587, Aug. 2022, doi: 10.1016/j.dcan.2022.03.020.

[20] S. Paul, A. Adhikari, and I. Bose, "White knight in dark days? Supply chain finance firms, blockchain, and the COVID-19 pandemic," Information & Management, vol. 59, no. 6, p. 103661, Sep. 2022, doi: 10.1016/j.im.2022.103661.

[21] M. J. Lahkani, S. Wang, M. Urbański, and M. Egorova, "Sustainable B2B E-Commerce and Blockchain-Based Supply Chain

Finance,” Sustainability, vol. 12, no. 10, p. 3968, May 2020, doi: 10.3390/su12103968.

[22] A. Rijanto, “Blockchain Technology Adoption in Supply Chain Finance,” Journal of Theoretical and Applied Electronic Commerce Research, vol. 16, no. 7, pp. 3078–3098, Nov. 2021, doi: 10.3390/jtaer16070168.

[23] J. Chod, N. Trichakis, G. Tsoukalas, H. Aspegren, and M. Weber, “On the Financing Benefits of Supply Chain Transparency and Blockchain Adoption,” Management Science, vol. 66, no. 10, pp. 4378–4396, Oct. 2020, doi: 10.1287/mnsc.2019.3434.

[24] M. Du, Q. Chen, J. Xiao, H. Yang and X. Ma, "Supply Chain Finance Innovation Using Blockchain," in IEEE Transactions on Engineering Management, vol. 67, no. 4, pp. 1045-1058, Nov. 2020, doi: 10.1109/TEM.2020.2971858.

[25] C.-H. Tsai, “Supply chain financing scheme based on blockchain technology from a business application perspective,” Annals of Operations Research, vol. 320, no. 1, pp. 441–472, Nov. 2022, doi: 10.1007/s10479-022-05033-3.

[26] V. Natanelov, S. Cao, M. Foth, and U. Dulleck, “Blockchain smart contracts for supply chain finance: Mapping the innovation potential in Australia-China beef supply chains,” Journal of Industrial Information Integration, vol. 30, p. 100389, Nov. 2022, doi: 10.1016/j.jii.2022.100389.

[27] A. Oualid, A. Hansali, Y. Balouki, and L. Moumoun, “Application of Machine Learning Techniques for Credit Risk Management: A Survey,” Lecture Notes in Networks and Systems, pp. 180–191, 2022, doi: 10.1007/978-3-030-91738-8_18.

[28] H. Sadok, F. Sakka, and M. E. H. El Maknouzi, “Artificial intelligence and bank credit analysis: A review,” Cogent Economics & Finance, vol. 10, no. 1, Jan. 2022, doi: 10.1080/23322039.2021.2023262.

[29] I. R. Berrada, F. Z. Barramou, and O. B. Alami, “A review of Artificial Intelligence approach for credit risk assessment,” 2022 2nd International Conference on Artificial Intelligence and Signal Processing (AISP), Feb. 2022, doi: 10.1109/aisp53593.2022.9760655.

[30] M. Islam, L. Zhou, and F.Li, “Application of artificial intelligence (artificial neural network) to assess credit risk: a predictive model for credit card scoring,” MSc thesis, Blekinge Institute of Technology School of Management 2009.

[31] D. Mhlanga, “Financial Inclusion in Emerging Economies: The Application of Machine Learning and Artificial Intelligence in Credit Risk Assessment,” International Journal of Financial Studies, vol. 9, no. 3, p. 39, Jul. 2021, doi: 10.3390/ijfs9030039.

[32] N. Milanović, M. Milosavljević, S. Benković, D. Starčević, and Ž. Spasenić, “An Acceptance Approach for Novel Technologies in Car Insurance,” Sustainability, vol. 12, no. 24, p. 10331, Dec. 2020, doi: 10.3390/su122410331.

[33] M. Hussain and A. Papastathopoulos, “Organizational readiness for digital financial innovation and financial resilience,” International Journal of Production Economics, vol. 243, p. 108326, Jan. 2022, doi: 10.1016/j.ijpe.2021.108326.

[34] H. Gupta, S. Kumar, S. Kusi-Sarpong, C. J. C. Jabbour, and M. Agyemang, “Enablers to supply chain performance on the basis of digitization technologies,” Industrial Management & Data Systems, vol. 121, no. 9, pp. 1915–1938, Nov. 2020, doi: 10.1108/imds-07-2020-0421.

E-government Divide – Case Study Serbia

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Abstract—The paper investigates the phenomenon of the e-government divide, which is assumed to present one of the main obstacles for the further development of digital services, and public administration in general. The results of quantitative and qualitative research indicated that it is necessary to redefine the methodological framework for measuring and monitoring both the digital divide in general and the e-government divide. Emphasis was placed on digital skills, which were found to represent one of the main factors of e-government inclusion. A methodological approach based on the definition of gap levels, with corresponding indicator is proposed. This solution is analyzed through a case study: e-government divide in the Republic of Serbia. The indicators defined in this way are given and their base values calculated for 2022.

Keywords - e-government divide, digital skills, indicators

I. INTRODUCTION

There are at least four factors determining the success of implementation of e-government: political, technological, organizational and social factors [1]. The focus of this paper is researching the social factors that are associated with the skills of the public on new technologies in order to reduce the e-government gap and increase digital inclusion, in general. Digital inclusion is the process of bringing the knowledge and use of information communication technology (ICT) closer to those who do not already have it, thus, bridging the digital divide [2].

The digital divide has long been established in the literature as complex phenomenon with social, political, economic, technological, and educational dimensions [3]. The digital divide (gap or digital inequality) has been defined in three different ways [4]:

- inequality of opportunities in technological access and connectivity to devices and networks, the internet on first place;
- illiteracy in computer skills to use technology among those who have access; and
- lack of the necessary digital competences for doing things and creating with ICT in complex situations such as education, business and e-commerce.

According to some scholars, digital literacy and digital skills are not synonyms. They state that digital literacy is a broader concept that implies digital skills and the ability to understand, evaluate and reuse information [5]. However, after secondary research, it can be concluded that this difference is increasingly erased, in benefit of digital skills [6].

The e-government divide is a gap between those who use and don't use e-government services, regardless of whether they have or do not have access to these services. It is indisputable that e-government requires citizens to be digitally literate, with a certain level of digital skills.

The subject of research in this paper is the analysis of the methodological concept and practical implications of the e-government divide, through a case study (CS) of the Republic of Serbia (RS) in order to reduce this divide. It starts from policy analysis, to specific definitions of indicators for monitoring set goals. The paper presents the results of research that indicate the main factors of the e-government divide in Serbia and the shortcomings in the existing indicators for their monitoring, which must be in focus of policymakers. Also, the conclusions give a set of recommendations for their improvement.

II.METHODOLOGY

Research and analysis of the available literature and other documentary sources in which the synthesis of the results is the basic methodological procedure applied in this paper.

The main research are:

- Usage of ICT in the RS, 2022, Households/Individuals as quantitative secondary research [7], and

- Online focus groups, as qualitative research.

The results of survey on ICT usage were conducted as CATI survey on a representative sample of 2.800 households/individuals on the territory of the Republic of Serbia (excluding Kosovo). The reference period was January 2022 (the three months preceding the telephone interview) and selected question were referred to the entire previous year (2021). The response rate was 90.6% (2.537 individuals). The basic methodological notes are shown in Figure 1. Statistical Office of the Republic of Serbia (SORS) conduct this survey based on EUROSTAT methodology, every year, from 2005.

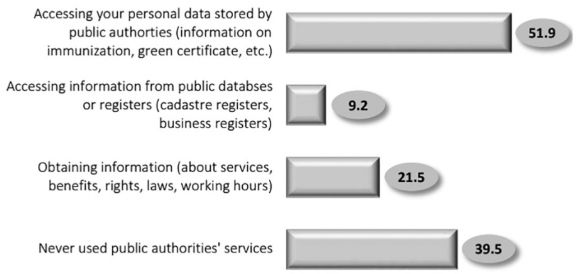

Fig. 1. Methodological frame of survey on ICT usage in RS [7]

The basic definitions are:

- Online population: The percentage of population aged between 16 and 74 who have used the Internet in the last three months, and
- Offline population: Percent of population aged between 16 and 74 who have not used the Internet in the last three months.

To further clarify the results obtained from quantitative research, two online focus groups were conducted. The following variables were controlled based on the disaggregation variables in the quantitative research:

- Age,
- Sex,
- Educational level, and
- Employment situation.

Twenty respondents were divided into two groups of 10 participants each:

- e-government non-users, representing the online population who have never used digital public authorities' services (experimental group), and
- e-government users (control group).

The research was conducted separately for both groups, with the same moderator, lasting 90 minutes, on April 14, 2023, under the Microsoft Teams meeting platform.

III. RESULTS

E-government services can be categorized as either informational or transactional [Nadal]. The level of necessary skills and literacy of users also depends on the category of use.

- **Informational services** are characteristic of advertising space models (billboard stage) in which the institution's website is perceived only as a static mechanism for displaying information. Practically no form of communication is established, as citizens are passive observers
- With **transactional services**, interaction is established, as one-way and two-way communication between the government and the users. Transactional services require much more digital skills and presents one of the main challenges in using e-government and increasing of e-the government divide.

The e-government divide is directly connected with the digital divide in general. which represents a gap in the possibility and ability to use public authorities' services, on different levels, measured by various indicators.

The e-government divide has been defined at different levels:

- **Access gap**, which is a consequence of inequality in opportunities of technological access and internet connectivity. This divide stratifies the general population into the online and offline population.
- **E-government gap**, which is a divide within the online population between those who use and those who do not use e-government services. This divide stratifies the online population into e-government users and non-users

Inequality among e-government users also exists:

- **E-government skills gap**, which is a consequence of computer illiteracy and lack of ICT skills among those who have access. This divide stratifies e-government users into the "basic" and "above basic skills" categories.
- **E-government digital competence gap**, which is a consequence of the lack of necessary digital competences to achieve beneficial outcomes in various complex processes such as education, business (including e-commerce and e-government). This divide stratifies e-government users into those who only use informational services and those who use transactional services as well.

Based on the research results, a third category is added to this classification:

- **E-government subjective divide gap**, as a consequence of subjective reasons for not using public digital authorities' services. The assumption that this category includes e-government users with "basic skills" is confirmed in conclusions from online focus groups (Case study: RS).

In order to reduce the e-government divide, which also implies reduction each of the aforementioned gaps, it is necessary to define a strategic and methodological framework with indicators for monitoring.

At the EU level, in 2014, the Digital Skills Indicator (DSI) was defined as a composite indicator based on selected activities related to internet or software use those individuals aged 16-74 perform in five specific areas (Information and data literacy, Communication and collaboration, Digital content creation, Safety, and Problem solving) [8]. It is assumed that individuals who have performed certain activities possess the corresponding skills.

Based on the variety of activities performed, two levels of skills ("basic" and "above basic") are computed for each of the five areas. Finally, an overall digital skills indicator is calculated based on the component indicators for each area, serving as a proxy for the digital skills of individuals. The overall indicator includes categories such as "no skills", "limited", "narrow", "low", "basic", "above basic", or "at least basic skills" [9].

DSI implementations:

- DSI is used as an indicator for monitoring the Digital Decade, a strategic document that sets concrete targets for 2030 in four key areas: skills, infrastructures, digital transformation of businesses, and public services. Therefore, skills and public authorities' services are interconnected in the digital transformation package, accompanied by infrastructures [9].
- DSI is used as an indicator for monitoring the Digital Compass, an action plan that includes the target of ensuring that at least 80% of citizens (identified as the share of individuals aged 16-74) have at least basic digital skills by 2030 [10].
- DSI is used for constructing the DESI Index (the Digital Economy and Society Index), which monitors the annual progress of EU Member States in the digital domain. This report includes country profiles that help Member States identify areas for priority action, along with thematic chapters providing EU-level analysis in four main policy areas [11]. [11].
- DSI also monitors the implementation of the European Skills Agenda, which aims to achieve a target of 70% of adults aged 16-74 having at least basic digital skills by 2025 [8].
- Finally, DSI supports the implementation of the Sustainable Development Goals [12].

DSI has been revamped in its second edition, DSI 2.0, introduced in 2022. The Digital Skills Indicator 2.0 (DSI 2.0) categorizes digital skill levels as Basic, Intermediate, Advanced, and Digital Expert [6].

Based on the above, it can be concluded that the EU has a well-established methodological framework for monitoring digital skills. DSI 2.0 is accompanied by a revamped methodological framework based on the European Commission's Digital Competence Framework (DigComp) and its second edition [13].

IV. CASE STUDY: E-GOVERNMENT DIVIDE IN RS

A. National strategic framework

The national strategic framework for digital skills in RS is the Strategy for development of digital skills in the Republic of Serbia (Strategy) for the period from 2020 to 2024 [14]. The Strategy is based on the Digital Agenda for RS, which includes the Strategy for the Development of the Information Society in RS until 2020 and the Strategy for the Development of Electronic Communications in RS from 2010 to 2020. Since the Strategy aligns with the European framework DigComp 2.0, it does not contain the same indicators as DSI. Therefore, DSI cannot be directly applied to monitor the e-government divide in RS, as its target audience is primarily ICT professionals and other digital experts. Furthermore, there are no DSI results available for RS.

The general goal of the Strategy is to improve the digital knowledge and skills of all citizens, including members of sensitive social groups [15]. Among the four specific goals of the Strategy, specific goal 2, "Improvement of basic and advanced digital skills for all citizens," is primarily focused on enhancing digital literacy. An indicator has been defined at the level of this specific goal: the share of citizens aged 16-74 who have never used a computer (total).

The Strategy does not include a single indicator specifically for monitoring the e-government divide, despite stating in the text of the Strategy that "Divisions based on gender, age, and other personal characteristics in ICT have led to less inclusion in this field for women, persons with disabilities, the elderly, and other marginalized groups" [14].

At the general objective level, the indicator is the share of computer users aged 16-74 (total). Although disaggregated data exist in the reports of the Statistical Office of the Republic of Serbia (RSO) that pertain to the basic demographic factors of the e-government divide, they are not specifically mentioned in the targets, even though the Strategy text states that "the collected data should be disaggregated by age, gender, disability, and other characteristics that define the target population" [15]. The source for verification is the Annual reports of the RSO "Use of Information and Communication Technologies in the Republic of Serbia."

Other strategic documents and plans also do not address the issue of the e-government divide. For instance, the general goal of the e-Government Development Programme of the Republic of Serbia 2020-2022 focused on "the development of an efficient and user-oriented administration in a digital environment," with one of the specific goals being to increase the accessibility of e-government to citizens and businesses through the enhancement of user services and the availability of data in public administration [16]. Consequently, the emphasis is placed on the further development of services, registers, and records, as well as the improvement of functionality and design of the e-Government Portal, rather than on their utilization by all citizens.

In line with the above, no specific indicator is provided for monitoring the e-government divide.

B. E-government divide indicators

Based on the analysis of scientific literature and professional studies, the simplest indicators for measurement, derived from the results of quantitative research [7], have been defined with their respective values (Figure 2).

- **Access gap**: stratification of the general population into online and offline population. The percentage of the offline population in RS, aged between 16 and 74, who have not used the Internet in the last three months: 16.5%.
- **E-government gap**: stratification of the online population into e-government users and non-users. The percentage of e-government non-users in RS: 39.5%.
  - **E-government skills gap**: among e-government non-users, this gap is attributed to lack of skills, which includes not knowing how to use the website or finding it too complicated, as well as relying on another person to perform tasks on their behalf. The percentage for this skills gap is calculated as 5.2% (lack of skills) + 9.5% (another person did it on my behalf), resulting in a total of 14.7%.
  - **E-government digital competence divide**: the percentage of e-government non-users who have requested official documents or certificates, requested benefits or entitlements, or made other requests or complaints is 10.7%.
- **E -government subjective divide**: this divide is determined by factors such as not needing to request any documents or submit any requests, as well as concerns about security or personal data, and unwillingness to pay online due to credit card fraud. The percentages for this subjective divide are calculated as 63.0% (no need to request any documents or submit requests) + 2.4% (concerns about security or personal data), resulting in a total of 65.4%.

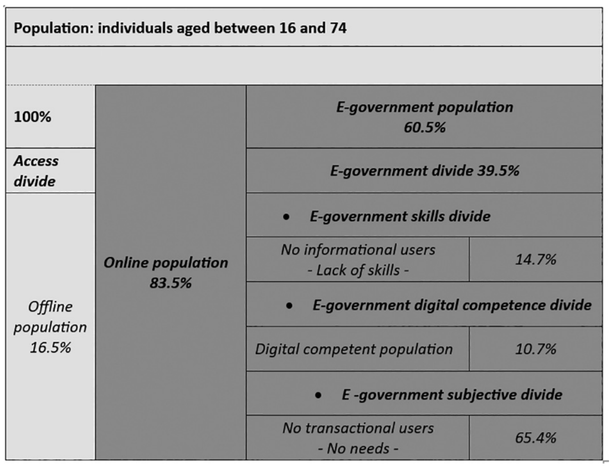

Fig. 2. Methodological frame of survey on ICT usage in RS

The results presented in Figure 2 are provided at the highest level of aggregation without variables for disaggregation, such as age, sex, educational level, and employment situation. However, complete results of disaggregation can be found in the report [7]. For instance, the structure of e-government non-users disaggregated by age and sex is presented in Table 1.

Table I. E-government non-users, disaggregated [7]

Age					Sex	
16-24	25-34	45-54	55-64	65-74	Men	Women
41.9	30.7	43.6	40.2	53.0	37.6	41.4

In this table, a noticeable difference in age among e-government non-users can be observed, and this difference is statistically significant. While it was expected that the younger population would use e-government services more, the extent of the digital divide between men and women is unexpectedly large.

It is important to note that the choice of indicators for measuring the e-government divide can significantly influence the overall understanding of the situation. For instance, if the indicators are based on the definitions provided in Figure 3, the values for the e-government skills gap and digital competence divide may differ significantly from the values shown in Figure 2.

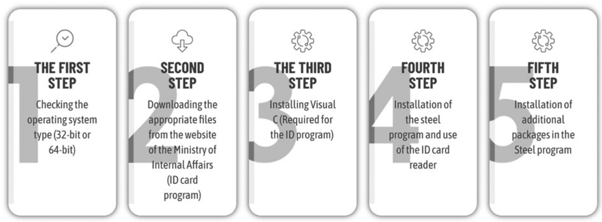

Fig. 3. Use of e-government services among the online population in the last twelve months in RS [7]

Already on the basis of this simple example an important conclusion can be drawn: it is important to precisely create/choose a methodology, which implies an unambiguous definition of indicators and monitoring their dynamics over time.

In order to clarify research doubts related to the E-government divide in Serbia in more detail, online focus groups are conducted.

C. Clarification of the e-government subjective divide

A similar situation as in developed countries, where the impact of the access divide is diminishing and digital skills and competencies are becoming crucial factors in these disparities, is also expected in RS. Despite many citizens having internet access, it does not automatically translate into a high adoption of e-government services. Research indicates that certain e-government initiatives fail to attract a significant portion of the population [2].

After conducting online focus groups research, two key findings emerged regarding the e-government subjective divide:

- Insufficient knowledge of available services

- Complexity in use.

Both user and non-user groups expressed a lack of awareness about the available services, although it was expected to be more prevalent among non-users. This is often cited as the main reason for not utilizing public authorities' services, which is a common response from both groups. However, when the moderator reminded the focus group participants about specific services, their interest would be piqued, and the basic obstacle hindering their usage—the complexity of use—would be mentioned.

To determine whether the difficulty lies in complex usage or a lack of basic ICT skills, an experiment was conducted. The installation process of the ČELIK application (electronic ID card reader), which is used for obtaining certificates for electronic signing (an example of transactional services), was demonstrated.

The moderator showcased the installation procedure, which consists of five steps (Figure 4). Despite the website claiming that the installation is simple, the participants did not find it to be so. One prerequisite for the installation is to have a smart card reader.

Survey period	• The survey was carried out from 15 February to 28 February 2022
Type of survey	• Telephone interview
Sample size	• 2 800 households • 2 800 individuals
Target population	• For households: target population is made of all households with at least one member aged betwee 16 and 17 • For individuals: target population is made of all individuals aged betwee 16 and 74
Type of sample	• Two-stage, stratitified sample
Geographic scope	• Territory of the Republic of Serbia (without AP Kosovo and Metohia)

Fig. 4. Steps in the Installation of steel program [17]

It is emphasized as an important requirement during the installation process:

The most important thing when installing the new version of the ID reader software is that you now need to install:

1. **two VISUAL C packages**, not just one as before
2. **application Steel**, version 1.3.4.0
3. **two additions to the program** that did not exist before - one is for reading ID cards issued before August 18, 2014. (RSIDCardMW), and others – for reading identity cards issued after 18.08.2014. (TrustEdge)

Finally, on the web portal of the Ministry of Interior of the Republic of Serbia, it is stated [18]:

"In the event that Čelik+ cannot be installed, certain system libraries are probably missing, so it is necessary to install Microsoft Visual C++ 2008 SP1 Redistributable Package (x86) (zip format, 4MB)"

Although the complete instructions for installation are written in the Serbian language, participants from both groups expressed personal frustration with the installation process. Even four participants from the control group, who were already using the Čelik application, confirmed that they encountered difficulties during installation. Only one participant managed to install the application on their own, while the other three required assistance. One user was unable to install the app and gave up using it, while another had to switch to a different device because the app didn't work on the first one. These observations are noteworthy considering that the control group participants were experienced computer users and belonged to the "above basic skills" category of e-government users.

The following conclusions can be drawn:

1. Digital literacy and digital skills can be considered as indicators for the e-government divide in general, but e-government services need to be more accessible and user-friendly.
2. In order to address the e-government subjective divide gap, which arises from subjective reasons for not using public digital authorities' services, a similar approach as that used for the online population with basic skills can be employed.

It's important to note that these results are based on qualitative research conducted with focus groups and may not be representative, but they provide insights and potential conclusions.

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The paper's title suggests that the author considers the digital divide as a significant barrier to the further development of e-government in RS. Therefore, policymakers need to prioritize addressing this issue by implementing appropriate state policies [3].

Through an analysis of the literature and other secondary sources, including empirical studies, it is evident that the field of e-government in RS is well-covered in both professional and scientific papers. Additionally, it is organized through the government's strategic documents such as strategies and plans.

However, the same cannot be said for the phenomenon of the digital divide, especially in terms of the indicators required for its monitoring as an integral part of action plans. The findings of the presented research support the need to redefine the methodology for defining, identifying, reducing the digital gap, and improving the existing indicators for monitoring the e-government divide in RS.

As a contribution to this area, the research proposes a redefinition of the e-government divide by stratifying the online population into e-government users and non-users based on their digital literacy and skill level, including the e-government subjective divide gap category. The proposed methodological changes are illustrated through the case study of RS.

B. Recommendations

To address the basic challenges in the use of public authorities' services and reduce the e-government divide in Serbia, several activities are necessary:

- Improvement of the methodology and identification of appropriate indicators for effectively reducing the e-government divide.
- Promoting awareness and knowledge of available e-government services among citizens to overcome the barrier of insufficient knowledge.
- Simplifying the process and enhancing the usability of e-government services to alleviate complications faced by users.
- Providing training and support programs to enhance digital skills and competencies among citizens, enabling them to effectively utilize e-government services.

Future research efforts should focus on exploring the category of e-government subjective divide gap, which stems from subjective reasons for not using public digital authorities' services. The hypothesis for such research could be that this category primarily comprises an online population lacking "basic skills."

It is important to develop separate frameworks for digital skills and competencies tailored to the public sector, companies, and citizens to address their specific needs and requirements.

By implementing these measures and conducting further research, it is possible to make significant progress in reducing the e-government divide and enhancing the accessibility and utilization of public digital services in Serbia.

REFERENCES

[1] V. Weerakkody, Z. Irani, K. Kapoor, U. Sivarajah and Y.K. Dwivedi, “Open data and its usability: an empirical view from the Citizen´s perspective”, Information Systems Frontiers, 19(2), 2017 285–300. https://doi.org/10.1007/s10796-016-9679-1

[2] T. M. Nadal and M. A. Esteban-Navarro, Digital Competences for Improving Digital Inclusion in E-Government Services: A Mixed-Methods Systematic Review Protocol, International Journal of Qualitative Methods, Volume21:1–9 2022. https://journals.sagepub.com/doi/full/10.1177/16094069211070935

[3] Z. Kovacic, and D. Vukmirovic, “ICT adoption and the digital divide in Serbia: Factors and policy implications”, Informing Science + Information Technology Education, Joint Conference, Varna, Bulgaria, 2006, DOI: 10.28945/3247

[4] M.A. Esteban-Navarro, M.A García-Madurga, T. Morte-Nadal and A.I. Nogales-Bocio, “The rural digital divide in the face of the covid-19 pandemic in Europe-recommendations from a scoping review”, Informatics, 7(4), 1–18. 2020, https://doi.org/10.3390/informatics7040054

[5] A. Bradić-Martinović and J. Banović, “Assessment of Digital Skills in Serbia with Focus on Gender Gap”, Journal of Women's Entrepreneurship and Education No 1-2 (2018), https://doi.org/10.28934/jwee18.12.pp54-67

[6] R. Vuorikari, N. Jerzak, Z. Karpinski, A. Pokropek and J. Tudek, “Measuring Digital Skills across the EU: Digital Skills Indicator 2.0”, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-55856-9, doi:10.2760/897803, JRC130341.

[7] SORS, “Usage of information and communication technologies in the Republic of Serbia”. Statistical Office of the Republic of Serbia, 2022.

[8] DSI, “Digital Skills Indicator – derived from Eurostat survey on ICT usage by Individuals” Methodological note – 2015, https://eufordigital.eu/wp-content/uploads/2019/10/Digital-Skills-Indicator-survey-on-ICT-usage-by-Individuals_Methodological.pdf

[9] Eurostat “Individuals' level of digital skills (from 2021 onwards)”, ESMS Indicator Profile (ESMS-IP), Compiling agency: Eurostat, the Statistical Office of the European Union.

[10] EU 2030 Digital Compass: the European Way for the Digital Decade, Resolutions and Declarations, European Commission, 2021, https://dig.watch/resource/the-digital-compass

[11] DESI Digital infrastructures, European Commission, 2023, https://digital-strategy.ec.europa.eu/en/policies/desi

[12] T. Yenni, L. Cui, and Z. Sheng. "Digital resilience: How rural communities leapfrogged into sustainable development." Information Systems Journal 31, no. 2 (2021): 323-345.

[13] G. Valentinova Misheva, “Digital Skills Indicator 2.0: Measuring Digital Skills across the EU”, Digital skills & Jobs platforms, European Commission, 2022, https://digital-skills-jobs.europa.eu/en/inspiration/resources/digital-skills-indicator-20-measuring-digital-skills-across-eu,

[14] D. Kresović, R. Popovac, S. Radojičić, N. Stanojević, D. Vukmirović and A. Krstić “Digitally literate population as the basis of e-government development - the example of the Republic of Serbia”, 28. YU INFO 2023 Conference. Unpublished

[15] Strategy (2020). Strategy for the development of digital skills in the Republic of Serbia for the period from 2020 to 2024. "Official Gazette of RS", no. 21 of March 6, 2020

[16] The e-Government Development Programme of the Republic of Serbia 2020−2022 (hereinafter: the Programme) https://www.srbija.gov.rs/dokument/45678/strategije-programi-planovi-.php

[17] Kako instalirati čitač lične karte? Celik MUP - jednostavna instalacija. Čelik verzija 1.3.8.2 Citaci.kartica.rs, JAN 2023, https://citaci.kartica.rs/instalacija-celik-programa-za-citac-licne-karte/

[18] Ministry of Interior of the Republic of Serbia, Electronic ID card reader, Official web site of the Ministry of the Interior. http://www.mup.gov.rs/wps/portal/sr/gradjani/dokumenta/

Digital Transformation in the Judiciary

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Abstract—This paper focuses on presenting the current state and future plans of digital transformation in the Serbian judiciary. The digitalization of judicial processes holds great potential for improving efficiency, accessibility, and transparency. By analyzing available literature, official reports, and relevant data, this research provides an overview of the existing digital initiatives in Serbian courts. It examines the implementation of electronic case management systems, online filing procedures, and digital communication channels. Additionally, the study explores the challenges faced in the process, including infrastructure limitations, legal frameworks, and stakeholder acceptance. Furthermore, it outlines the strategic plans and initiatives devised by Serbian judicial authorities to further advance digitalization efforts. The findings of this research contribute to a better understanding of the current state of digital transformation in the Serbian judiciary and provide insights into the future trajectory of digital initiatives in the sector.

Keywords - eJustice, digital transformation, eGoverment, Legal Tech

I. INTRODUCTION

The traditional model of workflow in the judiciary primarily involves paper as a data carrier that is exchanged between authorized persons. Mostly, the procedure is initiated by the interested subject who initiates the procedure by submitting the initial act (lawsuit, proposal, application, etc.) by direct delivery or by sending it by mail to the reception offices (offices) that files the acts in book of files, classify them, form cases for paper register, apply the rules on awarding specifi subject to work on case, the processor, who prepares the draft of the act, and through the person authorized to pass the act, who signs it and authenticates it with the stamp of the authority (state body) and the delivery of that act to the person to whom the act refers (addressee).

In this area, which due to the impact of the work of judicial authorities and judicial professions on basic human rights, the advantages of digital transformation are being used, but with great caution due to possible negative effects on the protection of the aforementioned goods. The leaders in this field in Europe are certainly Estonia[1] as champion, followed by The Netherlands[2] and Norway[3], and the judicial system of Singapore[4] stood out on the global level. South Korea[5] is considered a world leader in the digital transformation of the entire public sector, not only the judiciary, and the lessons from their projects are very useful for the judiciary as well. What is common for all their achievements is that the work of courts and other judicial authorities is based on the use of advanced information systems for managing cases that are used by all participants in the procedure both for initiating the procedure (e-filling) and for performing a large number of actions in the online procedure to the extent that visiting court has become reserved only for stages of the procedure where, due to the nature of the matter, it is necessary (debates, testimonies and other personal participation) and the paper itself as a form is unnecessary or even prohibited. Qualified electronic signatures were implemented early in the electronic exchange of data and documents. The mentioned systems also have successful projects related to the implementation of blockchain in data exchange, machine learning based on large databases that were designed in such a way that appropriate data sets are recorded in them in the process and that serve as an auxiliary tool for bringing certain types decision.

Positive examples of these systems and the advantages of implemented technologies, through study visits and trainings of representatives of the ICT unit of the Ministry of Justice, directed the development of information systems in the judiciary and judicial professions towards the establishment of a single information system that will establish a uniform practice in the work of these authorities. In this paper, the degree of achievement so far will be presented.

II. THEORETICAL BACKGROUND

The concept of digital transformation itself is defined differently and is a vague term in its meaning. It is based on the application of modern technologies and innovations and usually implies a completely new way of doing business. In the case of digital transformation, although it represents the use of new technologies, the use of these technologies is not the key, but rather it is about introducing new digital models into business and adapting to new digital trends. In addition to the process, the basic factor of digital transformation is information itself as the key resource of modern business. [6]. Therefore, we cannot talk about the digital transformation of the judiciary without the existence of information in the form of electronic data and their exchange.

Also, we cannot talk about the digital transformation of the judiciary without the existence of IT technologies. Legal technologies, or as they are also called in the literature, "Legal Tech", are defined as technologies used in the field of law, and also as software that could be used in this field. The most widespread definition of legal technology is that it represents the application of modern digital technologies using computers to automate, simplify and improve the extraction, application, access and administration of law through innovation. In short, this is software technology that supports and replaces the work of lawyers[7] as well as administrative and technical staff in courts, as well as communication between parties and the judiciary.

For the last 20 years, European judicial systems have been making efforts to implement projects based on electronic judicial platforms that would have the greatest possible effects on practice, as evidenced by the European Commission for Monitoring the Quality of Justice (CEPEJ), which as a huge segment of its work includes monitoring the implementation of IT solutions in the judiciary. According to CEPEJ, the basic characteristics that e-Justice platforms for the digitization of the judiciary should fulfill in order to achieve the greatest possible effects are the comprehensiveness of functionality necessary for the establishment of a complete digital process in the courts, facilitating communication to all interested parties (parties, citizens, lawyers, etc.) , as well as and enabling the transition of judicial procedures from the traditional way (paper and memo) to the digital way [8]. With the implementation of every judicial digitization project, it is clear that changing the traditional way of communication through correspondence to an electronic way of communication does not mean simple copying and imitation of the existing direction of communication, but requires changes and optimization of the processes themselves, which often imply changes in national regulations. Digital transformation also implies normative transformation and not only the use of technologies and process changes.

Bearing this in mind, it can be said that the digital transformation of the judiciary is a process of transition and replacement of traditional processes with digital ones through the use of electronic platforms, and which must be governed by valid regulations in force. Therefore, in order to talk about digital transformation, there must be one rounded segment of the process or an entire procedure that is digitized (issuing certificates, delivering solutions, publishing letters on the notice board, conducting the sale procedure at a public sale, etc.) comprehensive enough to leave noticeable effects on practice, which is performed entirely or mostly electronically using electronic platforms, and which is governed by positive regulations. If the process that we digitize is not recognized and regulated by law or by-laws, we cannot say that a transformation has occurred, but we can say that the process is supported by electronic tools

The application and use of electronic platforms in judicial proceedings represents the conversion of legal prose into program code, which is a complex process that requires the conversion of the natural language of the law, which is expressive but also indefinite, into a program language that requires certainty. This fact certainly ranks the digital transformation of the judiciary in the highest rankings in terms of project complexity [9] .

The enormous financial effects that digitization has through savings do not bypass the judiciary either. Although the judiciary as a branch is not of a commercial character because the services it provides are not directed or guided by the realization of profit but the realization of rights, the savings that are realized in the budgets of judicial bodies by shortening the procedures and time required to carry out certain activities using electronic systems are enormous and their value is counted in billions of dinars. Also, speeding up court and judicial procedures affects the realization of higher profits in the private sector due to shorter and simpler procedures and a more favorable investment environment.

Digitization of the judiciary is a necessary and unavoidable tool and process that, first of all, should enable the shortening of the duration of the proceedings, greater accessibility of the judiciary, greater transparency of the proceedings, which further unifies the proceedings and increases the responsibility of the competent institutions. Overall, digitization helps to strengthen legal certainty, which is the ultimate goal of all judicial measures and activities.

The choice of tools that will be emphasized during the digital transformation must be adapted to each individual judicial (eco)system, bearing in mind that there are different characteristics of the problems that need to be solved in different countries in order to achieve the greatest effects on strengthening legal security. Looking at the global level, the segment that needs to be worked on the most is free and equal access to justice, bearing in mind that according to the Open Society Foundations research from 2016, 4 billion people live outside the protection of the law and the rule of law for various reasons, most often because they are marginalized from foreign society due to material condition, gender, etc(Access to Justice Stocktake of Initiatives Research Report, 2020).

As a good practice of shortening the duration of proceedings by using electronic tools for acceleration, the Judicial Information System (JIS) is used to shorten the process of obtaining data and documents necessary for the conduct of judicial and court proceedings by as much as 3 to 6 months. This shortening of procedures is the result of the fact that authorized persons in judicial bodies (courts, public prosecutor's offices, public notaries and public bailiffs) have access to data from official state registers in a few seconds via an electronic service. Since the introduction of this System in 2017, more than 25,000,000 inquiries have been made, replacing over 50,000,000 paper correspondence.

However, in addition to the benefits that the digital transformation of data exchange brings, in a system where personal data is available at the push of a button, it becomes crucial to prevent abuse of data access authority, i.e. unauthorized use of the system by persons to whom this system is officially accessible. The key to successful management of this challenge may be, in addition to the application of other procedures, in the application of blockchain technology during the process of ensuring the integrity, authenticity, transparency, traceability and auditability of databases of access and data use by system users, which will be discussed in the fourth chapter.

III. ANALYSIS OF CURRENT STATE OF DIGITAL TRANSFORMATION OF SERBIAN LEGAL SYSTEM

If we exclude the use of computers for word processing and statistical calculations, ICT in the sense of replacing registers and records in paper was introduced systematically for the first time in 2006 with the creation of a case management system (AVP) in commercial courts, which will be rolled out by 2011. to basic and higher courts. This system is decentralized and functions on the servers of 66 basic courts, 25 higher courts and 17 commercial courts, as well as in a special department for organized crime, that is, there are actually 109 application solutions (decentralized system of “data lakes”) that have a common central place for data replication, which is done once a day. The first public service has just been created from the replicated data of all courts, which is the Flow of court cases on the Serbian Judicial Portal. After the electronicization of case records in the courts and the provision of public access to this data, the next big steps in digitization followed after 2015 with the introduction of a series of web applications using more modern programming languages and technologies, and especially with the introduction of the ESB Microsoft BizTalk solution - a judicial bus for data exchange which made judicial applications interoperable.

From 2015 to 2023, a bundle of electronic systems and services were introduced, which can be divided into those that exist alongside the traditional process and make it faster and more legally secure, such as the establishment of a register of real estate transactions or electronic payment of court fees, and those that have completely replaced the traditional process electronically (such as eAuctions and submission of official documents for registration in the real estate cadastre and tax returns), those who created new procedures as an added value through digitization (issuance of extracts from the real estate list at the notary public), but also those who enabled electronic services such as service for citizens. The following will describe the systems, divided according to the described criteria, that have the greatest impact on the digital transformation of the judiciary.

eAuction is a system that was introduced into the execution and security procedure on September 1, 2020. when the amendments to the Law on Enforcement and Security entered into force, which, among other things, provided for an electronic public sale in this procedure. Bearing in mind that this law defines the procedure for the electronic public sale of the debtor's property by the public executor as an exclusive method, this system classifies the complete digital transformation of a traditional and electronic procedure in the judiciary. The developed platform "e-Auction" enabled the electronic sale of movable and immovable things by public bidding in the enforcement procedure, a fully electronic process of announcing the public sale, making an offer (bidding), closing the sale and automatically determining the most favorable offer. Since the introduction of this platform, over 50,000 public sales of movable and immovable property have been scheduled. The main benefit of this platform is the eradication of blackmailing potential bidders for abandoning the purchase and making bids through the built-in functionality of hiding the bidder's identity, which allows the bidder to remain anonymous until the end. This created the conditions for achieving the highest possible sale price, which strengthened the position of enforcement debtors.

The information system "+ePayment of court fees", which is available at the address https://etakse.sud.rs/, is a system that has overcome the challenges of the decentralized system for managing court cases. The decentralization of the System for handling cases in courts has for years conditioned the development of electronic services for court services, among other things, enabling the electronic payment of court fees. This challenge was overcome by the development of a completely new centralized application for matching payments from the Treasury Administration system and a central database to which court fee balances are replicated once a day. Furthermore, from this same system, it is possible to automatically enter the paid court fee into the case management system of each court. The last step that had to be implemented was the integration with the system of the Office for IT and eGovernment +ePlaćanje (+ePayment), after which a portal was developed for online payment of court fees, which gave all parties, individuals and legal entities, the opportunity to review in one place in the cut court fees in their case and to pay them at the same time by electronic payment, i.e. via the Internet. The system enables electronic review and payment of 249 different court fees completely electronically. However, this system, although it enables fully electronic filing and payment of court fees, is not regulated by regulation as the only way to pay court fees, which makes it a fully digitalized procedure that coexists with the traditional one.

Issuing certificates on rights regarding immovable property from real estates register (cadaster) at the public notary is an example of a project in which digital transformation creates new procedures and enables authorities that are not the source of data to issue certificates from records maintained by other authorities. In the digital transformation of the real estate registed (cadaster), which also is faced with the same challenge of decentralized systems of different services of the real estate cadastre, which in the transit period caused a difference between the real estate sheets obtained by the electronic service from the centrally replicated copy of the database of all cadastres (delay of replications could cause date time difference of date of issusance can be up to 3 days after date of the latest update) and certificates on rights regarding immovable property from real estates register (cadaster) that could be obtained from the specific concrete cadastre service database, which reflected the current state of records (real-time). In joint cooperation, in the Decree on the conditions for issuing certificates from real estate and pipes register from the Geodetic Cadastre Information System, by public notaries and geodetic organizations ("Official Gazette of the RS", number 91 of June 26, 2020), priority is given to the digital certificate from the immovable property list, which further meant that all state authorities and public notaries and the cadastre services themselves see the same situation for a given immovable property. Also, with this regulation and the technical integration of the system of public notaries and the system of the Republic Geodetic Institute, it is possible for notaries to issue cesrtificate from the real estate register to parties, that is, a completely new service that did not exist before.

The ePromet Nepokretnosti (eProperty Transaction) Application is a project that has completely replaced the traditional way of registering facts important for registration in the real estate cadastre. Although the nominally subject of this Reform, which was declared to be the reform of year for 2019, is the Republic Geodetic Authority, the biggest burden in terms of integrating the systems and taking on the obligation of data digitization was borne by the judiciary, namely public notaries, courts and public bailiffs. From July 1, 2018, citizens can register their real estate with a public notary when selling real estate and enter it into the tax records on the spot, without going to the competent offices of the Cadastre and the Tax Administration. This involved the development of an application for input and delivery of data and documents used by notaries public and courts. For the sake of insurance against the fraud of double sale of the same real estate to different buyers, which was a frequent case until 2014, when this system was introduced (the Register of Real Estate Transactions is one example of an electronic tool that still exists alongside the traditional way of keeping records, but strengthens legal security because parties are protected against double sales from the same seller). This system has been expanded and harmonized for sending data to the real estate cadastre in such a way that the public notary only enters the data once, which are further distributed to 4 different authorities and the register (court to the register of real estate transactions, Geodethic authority to the records of the real estate cadastre, to the Tax Administration for classification of tax on the transfer of absolute rights and to the Local Tax Administration for the purpose of calculating property tax). This eliminates the four times entry of the same data in the state administration, but it also enables parties to avoid visits to the counters of as many as four different state bodies by making transactions with the public notary. The effects of this system are great, so since July 1, 2018, public notaries submited documents electronically for registration in the cadastre, submitted over 1,400,000 documents, which directly reduced the number of visits to the counters of various institutions by over 7,000,000.

The Electronic bulletin board (eTabla) is an example of a fully digitized procedure, but only for enforcement and security procedures. In order for all types of submissions to the judiciary to be covered by this way of delivery of decisions, it is necessary to continuously amend each procedural law, such as the Law on Civil Procedure, the Law on Criminal Procedure, the Law on Non-Litigation Procedure, etc. eTabla enabled citizens to have a quick and easy insight into the contents of court bulletin boards in one place. So far, the requirement for fiction has been fulfilled through the electronic bulletin board on the delivery of 1,282,962 letters (FIGURE ONE represent dyinamics of usage). The prerequisites for the introduction of this System, in addition to the creation of a software solution, also included the provision of sufficient storage space, taking into account the size of the pdf format of decisions and the number of documents stored annually in this solution.

eEnforcement is a project that will completely digitize the initiation (submission of a proposal for enforcement) and the management of the enforcement and security procedures, but also the communication of the authorities of the procedure. Once again, the amendments to the Law on Enforcements and Security enabled the transformation of a traditional procedure into a digital one. Unfortunately, the initiative to amend the law to make this procedure mandatory electronic for legal entities and advocate did not result in a legal amendment, so this project is an example of digitization that will exist alongside the traditional method. This application will enable the legal entities themselves to have full insight into the cases handled by their lawyers, scheduled hearings and all other information from all participants in the procedure in a timely manner. The business logic of this software fully supports all procedural provisions, communication between authorities and delivery of letters. However, bearing in mind that the software must also support the possibility of traditional communication with the procedural authority (the enforcement debtor is not registered as a user of the eEnforcement application and documents and written documents are received by mail) greatly complicates the very logic of the software, but the actions of the procedural authority, which will have to digitize all documents which is submitted on paper by a party that does not submit electronically and vice versa. This is an example of how digitalization, which is not complete, transfers the burden of data administration to procedural authorities.

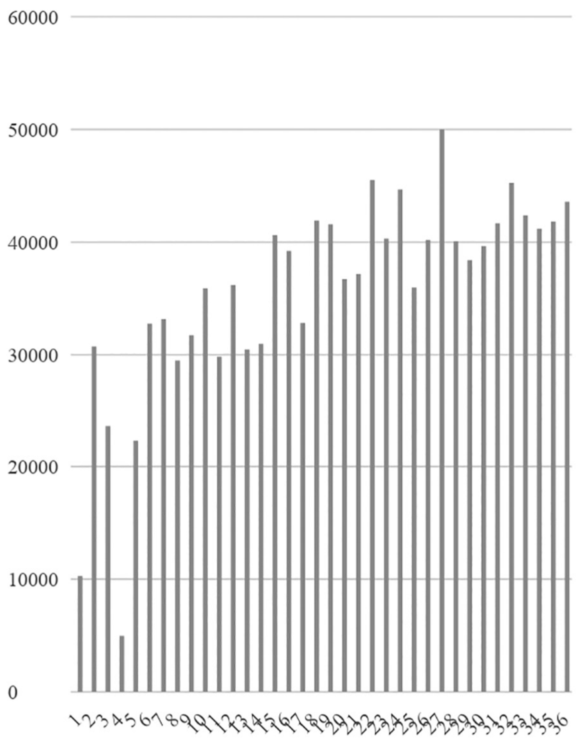

Fig. 1. Number of decisions on etabla per month

The Register of Powers of Attorney (https://epunomocja.sud.rs) is a register that is an additional tool in the work of public notaries as mean of legal security, i.e. a record in which they can check whether the person who presents himself as authorized to perform a certain legal transaction in the name and on behalf of another is really authorized (a document can be forged, a power of attorney can be revoked, the ruler can be deceased, etc.). The register contains an online database of issued and revoked powers of attorney, but also data regading the fact that the power of attorney ceases to be valid in the case of death of natural person or the liqudation of a legal entity as the owner, i.e. the fact of termination or revocation of the power of attorney. This register is not just a simple record of the status of the power of attorney, but has given a new value, which is the possibility of granting authorization remotely, because citizen from a remote location within or outside the territory of our country can authorize another citizen to undertake legal transactions which does not require form of signature verification, in more modern terms, this registry introduced a new C2C service. However, even though the interpretation of the legal framework, and especially the Law on electronic documents, this service is possible according to the current regulations. It remains to be widely accepted by all business entities of legal transactions (banks, state bodies, etc.) through which citizens present themselves with an electronical power of attorney as authorized to undertake transactions in someone else's name and for someone else's account.

The service of online issuance of criminal certificates is a project that in 2021 was rated by the Office for Information Technology and Electronic Administration as the most perfect electronic service on the eGovernment Portal, because it enables all steps to be taken electronically: submitting a request for the issuance of a certificate, paying the fee for the certificate, receiving an electronic certificates in the digital eMailbox on the eGovernment Portal. Looking back at the types of digital transformation that were described at the beginning, this service, although it completely rounds out the process of issuing a certificate, exists alongside the traditional way. From the beginning of the application of this service in July 2021 to May 2023, over 19,000 electronic certificates were issued, compared to the number of certificates that all courts issue annually (about 250,000), it cannot be said that the application, regardless of the efficiency of this service, is at its highest possible level. Closer look for the reasons for something like this is certainly the non-acceptance of these certificates in the transactions by other state bodies and that some of procedures do not recognize them in electronic form. For massive use of this service, digital transformation of other sectors in the RS will be necessary (state administration, educational administration, legal entities, etc.).

IV. DIRECTION OF THE FUTURE DEVELOPMENT OF EJUSTICE

The direction of further digitization of the judiciary is possible in two directions. The first would be the comprehensive digitization of existing procedures by implementing systems in a trend that already exists, through interoperable, more or less service-oriented private cloud applications with appropriate changes to legal and by-laws provisions that would exclusively or predominantly give preference to the digital way. Another direction would be the introduction and application of new technologies in the already digitized or not yet digitized judicial process, such as BlokChain and Artificial Intelligence.

New technologies should be applied where they can have the greatest value for judicial processes in terms of reducing administration for court and judicial staff, strengthening legal security or establishing new services for citizens and parties. Also, the investment in digitalization, since it is a matter of budget funds, is justified by the fact that the employees of the courts are freed from manual work and the courts are given time to devote more time to the work in which their knowledge gives the greatest value, which is, above all, the trial.

The methodology that should be used to identify the processes and technologies that should give these processes additional value is the creation of an Empathy map model that, through a series of questions that need to be asked, should answer the following elements: what are the user roles, what are their goals and needs, what are the most painful and frustrating points of the process and the system itself if it already exists, values that are important to specific users, what are the daily routines of the users of the system or process that is being digitized, what functionalities would overcome the set challenges and achieve additional values.

An example of the use of the Empathy map model can be shown in the analysis of the case management system in the courts, where, after recognizing the basic user roles within the court CMS, namely: Judges, Court clerks, Lawyers, Litigants, their representatives were set up in a thought-experimental process where above mentioned questions and their answers are recorded using the methodology of Empathy and putting yourself in their shoes (familization). Analyzing the possible answers further, using the design thinking method, recognized business requirements that would need to be implemented in the CMS, the type of users to whom they should be available, as well as the way (methodology, concept, technology) in which they can be realized.

Table 1 contains the result of this thought experiment, which identified the key needs in the work, which were then connected to the corresponding services and concepts.

Table 1. Emapthy map model

ID	EMPHATY MAP MODEL		
	Business requirement name	**User role**	**Software solutions**
1	Online submition of documents	Lawyers + Litigants	web service, eID
2	Online access to case documents	Lawyers + Litigants	web service, eID
3	Collaborative tool for documents	Judges + Court Clerks	share point, private cloud
4	Video-conferencing	Judges + Lawyers + Litigants	cloud
5	SaaS - Courts as end users	Court staff	cloud
6	Electronic data exchange	Judge + Court clerk	blockchain
7	Personal data protection	Judge + Court clerk + staff	blockchain, private cloud
8	Qualified electronic delivery	All users	web service, blockchain
9	Case weight	All users	machine learning
10	Issuing certificates	Court clerk + Litigants	web servis, eID, blockchain

After clearly identifying the processes in which the application of new technologies would give the greatest value, it is necessary to analyze the rationality and financial profitability of the introduction of this technology in relation to the benefits and added value they bring.

Without exception, Personal data protection in Electronic data exchange is the area in which the application of blockchain technology would have the most justification, regardless of the financial cost that the implementation would require. Bearing this in mind, we will look at the model that should be applied in the framework of electronic inspection and obtaining data from public registers of state bodies through JIS, which is described in chapter 3. Namely, bearing in mind that through this system, more than 25,000,000 electronic certificates from official registers for the purposes of conducting judicial processes, in addition to all the procedures that have been established, it is clear that the supervision and control of the acquisition of personal data is made more difficult by the transition to an electronic method. While we all enjoy the benefits of a data-driven society, there is growing public concern about user privacy.

Centralized organizations - both public and private - accumulate large amounts of personal and sensitive information. Individuals have little or no control over the data held about them and how it is used [11] . In this environment and scale, to ensure data protection, query execution monitoring must be frequent. Supervision must be carried out by controlling and comparing the database of the inquiry log and the subject in connection with which the inquiry was made with the data from the case, i.e. whether the subject of the inquiry is a party to the specified procedure. Also, even more effective monitoring of the use of data could be achieved by enabling a platform through which every citizen with an electronic signature could check which authorities and for what purposes checked personal data, which would represent irrefutable proof of the use and purpose of use of personal data.

This irrefutability of evidence can be achieved by using blockchain technology, i.e. multiple decentralized confirmations of data on executed queries and storage in multiple books, but so that the competent authority (in this case the Ministry of Justice) keeps the "Golden Record" - a log database of confirmed blocks in one central place . Each log should be validated by several nodes and aggregated into a block as part of the Justicechain that reflects the "true state" [12]. Each node has its own chain, but a copy of the confirmed one is kept in the central JIS log database. The set of surveillance data carried out by the competent authority (in this case the Ministry of Justice or the Commissioner for the Protection of Personal Data) will be the second block in the chain that is also written both in the distributed chain and as a copy of the consensus in the central log. In case of conflicting records from several chains, trust in the accuracy of the data should be given to the "Golden Record".

The application of new technologies such as AI Machine Learning, although for now in the area of the recommendation of the decision and the amount of the penalty based on the available information, was evaluated by the highest judicial authority as an impermissible influence on the free decision of the judge, its greatest contribution in the application, as shown by the Emphaty map, could show in Case Weight combined with random distribution of cases, so as to enable an equal workload for judges and thus ensure speeding up of proceedings, better planning of personnel capacities, but also rationalization and optimization of budget costs through better allocation of funds, which would more than justify the cost of introducing this technology .

V. CONCLUSION

A significant number of electronic services in the judiciary and the result of their use, measurable through the scope of use for processing data and documents, has shown that there is a justified need for digital transformation in this domain. In addition to the challenges related to the provision of infrastructure and human resources, which are present both in other domains and in the domain of the judiciary in other countries, in the Republic of Serbia it is necessary to orchestrate changes in the insufficiently precise legal framework, the selection and implementation of appropriate technologies and organizational changes that it is not easy to plan so that they are implemented in a timely manner, bearing in mind the strict and gradual legal procedure and the budget framework. In such an environment, and especially in the absence of a centralized information system that is present in the courts of more electronically advanced countries, the only breakthroughs towards further digitization were individual information systems that digitize individual procedures.

REFERENCES

[1] International Bank for Reconstruction and Development/The World Bank, "Kyrgyz Republic: From Vulnerability to Prosperity," 2018. [Online]. Available: www.worldbank.org

[2] X. Kramer, E. Van Gelder, and E. Themeli, "e-Justice in the Netherlands: the Rocky Road to Digitised Justice*." [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Digital_economy_and_society_statistics_-

[3] P. Bago et al., "Progress of the PRINCIPLE Project: Promoting MT for Croatian, Icelandic, Irish and Norwegian," 2020. [Online]. Available: www.elri-project.eu

[4] D. Fox and H. Yamagata, "Developing Court Capabilities and Insights through Data Conversion," International Journal for Court Administration, vol. 13, no. 1, 2022, doi: 10.36745/ijca.445.

[5] Julien Vilquin and Erica Bosio, "Improving court efficiency: the Republic of Korea's e-court experience."

[6] Petar Celik, "Bezbednosne implikacije digitalnog poslovanja," 2019.

[7] W. Frenz, Handbook Industry 4.0. 2022. doi: 10.1007/978-3-662-64448-5.

[8] F. Contini and D. Reiling, "Double normalization: When procedural law is made digital," Onati Socio-Legal Series, vol. 12, no. 3, pp. 654–688, Jun. 2022, doi: 10.35295/OSLS.IISL/0000-0000-0000-1305.

[9] P. Cvetković, "Contract as an algorithm: Introductory considerations," Zbornik radova Pravnog fakulteta Nis, vol. 60, no. 92, pp. 15–34, 2021, doi: 10.5937/zrpfn0-34462.

[10] "Access to Justice Stocktake of initiatives Research report," 2020. [Online]. Available: https://www.ag.gov.au/LegalSystem/Accesstojustice/Pages/default.aspx

[11] G. Zyskind, O. Nathan, and A. S. Pentland, "Decentralizing privacy: Using blockchain to protect personal data," in Proceedings - 2015 IEEE Security and Privacy Workshops, SPW 2015, Institute of Electrical and Electronics Engineers Inc., Jul. 2015, pp. 180–184. doi: 10.1109/SPW.2015.27.

[12] Nancy Liao, John R. Raben, Sullivan, and Cromwell, "A Brief Introduction to Blockchain."

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Analysis of Factors Influencing Website Conversion Rate

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Abstract—While designing the websites and determining the content for e-business, the conversion rate in terms of purchases done through the website is an important consideration. This paper attempts to analyze the various factors influencing the website conversion rate through a two stage approach with confirmatory factor analysis followed by multiple regression analysis. Data was collected through an online survey of Indian consumers. Attitude towards online shopping, price value, information quality of website, ease of navigation, and e-WoM were found to be significant factors influencing website conversion rate.

Keywords - Website conversion rate, e-WoM, Information quality, multiple regression

I. INTRODUCTION

The current era is known for its massive advancement in the field of information and communication technology (ICT). ICT has brought a new change in the lifestyle and economy of each country belonging to both developed and developing category. In this process, E-Business has become an effective alternative to traditional business. It involves buying and selling of goods and services over electronic networking, primarily using the internet facility. These transactions or exchange occur between both "Business to Customer" (B2C) and "Business to Business" (B2B).

Many businesses in the retail or offline sector went digital to improve their revenue stream by doing more sales online. Online businesses become successful if they are able to attract consumers/traffic to their websites which result in conversion of these website visits into purchase from the website [1].

Despite the importance of "conversion rate" (CR) in online sales, there has been little research or effort put into understanding the notion. Previous research has primarily focused on online consumer behaviour, with the assumption that purchase intent is the most important factor for the consumption of products [2].

The focus of this paper is to examine the effect of various factors influencing the conversion rate of e-commerce websites by analysing data from a cross section survey of online consumers in India. Using constructs from previous literature and integrating them into a comprehensive model, this study aims to investigate the effect of these factors on the purchase intention of consumers which translates into the conversion rate for the website. The relative importance of each of the factors is analysed with the help of multiple regression analysis.

II. LITERATURE REVIEW & RESEARCH FRAMEWORK

Digitization created new possibilities of transactions and processes, which in turn generated new forms of value creation [3]. With the growing success of new digital businesses, marketing and organizational research has focused on the elements that contributed to this success. Given the essence of conversion rates in sales, research into them is essential. Despite the importance of "conversion rate" in online sales, there has been little research or effort put into understanding the notion.

The "CR" is considered the single most important factor when it comes to growth of the online business. It is defined as number of transactions received for given set of visitors visiting the website. Given the huge growth of online users, most of the online websites have historically seen low CR, and any increase in the conversion rate can greatly bring profits to the online vendor [4].

Zeithaml et al. (2002) [5] suggest that dimensions to measure e-service quality should include: information availability and content, ease of use or usability, privacy/security, graphic style, and fulfilment. Mohapatra and Sahu (2012) [6] found that perceived ease of use and trust are essential antecedents in determining online consumer behaviour through behavioural attitude and perceived behavioural control.

This research contributes to the research on conversion rate for e-commerce websites using the various factors identified from previous literature as the theoretical framework and thereby fills the gap in literature by combining these factors into an integrated model for measuring their effect on the purchase intentions which lead to conversion rate for e-commerce websites.

The research model for this study comprises of six independent variables namely – attitude, price value, information quality, ease of navigation, electronic Word of Mouth (e-WoM) and trust. These variables have been identified from a rigorous literature review and through that the major factors covered by most of the previous studies have been integrated into the model. The effect of these independent variables has been assessed on the dependent variable of purchase intention which leads to website conversion rate.

Attitude is defined as the degree to which a person has a favourable or unfavourable evaluation of the behaviour under consideration [7]. In the context of online shopping, attitude refers to an individual's perception regarding the idea of online shopping on a website in either positive or in negative light. Several studies have found the attitude to be a significant predictor of behavioural intentions further leading to the actual behaviour [8].

Price value refers to consumers' perceived trade-off between the benefits of a technology and the monetary cost for using it [9]. The price value derived from use of a technology has a positive influence on the usage of that technology [10]. In the context of an e-commerce website, if the consumers feel that the value they are receiving for the money they spend on purchases from a website is high, they tend to purchase more from that website.

e-WoM has been found to be impactful in marketing online [11,12,13]. Consumers explore the reviews and information posted by previous customers, in order to be assured before making purchases from a website [14]. A favourable e-WoM is expected to have a positive effect on purchase intentions from the website and thus its conversion rate [15].

Information quality plays an important role in usage of websites [16]. When customers find that a website provides high quality information, they tend to trust the website more[17] as they can go through the information, they need to take decisions regarding purchasing the products. This leads to higher purchase intention and conversion rate. The usefulness and exactness of information provided on the website determines how important the consumer perceives it to be in making purchase decisions [18].

If the information presented on the website is found to be useful by the customer, he will develop trust for the website and subsequently online purchase intention from it [19]. On the other hand, if the customers perceive the information to be vague or incomplete, the customer tends to leave the website without purchase [20] leading to low conversion rates.

The ease of navigation is an important feature of the website which increases the conversion rate. If the consumers feel that the website has a convenient and user-friendly layout and appealing appearance, where it is easy to find the required information as per need, customers trust that website more and further have a higher intention to purchase from such websites [21].

Trust as a variable has three different aspects, namely – ability, integrity, and benevolence [22]. Trust in Ability is the belief that the trustee will be able to fulfil the needs of the trustor. Trust in Integrity refers to the belief that the trustee will honour the commitments made. Trust in Benevolence refers to the belief that the trustee will take care of the trustor's benefit.

In the context of online shopping from a website, trust can be defined as the willingness to accept the possibility of occurrence of an unfavourable situation during a shopping transaction on the website with the expectation that the website will act according to what is in the best interest of the consumer [23]. Trust has thus been suggested to be a significant factor in influencing purchase intentions [24,25].

The purchase intention has been taken as the dependent variable for estimating the measure of website conversion rate. Ease of navigation has also been found to be significant in affecting website conversion rate by increasing the purchase intention of consumers [6].

III. METHODOLOGY

A. Data & Analysis Methods

Purposive sampling technique was used to gather data from an online survey using a structured questionnaire based on 5 point Likert Scale. All scale items were adapted from prior literature. A total of 223 responses were gathered.

The analysis is done using multiple regression with purchase intention as the dependent variable and six independent variables of attitude, price value, information quality, ease of navigation, e-WoM and trust. All the scale measures were checked for reliability and validity using confirmatory factor analysis before proceeding for regression analysis.

Cronbach's alpha is used to see if multiple-item Likert scale are reliable. Convergent validity and discriminant validity were the 2 subsets of construct validity that were examined. Convergent validity assesses the relationship of items of the same construct and discriminant validity shows significant differences between the characteristics of different constructs.

Convergent validity was established by measuring the Average Variance Extracted (AVE) [26] of the constructs and Discriminant Validity was established using Fornell-Larcker Criterion [27].

B. Results

The Cronbach's alpha and AVE value for the variables are given in Table 1.

Table I. Reliability and Convergent Validity

Construct	Cronbach's Alpha	AVE
Attitude	0.821	0.848
Price Value	0.945	0.834
Information Quality	0.963	0.846
e-WoM	0.925	0.817
Ease of Navigation	0.847	0.766
Trust	0.724	0.529
Purchase Intention	0.891	0.748

Internal consistencies of all variables are considered acceptable since the Cronbach's Alpha values exceeded .70, signifying acceptable reliability. The average variance extracted (AVE) of each construct was higher than the standard 0.5, which indicated good convergent validity for the scale [26].

The Fornell-Larcker criterion is one of the most popular techniques used to check the discriminant validity of measurements models. According to this criterion, the square root of the average variance extracted by a construct must be greater than the correlation between the construct and any other construct. According to the Fornell-Larcker criterion, the constructs' discriminant validity was established.

Table II. Discriminant Validity

	ATTD	PVAL	IQUAL	eWOM	EON	TRUST
Attitude	0.921					
Price Value	0.422	0.906				
Information Quality	0.506	0.731	0.92			
e-WoM	0.594	0.626	0.695	0.933		
Ease of Navigation	0.537	0.569	0.581	0.633	0.875	
Trust	0.448	0.765	0.63	0.547	0.543	0.727

Result of the multiple regression analysis shown in Table II gives the coefficients of the independent variables: Attitude, Price Value, Information Quality, e-WoM, Ease of Navigation, and Trust all of which have positive and significant standardized (beta) coefficients except that for trust which is positive but significant only at 10%. From the standardized coefficients it can be seen that the most important factor relatively is the information quality available on website followed by attitude and ease of navigation. R square and Adjusted R square were found to be greater than 0.6 which implies that more than 60% of variance in purchase intention is being explained by independent variables that were taken in the model exhibiting satisfactory explanatory power.

Table III. Multiple Regression Results

Independent Variable	Coefficient	T Statistics	P Values
Attitude	0.244**	3.768	0.000
Price Value	0.194*	2.785	0.034
Information Quality	0.317**	3.218	0.001
e-WoM	0.219**	3.151	0.002
Ease of Navigation	0.227*	2.349	0.023
Trust	0.087	1.018	0.076
R Square	0.612		
R Square Adjusted	0.601		

** & * denote significant at 1% and 5% respectively.

IV.CONCLUSION

Results of the analysis exhibit that there exists a significant positive relationship between purchase intention and all the independent variables in the model except trust. Therefore, the attitude of people towards online shopping, price value, information quality, e-WoM, and ease of navigation provided on the website can enhance the purchase intentions and in turn the website conversion rates. The findings of this study will directly benefit the website designers and the engineers who develop the codes for the websites with an expected outcome of providing high conversion rates through the navigation ease and information presentation on the website using search queries.

Findings are also useful for the online merchants who can get their websites designed and programmed in keeping with the most important factors that drive purchase intentions and thus conversion rates from the website leading to higher revenue generation through their websites.

As the attitude towards online shopping has been found to be significant in influencing the purchase intentions in line with previous studies like Pavlou (2012) [28], it is important that the e-commerce websites have a general information section on their websites which clarifies the doubts in the minds of the visitors regarding online shopping and explains the benefits thereof while trying to disseminate information regarding security features and facilities of return, cash on delivery option and the like for developing a positive attitude among the customers.

Price value has been found to have a significant influence on purchase intention in line with the results of Venkatesh et al. (2012).[9] This implies that discounts and comparison of prices with other websites should be highlighted on the website and it should be easy to search the information related to prices because information quality and ease of navigation were also found to be a significant factor in driving the consumers towards purchase from the website. Therefore, while designing the website and coding for the search algorithms, it is imperative to take into consideration the factors that influence the customer's purchase intentions in order to achieve a high website conversion rate.

The e-WoM is also found to have a significant impact on customers' purchase intentions from the website. Thus, it is recommended to have a feedback mechanism built into the website to get first hand feedback from the customers and improve service quality in line with the feedback so that the customers give positive reviews about the website online which will have a favourable effect on potential buyers and drive up the conversion rate of the website.

Trust was found to have a less significant effect but nevertheless it was found to be positive. The reason for insignificant direct effect may be that trust is derived from information quality and e-WoM and hence the indirect effect may be stronger than the direct effect. This calls for further research on the topic incorporating both direct and indirect effects of various independent variables to provide greater insights into the area of study.

The significance of this study is to provide computer science professionals, IT companies and online merchants with information related to consumers' online purchase behaviour and traits that will help them improve their business by helping them understand the market and users better and will help them provide desired services to their respective clients. The results provide insights about consumers in India as well as other developing economies where online businesses are in an expansion phase and consumer incomes are growing.

REFERENCES

[1] Ru, L. J., Kowang, T. O., Long, C. S., Fun, F. S., & Fei, G. C. (2021). Factors Influencing Online Purchase Intention of Shopee's Consumers in Malaysia. International Journal of Academic Research in Business and Social Sciences, 11(1), 761–776.

[2] Kim, S.S. (2020). Purchase intention in the online open market: Do concerns for e-commerce really matter?. Sustainability, 12(3), 773.

[3] Duffy, G., and Dale, G. B. (2002) E-commerce processes: A study of criticality. Industrial Management and Data Systems, 102(8), 432-441.

[4] Di Fatta, D., Patton, D. and Viglia, G., 2018. The determinants of conversion rates in SME e-commerce websites. Journal of Retailing and Consumer Services, 41, 161-168.

[5] Zeithaml, V. A., Parasuraman, A., & Malhotra, A. (2002). Service quality delivery through web sites: a critical review of extant knowledge. Academy of Marketing Science Journal, Fall, 30, 362-375.

[6] Mohapatra, S. and Sahu, K.C., 2018. Empirical research on the adoption and diffusion of e-commerce portals. International Journal of Business Innovation and Research, 15(2), 137-151.

[7] Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211.

[8] Taylor, S., and Todd, P. (1995), Understanding the Information Technology Usage: A Test of Competing Models. Information Systems Research, 6(2), 144 –176

[9] Dodds, W. B., Monroe, K. B., and Grewal, D. (1991). Effects of Price, Brand, and Store Information on Buyers. Journal of Marketing Research 28(3), 307-319.

[10] Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Quarterly, 36(1), 157-178.

[11] Bickart, B., & Schindler, R. M. (2001). Internet forums as influential sources of consumer information. Journal of Interactive Marketing, 15(3), 31-40.

[12] Kumar, N., & Benbasat, I. (2006). The influence of recommendations and consumer reviews on evaluations of websites. Information Systems Research, 17(4), 425-439.

[13] Zhang, J. Q., Craciun, G., & Shin, D. (2010). When does electronic word-of-mouth matter? A study of consumer product reviews. Journal of Business Research, 63(12), 1336-1341.

[14] Pitta, D. A., & Fowler, D. (2005). Online consumer communities and their value to new product developers. Journal of Product & Brand Management, 14(5),283-291.

[15] Erkan, I., & Evans, C. (2016). The influence of eWOM in social media on consumers' purchase intentions: An extended approach to information adoption. Computers in Human Behavior, 61, 47-55.

[16] McDowell, W.C., Wilson, R.C. and Kile Jr, C.O., 2016. An examination of retail website design and conversion rate. Journal of Business Research, 69(11), 4837-4842.

[17] Milan, G. S., Bebber, S., Toni, D. D., & Eberle, L. (2015). Information quality, distrust and perceived risk as antecedents of purchase intention in the online purchase context. Journal of Management Information System & E-commerce, 2(2), 111-129.

[18] Chang, Y. S., & Fang, S. R. (2013). Antecedents and distinctions between online trust and distrust: predicting high-and low-risk internet behaviors. Journal of Electronic Commerce Research, 14, 149-166.

[19] Hsu, L. C., & Wang, C. H. (2008).A study of e-trust in online auctions. Journal of Electronic Commerce Research, 9, 310-321.

[20] Goode, M. M. H., & Harris, L. C. (2007). Online behavioral intentions: an empirical investigation of antecedents and moderators. European Journal of Marketing, 41, 512-536.

[21] Bart, Y., Shankar, V., Sultan, F., & Urban, G. L. (2005). Are the drivers and role of online trust the same for all web sites and consumers? A large-scale exploratory empirical study. Journal of Marketing, 69, 133-152.

[22] Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. Academy of Management Review, 20(3), 709-734.

[23] Lee, M. K., & Turban, E. (2001). A trust model for consumer internet shopping. International Journal of Electronic Commerce, 6(1), 75-91.

[24] Aslam, W., Hussain, A., Farhat, K. and Arif, I. (2020). Underlying factors influencing consumers' trust and loyalty. E-commerce. Business Perspectives and Research, 8(2),186-204.

[25] Ha, N., & Nguyen, T. (2019). The effect of trust on consumers' online purchase intention: An integration of TAM and TPB. Management Science Letters, 9(9), 1451-1460.

[26] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). Multivariate Data Analysis (7th Edition). Pearson Prentice Hall.

[27] Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 39-50.

[28] Pavlou, P.A. (2002). What drives electronic commerce? A theory of planned behavior perspective. Academy of Management Proceedings, A1-A6. Briarcliff Manor, NY 10510: Academy of Management.

The Impact of Social Media Influencers on Consumer Behavior in Digital Marketing

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Abstract—This paper presents key insights about the impact and effects of social media influencers on consumer behaviour. According to researched studies, social media influencers impact consumer behaviour in emotional and cognitive context, also impacting their decisions of purchasing and consuming products. An examination of positive and negative effects on consumer psychology impacted by influencers is also provided in order to fully understand consequences of influencer type digital marketing.

Keywords - influencers, social media, consumer behavior, psychology, digital marketing

I. INTRODUCTION

The influence of social media has impacted various fields - businesses, marketing strategies, individuals and social life as a whole. Interaction between people has moved from the offline to the online world, and this transition has influenced individual's perception of interaction with others, especially through the appearance of influencers. Influencers can be celebrities, sportists, fashion and lifestyle gurus, or really any individual who has gained a larger following on social media platforms. They captivate user's attention through their curated content, charisma and luxurious lifestyles. By sharing parts and highlights of their exciting lifestyle through social media, they pose themselves as prominent social references for self-comparison among individuals. This can create a distorted perception of reality, beauty standards and expectations for individuals about their lifestyle and a constant subconscious need for comparison.

II. PSYCHOLOGICAL EFFECTS OF SOCIAL MEDIA INFLUENCERS ON CONSUMER BEHAVIOR

A. Influencers as Social References for Self-Comparison

Social comparison theory, introduced by Festinger in 1954, proposes that individuals compare themselves to others in order to evaluate their own capabilities, values and beliefs. More precisely, the theory proposes the idea of upward comparison, which explains the need of individuals to create comparison between themselves and those who are seemingly more successful or superior. It is common that influencers represent those higher ideals and standards which are generally wanted by the majority of society and individuals and thus cause the need for upward comparison. Some of the effects that are generated by this include lower self-esteem between individuals and a general lower perception of one's self-worth.

Some studies have found that individuals who follow fitness influencers on social media tend to engage in upward comparison by comparing their bodies, fitness levels, and health behaviors to those of influencers (Fardouly et al., 2018). This can result in negative outcomes, such as decreased body satisfaction and increased body dissatisfaction, as individuals may feel inadequate or inferior compared to the seemingly perfect bodies of influencers. Similarly, studies have shown that individuals who follow fashion or beauty influencers may engage in upward comparison regarding their physical appearances, fashion sense, and lifestyle choices (Perloff, 2014). This can lead to increased materialism, self-objectification, and a preoccupation with appearance, as individuals strive to emulate the idealized lifestyles portrayed by influencers.

In addition to the psychological implications, influencers as social references for self-comparison also have social consequences. As more time passes influencers also gain broader knowledge from experience on how to produce even more attention captivating content, which is carefully aimed at their target audience and serves them in creating a desired image of themselves (Tiggemann & Slater, 2014). When being presented with this kind of quality content, individuals start to compare it with their own and become super aware of their own flaws, which leads to the constant race of reaching proposed standards by influencers. This can also change what individuals used to consider as valuable or necessary in life (Khamis et al., 2017).

It is important to note that the phenomenon of influencers as social references for self-comparison is not inherently negative. As opposed to upward comparison mentioned earlier, there is also a term known as downward comparison, which happens when individuals compare their lifestyles to the ones they consider lower on the ladder of success (Wills, 1981). Some of the positive effects influencer culture can have on the psychology of individuals are an increase in motivation for gaining a better life and inspiration for incorporating positive changes in life.

B. Emotional Engagement With Influencers And Its Impact On Consumer Behavior

Emotional engagement with influencers has significant psychological effects on consumer behavior. Emotional engagement with influencers refers to the emotional connection that individuals develop with influencers, often triggered by their relatability, authenticity, and perceived similarity to the followers (Buil et al., 2019; Phua et al., 2017). Influencers can inspire, entertain, motivate, or even create a sense of emotional attachment among their followers. This emotional engagement can profoundly influence the psychology of consumers, leading to various outcomes in terms of consumer behavior.

This kind of emotional engagement has immense potential in shaping consumer behavior, especially their intentions on buying products promoted by influencers. By consuming daily media content by influencers, individuals gain a stronger emotional connection with them, which is a good surface for building trust (Biswas et al., 2020; Khamis et al., 2017). The fast dynamic of social media platforms also provides a captivating space for consumers' attention, leading to the increase of total time spent in engagement with influencers. Consequences of this can include an even bigger influence on the behavior of users and also create a sense of codependency between consumers and social media figures.

Moreover, emotional engagement with influencers can also shape consumers' brand perceptions and loyalty. Emotional attachment to influencers can lead to a transfer of emotions and attitudes from the influencer to the endorsed brand (Hwang et al., 2020; Lin et al., 2019). Consumers may develop positive attitudes toward the brand and perceive it as more credible and trustworthy due to their emotional connection with the influencer. This can ultimately result in increased brand loyalty and advocacy, as consumers feel a sense of loyalty and identification with both the influencer and the endorsed brand.

It is also important to consider that emotional engagement with influencers can have various negative psychological effects. Influencers often portray luxurious lifestyles, unattainable beauty standards, or unrealistic ideals, which can trigger envy, social comparison, and feelings of inadequacy among their followers (Perloff, 2014; Tukachinsky et al., 2018). One of the known psychological impacts on consumer behavior caused by this is increased impulsivity and decision making regarding making purchases in order to compensate for the feelings of being less valued in comparison to prominent influencers.

C. Cognitive Processing Of Influencer Content And Its Effects On Consumer Psychology

Cognitive processing of influencer content involves various cognitive processes, including attention, perception, comprehension, and interpretation. Influencer content is often visually and verbally stimulating, capturing consumers' attention and influencing their perception of the content (Schouten et al., 2020). Influencers use persuasive techniques, such as storytelling, humor, and emotional appeals, to engage consumers and shape their perceptions of the endorsed products or services (De Veirman et al., 2019).

In addition to that, a common communication technique used by influencers is incorporating a style of language which is relatable to broad audiences and also a practice of sharing more personal and vulnerable stories (Jin et al., 2019). The cognitive effects this has on individuals is their perception of influencers as of people who are actually close to them, in a way similar with the relationship they may have with friends or even family. Some of the effects also include a shorter attention span, which is expected due to high dopamine levels gained from dynamic content.

III. SOCIAL AND SOCIETAL IMPACTS OF SOCIAL MEDIA INFLUENCERS

A. Origination Of Parasocial Relation And Its Contemporary Manifestation

The term parasocial relationship was first used by Horton and Wohl (1956). Horton and Wohl remark on the profound impact that the mass media has on viewers: “One of the striking characteristics of the new mass media - radio, television, and the movies - is that they give the illusion of face-to-face relationship with the performer”. A relationship can be defined as a parasocial one when there is a one-sided connection made: meaningful to the viewer, but the performer is usually not even aware of the connection’s existence. An important thing to remember is that sociologists and psychologists noticed these patterns and defined them within their own terms back then in 60’s, when people were given their first opportunities ever to interact with celebrities and personas interesting and significant to them through different media forms - even though that the interactions and relationships were one-sided. People got to get insights into performers' lives for the first time, read about their everyday habits, learn about their personal relationships and form their own opinions about the mentioned things and much more. Of course, as some time passed by, the public could occasionally hear performers’ own statements in press and television interviews, but the overall public impression was still mostly affected by one-sided contents - there were not enough opportunities for common people to interact with the stars, so the public did what they thought they had to do - come up with their own conclusions.

Access to the Internet provided significant amount of quality content to anyone interested in stars' work and life - suddenly people could get any wanted article or video in just a couple of seconds, along with contributing to discussions on newly formed forums, where anyone from anywhere in the world could find pieces of information and give some other back to the community. People talked about celebrities' bags, cars, diets and marriages, deciding what's exciting, important and appropriate, what's "in" and what's "out". The appearance of social media and stars' personal accounts changed everything - people were no longer restricted to billboards and music videos, and not even to the commercials and interviews - they could see their favorite people in their own homes, eating some chips or using their new makeup, taking their dog on a walk in the neighborhood, having fun at a certain bar with a certain cocktail in their hand while listening to a certain artist. It is now easier than ever to connect with people we want in ways more personal than ever before, because that's what social media grants us.

B. The Roles Of Source Credibility And Fairness In Parasocial Relationships And Product Interest

Nowadays not only performers, but anyone interesting enough to the public can use the unique interactivity of social media to build strong relationships with followers. Such relationships, which carry great marketing potential, appeal to corporations and brands. The results of an online survey conducted by Shupei Yuan and Chen Lou in 2020 showed that followers' perceived attractiveness of influencers, similarity to influencers, procedural fairness, and interpersonal fairness of their interactions with influencers are positively related to the strength of their parasocial relationship with influencers, which further mediates the effect of the aforementioned factors on followers' interests in influencer-promoted products. The findings of mentioned study explicate the mechanism through which influencers foster relationships with followers and also provide practitioners with insights on orchestrating strategic influencer campaigns, implicating that a lot of parasocial relationships are not formed organically, but rather strategically. That's where ethical considerations come to the surface - transparency of influencer's advertising decisions, actions and strategies, credibility of the information provided, fairness of the communication conducted, presence of any form of manipulation and even exploitation of the followers.

It is a common occurrence that influencers choose to advertise, mostly subtly, different products and services presenting them as a part of their everyday life, even though they most certainly know they are deceiving their followers who are trusting them based on formed parasocial relationships, most probably through the previous months or years. In some cases the only damage is misuse of given trust and not giving followers what they truly want - a real connection through sharing sincere stories, advice, confessions and experiences. Other cases may also include advertising risky advice about health (diets, medicines), non-examined products (make up, supplements) or low quality services (cosmetic treatments or even surgeries) in order to earn material resources (money, free products and services) by promoting suspicious or even illegal brands. However, social media also offers the opportunity of selecting out relevant influencers with some help from followers themselves - they can like, comment, block or even report the content to the social media managing teams. Followers do collect, share their experiences and they do decide together if the brands that influencer advertises are relevant or not, making it hard for the influencer to keep their reputation on social media once they choose to purposefully manipulate their followers.

C. Trans-Parasocial Relation In Influencer Advertising And Its Implications

Chen Lou (2022) goes further and explains that afforded by new digital technologies consumer interactions are breaking the basic assumptions about the long-held conventional concept of parasocial relations. The ever-evolving human interactions, along with the influencer-follower relation, needed to be reassessed in order to gain a better understanding. His current analysis recommends an updated notion and theorization - a trans-parasocial relation - to capture a collectively reciprocal, (a)synchronously interactive, and co-created relation between influencers and their captive followers. Unlike parasocial relations, the trans-parasocial ones rely on social media and their highly interactive features to enable easier community forming and large scale effects ("collectively reciprocal"), easier addressing the followers - even though it is sporadic and not always personal ("(a)synchronously interactive") and co-creating of content and strategies (sharing and re-sharing, live videos, other ways of including the followers into the advertising). This trans-parasocial relation concept offers a foundation on which new communicative and advertising theories can be developed to explicate new forms of social interactions and consumer behavior, claims Chen Lou (2022). Based on his study, modern-day followers indicate mostly benign attitudes toward influencer-sponsored posts, interpret influencers' sponsorship disclosures as genuine and transparent, and internalize disclosure actions as inspiring and admirable - unlike parasocial relationships where advertising could easily be seen as a persuasive, repellent act.

The study further identifies and elucidates several psychological mechanisms that account for followers' overall appreciation of influencer-sponsored posts: positive bias, verification by cross-validation, and inspirational internalization. When it comes to information whose negative aspect carries no threat, people may tend to display a "positivity bias." Such a processing style may be explained by human tendency to avoid harmful stimuli and approach beneficial stimuli, and it reflects the flexibility of humans' cognitive processing (Smith et al., 2006; Rothermund et al., 2008). In the case of a built relationship with an influencer, along with being in a meaningful community and knowing the perks of working, socializing and simply being active on social media, people feel less in danger than before - thus, focusing more on favorable or potentially beneficial information. Verification by cross-validation addresses the existence of mentioned meaning communities which are easier to form and are developing greater than ever, giving their members the opportunity to discuss openly and in real time, collect their experiences and come to a certain conclusion about an influencer that's the most accurate - or at least the most sincere - from the beginning of existence of influencer-follower relationships. Finally, inspirational internalization is happening when the influencer becomes approachable, honest, familiar and relatable to the follower, so the follower can internalize the influencer's experience, talents and success as their own, making it easier for the influencer to create likable and influential content.

IV. INFLUENCE OF SOCIAL MEDIA INFLUENCERS ON CONSUMER DECISION-MAKING PROCESS

A. The Role Of Influencers In Raising Awareness About Products/Services

In this digital era influencers are the one of the most important roles in introducing new products and services on the market. Influencers can increase curiosity among their followers especially if they are already famous. A study by Influencer Marketing Hub (2019) found that 67% of marketers believe that influencer marketing campaigns help them reach a more targeted audience. A report by Nielsen (2015) found that most consumers trust recommendations from individuals, even if they don't know them personally, indicating the significant impact that influencers can have on consumer behavior.

One of the most problematic steps in increasing followers is attracting their attention and trust. But once they come to that stage, creating relatable content becomes a lot easier and more specific.

The advent of social media has changed the way consumers engage with brands and products. Influencers are a connecting link between brands and target audience. According to the theory of opinion leadership, opinion leaders are individuals who are knowledgeable about a particular product or service and are willing to share their opinions with others (Katz & Lazarsfeld, 1955). Consistently sharing content with their loyal public will strengthen the relationship and their opinions and recommendations will have more impact on their followers. This makes them an ideal partner for brands looking to raise awareness about their products/services.

B. Influence Of Influencers On Consumer Intentions, Such As Purchase Intention And Brand Loyalty

Influencers can shape consumer attitudes towards a product or service through their endorsements. Showing an honest opinion and realistic picture can help reach more followers and the public. Also that kind of audience is long term and will show more interest in such work and they can become more credible on this big market. A study by AdWeek (2016) found that 61% of consumers read online reviews before making a purchase decision. Influencer endorsements can, therefore, influence consumer attitudes towards a product, which can ultimately impact their purchase decisions.

Influencers can influence consumer intentions, such as purchase intention and brand loyalty, through their social media content. Providing a personal endorsement, influencers job is raising awareness and generating interest among their followers.

They are a popular marketing tool for brands in order to easily reach their target audience, because choosing the right person for presenting a product/service is, nowadays, the most important thing to do when it comes to making cooperation with people whose job is to promote products. About consumers' brand loyalty, a study by Takumi found that 60% of respondents are more likely to remain loyal to a brand that they discovered through an influencer (Takumi, 2019), so that is another proof that the relationship between those two is really strong.

The type of influencer can also impact their influence on consumer intentions. Micro-influencers, who have a smaller but more engaged following, have been found to have a higher level of influence on consumer behavior compared to macro-influencers and the reason for that is people recognize when someone's intentions are sincere and not just for profit. Macro-influencers have a larger but less engaged following (Influencer Marketing Hub, 2021) and that on the other side is also good because people have more safety and trust when the person is followed by many. This suggests that brands should consider partnering with micro-influencers to maximize the impact of influencer marketing on consumer intentions.

C. Influencer Impact On Consumer Purchasing Decisions

Influencers can have a significant impact on consumer purchasing decisions. A study by Google and Ipsos (2018) found that 70% of teenage YouTube subscribers reported trusting influencer opinions over traditional celebrities. This shows that influencers are becoming crucial in making consumers' purchasing decisions. Moreover, a report by Influencer.co (2020) found that 63% of consumers reported purchasing a product after seeing it promoted by an influencer, and that is proving the theory of the significant impact that influencers can have on consumer behavior.

Influencers can also influence post-purchase behaviors, such as product use and advocacy. By providing valuable insights into a product's features and benefits, influencers can encourage their followers to use the product correctly, ultimately leading to higher satisfaction levels. The interesting thing is that if an influencer uses a product after promoting and after consumer's purchasing, it leads to even more satisfied users.

Most common situation is that influencers can also impact repeat purchases. A study by Collective Bias found that 30% of consumers are more likely to buy a product again if it was recommended by an influencer (Collective Bias, 2016). In this way the consumer shows that they believe in a person who promotes stuff and is willing to buy again. So, this kind of commitment can help brands build long-term relationships with their customers by encouraging repeat purchases and all of that thanks to social media and their new ways of earnings and making people less dependent on jobs.

Also the impact of post-purchase behaviors is seen in encouraging user-generated content. The followers are often asked to share photos or videos of themselves using the products they promote, which can help create a sense of community around the brand. Encouraging consumers to share their experiences with a brand, can lead to increased product use and advocacy and from that all sides have profit. Of course, some of them are not happy with sharing their own experience and exposing it on social media, but luckily for those who are promoting, the number of non-cooperative people is not that big, so they still have an audience who are open to share their opinion.

Ability of social media influencers to raise awareness, form attitudes, and influence intentions, influencers have the potential to drive significant changes in consumer behavior. They have the power to make someone to love some product/service or even dislike them and influencer attitude becomes more relevant if the public trusts them. Their impact is felt the most among younger generations who are on social media all day, and tend to rely heavily on social media for product recommendations and lifestyle inspiration. It is important for brands and consumers to approach these endorsements with a critical eye and be aware that not everything is like it is shown on social media for the consumer side and for the brand side to choose wisely who they pick for their campaigns. Most probably, this kind of influence will become even stronger as time goes and there are big chances that this will make a bigger gap between generations.

V. CONCLUSION

The in-depth analysis of various impacts social media influencers have on consumer behavior provided in this paper allows for understanding the importance of this topic for individual human psychology and societal changes as well. Although powerful for digital marketing purposes, social media influencers can present negative effects upon consumer behavior and psychology, but also positive effects which are all presented in this paper.

REFERENCES

1. Chen Lou (2022). Social Media Influencers and Followers: Theorization of a Trans-Parasocial Relation and Explication of Its Implications for Influencer Advertising, Journal of Advertising, 51:1, 4-21, DOI: 10.1080/00913367.2021.1880345
2. Donald Horton & R. Richard Wohl (1956). Mass Communication and Para-Social Interaction, Psychiatry, 19:3, 215-229, DOI: 10.1080/00332747.1956.11023049
3. Rothermund, K., Voss, A., and Wentura, D. (2008). Counter-regulation in affective attentional biases: a basic mechanism that warrants flexibility in emotion and motivation. Emotion 8, 34–36. DOI: 10.1037/1528-3542.8.1.34
4. Shupei Yuan & Chen Lou (2020). How Social Media Influencers Foster Relationships with Followers: The Roles of Source Credibility and Fairness in Parasocial Relationship and Product Interest, Journal of Interactive Advertising, 20:2, 133-147, DOI: 10.1080/15252019.2020.1769514
5. Smith, N. K., Larsen, J. T., Chartrand, T. L., Cacioppo, J. T., Katafiasz, H. A., and Moran, K. E. (2006). Being bad isn't always good: affective context moderates the attention bias toward negative information. J. Pers. Soc. Psychol. 90, 210–220. DOI: 10.1037/0022-3514.90.2.210
6. Influencer Marketing Hub. (2019). Influencer Marketing Benchmark Report. https://influencermarketinghub.com/influencer-marketing-benchmark-report-2019/
7. Nielsen. (2015). Global Trust in Advertising. https://www.nielsen.com/content/dam/corporate/us/en/reports-downloads/2015-reports/global-trust-in-advertising-2015-report.pdf
8. Katz, E., & Lazarsfeld, P. F. (1955). Personal Influence: The Part Played by People in the Flow of Mass Communications. Free Press.
9. AdWeek. (2016). Why Online Reviews Matter for Your Business. https://www.adweek.com/digital/why-online-reviews-matter-for-your-business/
10. Takumi. (2019). Influencer Insights: The Rise of Influencer Marketing. https://takumi.com/wp-content/uploads/2019/05/Takumi-Influencer-Insights-Report.pdf
11. Influencer Marketing Hub. (2021). Micro vs. Macro Influencers: Which Should You Choose? https://influencermarketinghub.com/micro-vs-macro-influencers/
12. Google & Ipsos. (2018). YouTube Influencer Marketing: The Ultimate Guide. https://www.thinkwithgoogle.com/marketing-strategies/video/youtube-influencer-marketing/
13. Influencer.co. (2020). The State of Influencer Marketing 2020. https://influencer.co/resources/the-state-of-influencer-marketing-2020/
14. Collective Bias. (2016). The Power of Influencer Marketing. https://collectivebias.com/resources/the-power-of-influencer-marketing/
15. Fardouly, J., Diedrichs, P. C., Vartanian, L. R., & Halliwell, E. (2018). Social comparisons on social media: the impact of Facebook on young women's body image concerns and mood. Body image, 26, 38-45.
16. Perloff, R. M. (2014). Social media effects on young women's body image concerns: Theoretical perspectives and an agenda for research. Sex Roles, 71(11-12), 363-377.
17. Tiggemann, M., & Slater, A. (2014). NetGirls: The Internet, Facebook, and body image concern in adolescent girls. International Journal of Eating Disorders, 47(6), 630-643.
18. Khamis, S., Ang, L., & Welling, R. (2017). Self-branding, 'micro-celebrity'and the rise of Social Media Influencers. Celebrity Studies, 8(2), 191-208.
19. Buil, I., de Chernatony, L., & Martínez, E. (2019). Examining

the role of advertising and sales promotions in brand equity creation. Journal of Business Research, 96, 157-165.

20. Biswas, D., Kavaratzis, M., & Hemsley-Brown, J. (2020). The Effects of Emotional Engagement with Social Media Influencers on Purchase Intention. Journal of Business Research, 116, 356-364.
21. Hwang, Y., Hung, K., Chen, Y., & Chen, Y. (2020). When celebrity endorsement backfires
22. Schouten, A. P., Janssen, L., & Verspaget, M. (2020). Follow me and like my beautiful selfies: The impact of influencers on adolescents' self-esteem, social comparison, body image, and purchase intentions. Journal of Adolescence, 78, 232-240.
23. De Veirman, M., Hudders, L., & Nelson, M. R. (2019). The Persuasiveness of Influencer Marketing: The Role of Content, Credibility
24. Jin, S. V., Muqaddam, A., & Ryu, E. (2019). Influencer marketing: Effects of source type, product involvement, and platform on consumers' purchase intention. Computers in Human Behavior, 101, 205-214.

Adoption of Digital Marketing Technologies in Indian Healthcare Sector

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Abstract—This study aims at assessing the factors influencing the adoption of digital marketing technologies in the Healthcare Service Sector of India and to investigate the challenges as well as efficacy of digital marketing in Healthcare Sector in India. The study is based on a decomposed version of Technology Acceptance Model employing the PLS-SEM technique. The major constructs of TAM – Perceived Usefulness and Perceived Ease of Use have been measured as constructs decomposed into the their subdimensions as derived from previous literature and hence this study contributes to the existing literature which is lacking in this type of sub-dimensional analysis using TAM. Results reveal that both perceived usefulness and perceived challenges have a significant effect on attitude towards digital marketing and further the adoption of digital marketing technologies.

Keywords - Digital Marketing, PLS-SEM, Technology Acceptance Model, Indian Healthcare

I. INTRODUCTION

With the advent of digital media and social networking, businesses are more than ever required to market their products and put brand building efforts through digital marketing.[1] These efforts need the adoption of digital marketing technologies [2] and there is a need to study the factors that influence the employees who are involved in usage of these technologies directly or indirectly in an organization because any new change introduced in an organization must be supported by the team for it to become effective in achieving its objectives. Digital marketing is the use of technologies to help marketing activities in order to improve customer acquisition and satisfaction by matching their needs. Specifically, it may be defined as "Achieving marketing objectives through applying digital media, data and technology." [3]

The use of digital marketing technologies has transformed the mechanism of marketing communication with the consumers. As the penetration of computers and mobile devices grew manifold, it led to a significant growth of digital marketing spending.[4]

There are numerous benefits as well as challenges which one can think of when it comes to adoption of digital marketing technologies [5] and all of these affect the attitude of personnel involved in employing these technologies towards its adoption. Indian Healthcare Service Sector is a growing sector with many private organizations expanding their operations in the country. This has brought a paradigm shift in the way this industry has operated in past and now the healthcare providers must compete with each other to increase their customer base and revenue. This has given rise to the need for these organizations to adopt digital marketing technologies and to assess how the costs and benefits weigh against each other in the adoption of these technologies in the sector.

The willingness to adopt technology traditionally is explained by the technology acceptance model (TAM) [6] TAM has been applied to adoption of Digital Marketing by businesses [7,8,9,10]. The focus of this paper is to examine the effect of various factors influencing the adoption of digital marketing technologies in Indian Healthcare Industry using a decomposed framework of Technology Acceptance Model (TAM) [6] applying PLS-SEM technique using SmartPLS 4. [11]

II. LITERATURE REVIEW & RESEARCH FRAMEWORK

Research framework for the present study has been derived from a rigorous review of existing literature to arrive at the various factors affecting the adoption of digital marketing and its effect including the different mediating variables and antecedents. The study adopts Technology Acceptance Model (TAM) [6] as the theoretical basis to investigate the adoption of digital marketing.

The basic constructs of Perceived Usefulness and Perceived Ease of Use as propounded by TAM have been adapted for the study in a decomposed form with subdimensions of each serving as the independent variables in the model. This sub dimensional analysis is the contribution of this study to the literature as previous studies have taken these constructs at an aggregate level only without looking into the sub aspects of these.

The antecedents of digital marketing adoption is well documented in previous literature, but different studies have analysed specific factors without integrating them together. There is also a dearth of such studies for Healthcare sector in India. This study is an attempt to devise a comprehensive model incorporating various antecedents of adoption of digital marketing technologies in Healthcare in order to provide more insights to the existing knowledge in this area.

By integrating the factors studied by different studies into the subdimensions for measuring the constructs of perceived usefulness and perceived challenges, this study adds to the existing literature in presenting a more comprehensive analysis of the factors influencing the adoption of digital marketing techniques by Healthcare Service Providers in India.

i) Perceived Usefulness

TAM specifies perceived usefulness and perceived ease of use, as determinants of attitude towards behavioural intentions and IT usage. This study has adapted the perceived usefulness construct from TAM and decomposed it while measuring it using subdimensions from existing literature as items. Perceived usefulness (PUSE) is defined as the extent to which a person believes that using a particular system would enhance performance.

In the context of digital marketing, the perception of employees regarding its benefits in branding, customer engagement, market penetration, resource efficiency and revenue generation have been considered as items for measuring the PUSE construct. These advantages of digital marketing have been well mentioned in the existing literature [12].

Relative advantage of using a product or service was found to be a significant factor in determining adoption of new innovations. [13] In general, perceived relative advantage or usefulness is found to be positively related to the rate of adoption of a product, process or service. [14] In view of the advantages that digital marketing offers for an organization, it would thus be expected that individuals who perceive digital marketing as useful would be more likely to have a positive attitude towards adopting the same.

ii) Perceived Challenges

The Perceived Ease of Use construct in Technology Acceptance Model has been modified for use in the context of digital marketing challenges in the Healthcare Sector. Perceived ease of use represents the degree to which a particular system is perceived as being free of effort in being easy to understand, learn or operate.

The construct in this study was modelled as challenge in usage as most people seem to be more aware of challenges associated with digital marketing and can recall the same more easily instead of rating the ease of use of digital marketing technologies because the technical implementation of digital marketing is only known to the technical departments of an organization.

Challenges in adopting digital marketing are multifaceted [15] and include the knowledge constraints [16, 17], financial constraints [18], strategic limitations [19] and issues arising due to negative feedback online [20]. All these have been adapted from the cited studies and included as items to measure Perceived Challenges.

Attitude towards Digital Marketing & Adoption Measures

The Attitude towards digital marketing (ATTD) refers to how an individual feels regarding digital marketing and how much value one attaches to it. People who are less aware regarding digital marketing usefulness tend to have a lower importance assigned to it. [6] Therefore, perceived usefulness is expected to be a major antecedent of the attitude towards digital marketing because those who perceive digital marketing to be useful for the organization will be having a more positive attitude towards the same.

Similar reasoning follows for the adoption of digital marketing and hence there is expected to be direct as well as indirect relationship between the perceived usefulness, attitude towards digital marketing and its actual adoption. Perceived Challenges on the other hand are expected to have a negative effect on the attitude towards digital marketing. The measures of digital marketing adoption were adapted from the actual usage measures given by Davis (1989) [6].

III. METHODOLOGY AND ANALYSIS

A. Data & Methods

Purposive sampling technique was used to gather data from an online survey of healthcare employees in India using a structured questionnaire based on 5 point Likert Scale. All scale items were adapted from prior literature as mentioned in the previous section. Power analysis was used to calculate the required sample size for the study using G*Power software [21]. Actual sample size used for the study is 280 which is well above the minimum required size for 90% power at 5% significance level.

The research framework of this study attempts to analyse a structural equation model for evaluating the relationship of Digital Marketing Adoption with its different antecedents. Structural Equation Modelling (SEM), is a statistical technique widely used in modelling for various domains. It is operationalized as a combination of factor analysis and multiple regression or path analysis.

Structural Equation Modelling focusses on theoretical constructs, represented by the latent or unobservable factors. The relationships between the various latent constructs are represented by regression or path coefficients between them. Structural equation modelling provides a feasible framework for statistical analysis of complex models that include several multivariate procedures.

The PLS-SEM approach is preferred by researchers because it facilitates the estimation of complex models which are made up with multiple constructs, having different kinds of indicator variables and many structural paths. PLS-SEM also has the advantage of being a non-parametric approach not having assumptions related to distributional properties of the data.

But the most significant argument for the use of PLS-SEM is the causal-predictive approach to SEM followed in this methodology which emphasizes on prediction in estimation of models, designed to come up with causal explanations.

A path model comprises of two elements: first, the structural model which represents the causal-predictive relationships between the constructs, and second, the measurement models which represent the relationships between each construct and its respective indicators.

The structural model is also referred to as the inner model and the measurement models are at times, referred to as outer models in PLS-SEM. Assessment of path model is based on both structural theory and measurement theory, that is, the theoretical basis for the relationships between the constructs as well as the basis of the relationships between the construct and its indicators.

The measurement model assessment involves the examination of the internal consistency reliability, through the calculation of Cronbach's Alpha with higher Cronbach's Alpha values indicating higher reliability. Values above 0.60 are considered satisfactory in exploratory research, while the values between 0.70 and 0.90 are recommended for established constructs.

Cronbach's alpha was calculated to check for internal consistency reliability of the constructs and convergent validity was established through the calculation of Average Variance Extracted (AVE) [22]. Discriminant Validity of the various constructs in the model was established through Fornell-Larcker [23] and HTMT criterion [24]. Structural Model was then analysed for the significance of hypothesised relationships and explanatory power.

B. Results

Table I presents the results for internal consistency reliability and convergent validity for the constructs. All Cronbach's Alpha values were above .70, with AVE of each construct exceeding 0.5, thus establishing reliability and convergent validity for the scale [24].

Table I. Reliability And Convergent Validity

Construct	Values			
	Item Loadings		Cronbach's Alpha	AVE
Adoption of DM	ADOPT1 ADOPT2	0.779 0.854	0.719	0.624
Attitude towards DM	ATD1 ATD2	0.736 0.814	0.754	0.606
Perceived Usefulness	Branding Customer Engagement Market Penetration Resource Efficiency Revenue Growth	0.918 0.879 0.787 0.865 0.831	0.871	0.719
Perceived Challenges	Financial Constraints Knowledge Constraints Negative Feedback Strategic Limitations	0.729 0.812 0.819 0.786	0.794	0.726

Table II gives the discriminant validity results based on F-L criterion [23] and Table III presents the HTMT ratios which are all below 0.85, which establishes the discriminant validity of the constructs.[24]

Table II. Discriminant Validity (Fornell-Larcker)

	ADOPT	ATD	PUSE	PCHAL
Adoption of DM	0.768			
Attitude	0.623	0.895		
Perceived Usefulness	0.521	0.712	0.801	
Perceived Challenges	0.517	0.648	0.574	0.932

Table III. Discriminant Validity (HTMT)

	ADOPT	ATD	PUSE	PCHAL
Adoption of DM				
Attitude	0.460			
Perceived Usefulness	0.758	0.645		
Perceived Challenges	0.347	0.715	0.446	

Result of the structural model analysis are shown in Table IV. All the independent variables have been found to exert a significant effect on the dependent variables in the model. R square and Adjusted R square were found to be greater than 0.7 exhibiting good explanatory power of the model with 70% of the variation in endogenous variables being accounted for by the independent variables. SRMR was found to be below 0.08 which shows that model is having acceptable goodness of fit.

Table IV. Structural model results

Path	Coefficient	T Statistics	P Values
Perceived Challenges -> Attitude	- 0.118	2.501	0.012
Perceived Usefulness -> Attitude	0.368	5.607	0.000
Perceived Usefulness -> Adoption	0.491	8.125	0.000
Attitude -> Adoption	0.143	2.876	0.003
R Square (Adoption)	0.722		
R Square Adjusted (Adoption)	0.718		
R Square (Attitude)	0.705		
R Square Adjusted (Attitude)	0.701		
SRMR	0.064		

IV. CONCLUSION

The purpose of this study was to analyse the factors influencing the adoption of digital marketing technologies in the light of Technology Acceptance Model (TAM) by considering the various aspects of perceived usefulness and challenges on attitude towards adopting digital marketing technologies and the actual adoption of these technologies in Indian Healthcare industry. As expected, the perceived usefulness of the technologies was found to have a significant positive effect on the attitude as well as actual adoption. Positive attitude also leads to higher adoption of the digital marketing technologies. The way this study measured perceived usefulness paves the way for further research by developing scales based on these subdimensions and test for the individual relationships for deeper understanding as all the aspects related items had significant loadings.

Similarly, the different types of challenges were asked about in a specific manner which makes the measurement more reliable. Challenges were found to have a significant negative effect on adoption of digital marketing technologies. Therefore, healthcare organizations must make efforts to deal with the different types of constraints operating in their environment in order to improve the attitude of their employees towards adopting digital marketing technologies and hence effectively adopt them to realise their advantages in terms of revenue growth and brand building.

Organizations must train their non-technical employees also on the use of digital marketing techniques so that all the employees are on a common level when a concerted marketing campaign is run.

The findings of this study are significant for the healthcare service providers as well as the digital marketing companies which may provide the technology and expertise for the same. By taking into account the various aspects of the factors that affect the attitude and actual adoption, detailed plans can be devised for effective implementation of these technologies. Further research may be conducted in different sectors for establishing the generalizability of these results and qualitative research can be conducted to explore further dimensions of the perceived usefulness and challenges constructs.

REFERENCES

[1] Chaffey, D., & Ellis-Chadwick, F. (2019). Digital Marketing. Pearson U.K.

[2] Bala, M., & Verma, D. (2018). A critical review of digital marketing. M. Bala, D. Verma (2018). A Critical Review of Digital Marketing. International Journal of Management, IT & Engineering, 8(10), 321-339. https://ssrn.com/abstract=3545505

[3] Chaffey. D (2023). What is digital marketing? A visual summary of 18 key techniques. Smart Insight Blog, March 29. https://www.smartinsights.com/digital-marketing-strategy/what-is-digital-marketing/

[4] Cooper, P. (2018). Social media advertising stats that matter to marketers in 2018, available at: https://blog.hootsuite.com/social-media-advertising-stats

[5] Desai, V., & Vidyapeeth, B. (2019). Digital marketing: A review. International Journal of Trend in Scientific Research and Development, 5(5), 196-200. https://www.ijtsrd.com/papers/ijtsrd23100.pdf

[6] Davis, F.D., (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340. https://doi.org/10.2307/249008

[7] Ritz, W., Wolf, M., & McQuitty, S. (2019). Digital marketing adoption and success for small businesses: The application of the do-it-yourself and technology acceptance models. Journal of Research in interactive Marketing, 13(2), 179-203. https://doi.org/10.1108/JRIM-04-2018-0062

[8] Lacka, E. and Chong, A. (2016), Usability perspective on social media sites' adoption in the B2B context. Industrial Marketing Management, 54, 80-91.

[9] Michaelidou, N., Siamagka, N.T. and Christodoulides, G. (2011), Usage, barriers and measurement of social media marketing: an exploratory investigation of small and medium B2B brands. Industrial Marketing Management, 40 (7), 1153-1159.

[10] Siamagka, N.T., Christodoulides, G., Michaelidou, N. and Valvi, A. (2015), Determinants of social media adoption by B2B organizations, Industrial Marketing Management, 51, 89-99

[11] Ringle, C. M., Wende, S., and Becker, J.1M. (2022). "SmartPLS 4." Boenningstedt: SmartPLS GmbH, http://www.smartpls.com.

[12] Hollebeek, L. D., Glynn, M. S., & Brodie, R. J. (2014). Consumer brand engagement in social media: Conceptualization, scale development and validation. Journal of interactive marketing, 28(2), 149-165.

[13] Tornatzky, L. G., and Klein, K. J. (1982) Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings. IEEE Transactions on Engineering Management (29:1), pp. 28-45.

[14] Rogers, E. M. (1983) Diffusion of Innovations, New York: Free Press.

[15] Mazurek-Łopacińska, K., & Sobocińska, M. (2016). Marketing communication in the light of challenges brought about by virtualisation and interactivity. Economics and Business Review, 2(4), 65-76.

[16] Leeflang, P. S., Verhoef, P. C., Dahlström, P., & Freundt, T. (2014). Challenges and solutions for marketing in a digital era. European Management Journal, 32(1), 1-12.

[17] Herhausen, D., Miočević, D., Morgan, R. E., & Kleijnen, M. H. (2020). The digital marketing capabilities gap. Industrial Marketing Management, 90, 276-290.

[18] Abou Nabout, N., Skiera, B., Stepanchuk, T., & Gerstmeier, E. (2012). An analysis of the profitability of fee-based compensation plans for search engine marketing. International Journal of Research in Marketing, 29(1), 68-80.

[19] Bae, I. H., & Zamrudi, M. F. Y. (2018). Challenge of social media marketing & effective strategies to engage more customers: selected retailer case study. International Journal of Business & Society, 19(3).

[20] Behera, S., & Balaji, P. (2019). Social Media Marketing: Opportunities and Challenges. International Journal of Management, Technology and Engineering, 9, 5637-5648.

[21] Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41(4), 1149-1160. https://doi.org/10.3758/BRM.41.4.1149

[22] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). Multivariate Data Analysis (7th Edition). Pearson Prentice Hall.

[23] Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 39-50. https://doi.org/10.1177/002224378101800104

[24] Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM). 3rd Edition. Thousand Oaks: Sage.

E-commerce and Ethics: Insights from Industry Practitioners

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Abstract—The advent of e-commerce has brought about substantial changes in the operational landscape of businesses and consumer purchasing patterns, leading to a multitude of advantages and improved efficacy. The exponential expansion of electronic commerce has prompted ethical considerations that require meticulous examination to establish a viable and socially conscientious electronic commerce environment. The objective of this investigation is to examine the ethical dimensions of electronic commerce, as perceived by professionals in the industry. The study employed qualitative interviews as a means of gathering data to explore the challenges experienced by the participants and the most effective strategies they employ. The objective of this research is to enhance comprehension of ethical conduct in the e-commerce industry by examining concerns associated with data confidentiality, safeguarding, impartiality, and ecological accountability. The aim is to provide practical suggestions for both businesses and consumers.

Keywords - e-commerce, ethics, privacy, consumer behavior

I. INTRODUCTION

The advent of electronic commerce has sparked a substantial transformation in the global economy, fundamentally changing the way in which businesses conduct their operations and individuals interact with the commercial sphere. The considerable growth of the e-commerce sector can be attributed to the extensive incorporation of digital platforms and the integration of online transactions into conventional practises[1]. The emergence of the digital revolution has resulted in numerous benefits, including increased user convenience, effectiveness, and accessibility, as well as new opportunities for businesses to expand their reach and broaden their range of products.

The advent of e-commerce has generated a multitude of ethical issues that require thorough scrutiny, despite its advantages [2]. The concerns mentioned above encompass a wide range of subjects, including but not limited to maintaining the confidentiality and security of data, promoting fair and transparent business practises, protecting intellectual property rights, ensuring consumer welfare, and advancing ecological sustainability. The integration of ethical considerations holds significant significance in the creation of a durable electronic commerce structure that is impartial to all stakeholders, including corporations, consumers, and regulatory authorities.

Comprehending the challenges and potential solutions is imperative in addressing the intricate and multifaceted ethical dilemmas that arise within the realm of electronic commerce. Given the continuous advancements in the field, it is crucial for organisations to adopt ethical standards that not only comply with legal requirements but also promote confidence, openness, and responsibility [3]. Concurrently, it is crucial for individuals to acquire a comprehension of the ethical implications of their online engagements and demonstrate discretion in their decision-making that aligns with their individual values and convictions. The analysis of ethical considerations in the realm of electronic commerce establishes a foundational framework for effectively addressing the challenges and opportunities that arise from this rapidly evolving domain. By scrutinising the ethical dimensions of electronic commerce, a range of stakeholders including businesses, consumers, and regulatory bodies can work together to create a digital marketplace that is both socially responsible and sustainable. The primary objective is to promote fundamental principles, including equity, accountability, and sustainable development.

The widespread adoption of electronic commerce has given rise to a multitude of ethical concerns that require careful examination from the perspectives of businesses, consumers, and regulatory entities[4]. The present investigation employs a qualitative methodology to improve understanding of the previously mentioned concerns. The present study utilises a qualitative research methodology, specifically in-depth interviews, to investigate the ethical dilemmas encountered by professionals working in the e-commerce industry. Moreover, the aim of this inquiry is to determine the most effective approaches employed by these experts to address the ethical dilemmas mentioned earlier.

II. BACKGROUND

The rapid growth of e-commerce has resulted in new ethical challenges for businesses[5]. The emergence of the internet has created a new platform for unethical behaviour, which includes deceitful practises, unauthorised use of personal information, and violations of confidentiality[6]. The importance of ethical behaviour in electronic commerce is widely recognised by many businesses. However, there is a lack of academic research on how businesses perceive the ethical aspects of this emerging platform. The issue of security is a prominent ethical consideration within the domain of electronic commerce[7]. It is crucial for organisations to adopt measures that are directed towards preserving the confidentiality and integrity of sensitive data that pertains to their customers and suppliers. The incorporation of resilient passwords, encryption protocols for data, and the assimilation of security measures such as firewalls and intrusion detection systems are imperative to guaranteeing the security of electronic systems. This entails adhering to time constraints, upholding obligations, and furnishing precise data. The ethical consideration of non-deception is a pertinent issue within the realm of e-commerce[8]. It is imperative that businesses refrain from participating in any form of deceptive or misleading conduct. This pertains to the practise of manipulating the attributes of products or services, propagating false claims, and utilising a fraudulent promotional tactic commonly referred to as bait-and-switch. The importance of common values is a noteworthy aspect in the domain of electronic commerce. It is imperative for businesses to align their values with those of their customers and suppliers. The values mentioned above comprise of honesty, integrity, and fairness. The ethical implications of service recovery in the context of e-commerce are of considerable importance. It is imperative for businesses to exhibit responsiveness towards customer complaints and undertake prompt and equitable measures to resolve any issues. The ethical implications of communication in the context of electronic commerce are of considerable importance. Establishing effective communication channels with customers and suppliers is crucial for businesses[9]. This entails furnishing unambiguous and precise information, promptly addressing queries, and exhibiting openness and transparency in business operations. Through the resolution of ethical dilemmas, enterprises can establish a sense of reliability and authenticity among their clientele and vendors. This phenomenon possesses the capacity to yield increased revenue generation, elevated levels of customer satisfaction, and stronger interconnections. Numerous scholarly investigations have recognised a variety of ethical apprehensions that commercial enterprises possess in relation to electronic commerce. The aforementioned factors encompass security, privacy, dependability, authenticity, communal principles, remedial measures, and effective correspondence. It is crucial for businesses to implement ethical measures in order to cultivate trust and establish credibility with their customers and suppliers.

III. METHODOLOGY

The present investigation employed a qualitative approach, employing semi-structured, comprehensive interviews with professionals operating in the e-commerce sector, including business proprietors, administrators, and subject matter specialists. The objective of conducting interviews was to examine the ethical quandaries faced by professionals and the strategies they employ to address these challenges. For the purpose of conducting interviews, a sample size of 20 participants was selected in this study. After the data was collected, a thematic analysis was conducted in order to identify noteworthy patterns and themes.

After completing the research design and sampling strategy, the research team commenced participant recruitment. The objective was to create a diverse and inclusive group of e-commerce professionals, consisting of business owners, managers, and subject matter experts within the field. The recruitment process was initiated by the team through the utilization of their professional networks, specifically by reaching out to colleagues and acquaintances who are employed within the e-commerce industry. The individuals in question also engaged in virtual forums and communities specifically designated for the discourse of electronic commerce. The individual participated in professional discourse within online discussion forums and expressed their intention to enlist participants for their research investigation.

Simultaneously, the researchers utilized diverse social media platforms, such as LinkedIn and Twitter, to identify potential participants. The researchers conducted a comprehensive inquiry to identify individuals who possess relevant professional designations, industry knowledge, and specialized skills. Following this, the researchers conducted a thorough examination of the profiles of prospective participants in order to determine their eligibility for the study. After assembling a list of potential participants, the research team proceeded to send personalized electronic communications to everyone, briefly summarizing the objectives of the study and politely inviting them to participate in the research. The email included an additional attachment in the form of an educational brochure that provided additional information about the investigative methodology, procedures, and metrics that would be employed to safeguard the confidentiality and privacy of the participants.

The scholars expressed satisfaction upon noting that the feedback was largely positive, with a significant proportion of participants demonstrating their eagerness to participate in the study. During the subsequent weeks, the research team engaged in written communication with potential participants, addressing inquiries and alleviating any concerns that may have arisen. As a result, a research study was conducted, consisting of a group of 20 participants who were chosen to reflect a range of roles and e-commerce businesses. The study's participants provided their informed consent to participate voluntarily.

After achieving successful participant recruitment, the research team was able to proceed to the next phase of their investigation. Following the successful recruitment of participants, the research team commenced the data collection phase, which entailed conducting semi-structured, in-depth interviews with each participant. The procedure was executed over a duration of three months, wherein the team members synchronized their schedules to guarantee adequate time and focus for each interview. The investigative team provided a range of interview options to cater to the preferences and availability of the participants. The available alternatives encompassed face-to-face gatherings, telephonic discussions, and virtual conferences. A significant percentage of participants selected video conferencing as their preferred mode of communication owing to its convenience and capacity to sustain a visual connection during the entire interaction.

Prior to each interview, the researchers administered a consent form to the participants, utilizing either digital or print media, based on the mode of interview [10]. The study's objectives and methodology were explicitly stated in the informed consent document, with particular emphasis on the voluntary nature of participation. The study implemented measures to safeguard participant anonymity and response confidentiality, explicitly indicating that all personally identifiable information would be eliminated from the ultimate report. Upon obtaining the signed consent forms, the research team initiated the interview process. At the commencement of each interview, the investigators presented a concise preamble that restated the objective of the investigation, underscored the optional character of involvement, and delineated the confidentiality protocols that were implemented. The investigators conducted a semi-structured interview, utilizing open-ended inquiries that were meticulously crafted to investigate the ethical dilemmas encountered by practitioners in the e-commerce sector, along with the tactics they employed to tackle these predicaments.

The study analyzed diverse ethical considerations in the realm of electronic commerce, encompassing safeguarding data confidentiality, preserving security, ensuring fairness, upholding intellectual property entitlements, ensuring consumer protection, and promoting ecological sustainability. The investigators employed prompts to elicit expansion from the participants concerning their experiences and viewpoints, leading to abundant, intricate, and perceptive responses. During the interviews, the research team diligently recorded detailed notes, documenting significant characteristics and noteworthy observations. Following the completion of the data collection phase, the research team proceeded to transcribe the interviews and engage in data analysis in order to identify significant themes and patterns.

The rigorous process of transcribing the interviews enabled the researchers to thoroughly review and analyze the data, laying a solid groundwork for the subsequent analysis.

After completing the transcription process, the researchers imported the transcripts into a software program NVIVO version 11, that was specifically developed for the analysis of qualitative data. The utilization of software in this study enabled the research team to enhance the efficiency of coding and analysis of interview data, thereby equipping them with the necessary resources to proficiently recognize significant themes and patterns.

The primary analytical approach utilized by the researchers was thematic analysis, which followed the six-step process [11]. The research methodology utilized in this study entailed a methodical arrangement and classification of the interview data, predicated on the salient themes that surfaced from the participants' feedback.

The process of thematic analysis comprised six distinct phases:

- Familiarization: The members of the research team engaged in a comprehensive process of reviewing and analyzing the interview transcripts to acquaint themselves with the data and develop a preliminary comprehension of the principal concepts and patterns.
- Initial Coding: The researchers initiated the coding process by assigning codes to interview data segments that were identified as the fundamental units of meaning relevant to the research inquiries.
- Generating Themes: After the code generation process, a sorting method was employed to detect potential themes that could encompass the overarching patterns and concepts that surfaced from the data.
- Reviewing Themes: In the analysis phase, the research team held regular meetings to comprehensively scrutinize and improve the emerging themes, ensuring consistency among coders and augmenting the dependability of the results. In this phase, the themes were subjected to a process of consolidation, differentiation, or elimination in order to achieve coherence and consistency.
- Defining and Naming Themes: The themes were subjected to further refinement and subsequently designated with a succinct and descriptive label that precisely captured their fundamental essence.
- Producing the Report: The researchers compiled their findings into a comprehensive manuscript, weaving together established patterns and supporting them with references and examples from the interview data.

Throughout the data analysis process, the research team maintained ongoing communication, sharing ideas and interpretations and addressing any challenges that arose. The implementation of a collaborative methodology fostered a culture of meticulousness and responsibility among the team, ensuring that the final themes accurately reflected the perspectives and encounters of the participants.

IV. RESULTS

After conducting a thorough thematic analysis of the interview data, the research team has identified five key themes that encompass the ethical challenges faced by professionals in the e-commerce sector and the strategies they employed to address these issues. The study's findings have made noteworthy advancements in comprehending the ethical structure of the e-commerce industry and have uncovered efficacious approaches for cultivating conscientious and persistent conduct.

A. Data Privacy and Security

The participants consistently emphasized the importance of protecting data privacy and security, acknowledging the potential risks that may arise from mishandling client information [12]. The participants in the study exhibited a diverse range of approaches employed to protect confidential information. The implemented measures entailed securing explicit consent from clients prior to data collection or manipulation, anonymizing data when feasible, and employing encryption techniques for both data transmission and storage. As per the testimony of a respondent who is the proprietor of a petite online boutique, patrons are apprised of the utilization of their personal information and are provided with the choice to abstain from it if they deem it unsuitable.

B. Fairness and Transparency

Several participants emphasized the importance of fairness and openness in electronic commerce initiatives. The study's participants articulated apprehensions pertaining to discriminatory behaviors and emphasized the significance of furnishing unambiguous and precise details about the merchandise. The study's participants proposed various strategies to promote trust and fairness, such as the adoption of transparent terms and conditions, utilization of impartial algorithms for product recommendations, and granting customers access to comprehensive product specifications and reviews. According to a statement made by a manager associated with a reputable e-commerce platform, the organization endeavors to establish a fair marketplace that enables customers to make well-informed decisions founded on precise and genuine data.

C. Intellectual Property Rights

Several respondents emphasized the importance of adhering to copyright and trademark regulations and inhibiting the spread of counterfeit merchandise, thereby bringing to the fore the issue of intellectual property rights as a significant matter. The participants engaged in a valuable exchange of insights, which encompassed the implementation of stringent policies to address intellectual property infringement, utilization of advanced technologies for counterfeit product detection, and establishment of partnerships with intellectual property rights holders to enforce protective measures. According to an authority in the field of intellectual property law with a specialization in electronic commerce, the platform maintains a rigorous protocol that prohibits the authorization of fraudulent goods. Moreover, they establish a close partnership with brand proprietors to guarantee the genuineness of the commodities showcased on their digital platform.

D. Consumer Protection

The participants placed significant emphasis on the recurring theme of consumer protection, frequently engaging in discussions regarding the crucial nature of secure payment methods, precise product information, and effective dispute resolution mechanisms. The attendees exchanged optimal methods, which included the implementation of established industry protocols for product specifications, utilization of secure payment gateways, and the establishment of specialized frameworks for addressing customer complaints. The proprietor of an e-commerce electronics retail enterprise has expressed that their primary objective is to ensure customer satisfaction. A team of professionals has been designated to manage any possible complications or disputes that may arise, guaranteeing a seamless and satisfactory procurement process.

E. Environmental Sustainability

Several participants acknowledged the environmental implications of e-commerce operations, particularly in areas such as packaging, transportation, and waste management. The discourse among the participants centered on the execution of ecologically aware packaging materials, optimizing logistics procedures to reduce emissions, and promoting sustainable consumption practices through endeavors such as product recycling programs and carbon offsetting [13]. As per the declaration of a manager affiliated with a distinguished e-commerce enterprise, deliberate steps have been taken by the company to acquire ecologically sustainable packaging materials and engage in partnerships with logistics providers to mitigate their environmental footprint.

Table I.

Theme	**Description**	Actions
Data Privacy and Security	The safeguarding of data privacy and security is of paramount importance, with due recognition of the potential hazards associated with the mishandling of client information.	For ethical and secure data collection and manipulation, get client consent. Anonymize data whenever possible for privacy. Encrypt data transit and storage.
Fairness and Transparency	The significance of equitable and transparent e-commerce practises. This discourse pertains to apprehensions regarding discriminatory conduct and the significance of furnishing lucid and precise particulars about products.	Best practises include transparent terms and conditions, unbiased product recommendation algorithms, and detailed product details and reviews.
Intellectual Property Rights	The significance of complying with copyright and trademark regulations and preventing the proliferation of counterfeit merchandise.	Adopting strict regulations to combat intellectual property violations, using advanced technologies to detect counterfeit products, and working with IP rights holders to implement protective measures.
Consumer Protection	The focus is on safeguarding consumer interests, encompassing deliberations on reliable payment modes, precise product details, and efficient conflict resolution mechanisms.	The adoption of established industry protocols for product specifications, utilisation of secure payment gateways, and the development of specialised frameworks to handle customer grievances are crucial measures for ensuring business success.
Environmental Sustainability	The acknowledgement of the environmental ramifications associated with e-commerce activities, specifically in the areas of packaging, transportation, and waste disposal.	Ecological sustainability can be achieved by using eco-friendly packaging, streamlining logistics to reduce emissions, and encouraging sustainable consumption practises like product recycling and carbon offsetting.

V. IMPLICATIONS

The research on ethical considerations in e-commerce has noteworthy implications for various stakeholders, including businesses, consumers, policymakers, and researchers.

A. For Businesses

The current research sheds light on the ethical dilemmas encountered by e-commerce professionals and the most efficacious strategies they utilize to tackle these predicaments. By implementing these efficacious methodologies, corporations can guarantee their ethical and responsible conduct, consequently augmenting their standing, cultivating consumer confidence, and advancing their enduring prosperity. Moreover, giving precedence to ethical considerations can furnish corporations with a competitive edge in an exceedingly competitive marketplace and entice an expanding cohort of consumers who are cognizant of ethical concerns [14].

B. For Consumers

The findings obtained from this research have the potential to enhance consumers' ability to make better-informed decisions when interacting with digital commerce platforms. Through an understanding of the ethical dilemmas encountered by the corporate world and the successful strategies implemented by conscientious enterprises, individuals can discern and endorse businesses that accord primacy to ethical considerations [15]. Consequently, this has the potential to facilitate the creation of a more conscientious and enduring digital commercial environment.

C. For Policymakers

The results of this research have the potential to provide valuable insights for policymakers in their efforts to create and revise regulations and protocols related to the electronic commerce sector. Through a thorough examination of ethical dilemmas and optimal strategies outlined in this study, policymakers can formulate a regulatory structure that fosters conscientious business practices and safeguards the welfare and concerns of consumers. The implementation of the measure has the potential to promote fairness among businesses and establish a morally and environmentally aware e-commerce ecosystem.

D. For Researchers

The present research adds to the extant scholarly literature on ethical considerations in electronic commerce, thereby establishing a basis for subsequent investigations in this domain. The themes and patterns identified in this research may serve as a foundation for future investigations to explore these issues in greater depth, examine them within alternative contexts, or assess the efficacy of diverse approaches implemented by organizations to tackle ethical quandaries. Moreover, the current study has the potential to stimulate interdisciplinary investigations and foster collaboration among specialists from diverse domains, including business, ethics, law, and technology, in order to develop a more holistic comprehension of ethical predicaments in electronic commerce.

VI. LIMITATIONS

Notwithstanding the valuable insights it provides, this investigation pertaining to ethical considerations in electronic commerce is susceptible to certain constraints that necessitate recognition:

The study's outcomes could be constrained in their applicability owing to the limited sample size and narrow demographics, comprising only 20 participants. Although the data obtained from this sample was abundant, it may not comprehensively encompass the wide spectrum of experiences and viewpoints prevalent within the realm of e-commerce. The study's sample was restricted to individuals who occupied roles as business proprietors, executives, and specialists within the relevant field. There is a potential for bias towards their perspectives. The study was limited to a specific country or area, which may limit the applicability of the results to other regions with distinct cultural, legal, and regulatory structures.

The research employed a qualitative methodology, which, although offering comprehensive comprehension, may be susceptible to researcher bias and interpretation. The incorporation of numerical data within a mixed-methods framework could have yielded a more all-encompassing comprehension of the ethical implications within the realm of electronic commerce.

VII. FUTURE RESEARCH DIRECTIONS

Based on the limitations of the current study, various potential directions for future research can be discerned.

Subsequent research endeavors could potentially expand the scope of the sample size and demographics to encompass a more diverse and varied cohort of participants. The potential significance of active involvement from diverse stakeholders, including consumers, regulators, and e-commerce industry professionals, cannot be overstated. The action would facilitate a more all-encompassing comprehension of the ethical implications inherent in the field.

The integration of qualitative and quantitative research methodologies, known as mixed methods, has the potential to provide a more comprehensive understanding of the ethical considerations within the domain of electronic commerce. Academic researchers may choose to employ surveys or experiments as a means of complementing the qualitative data obtained through interviews.

Future research endeavors could explore the effectiveness of ethical strategies employed by businesses in addressing ethical predicaments in the realm of e-commerce. The present investigation holds promise in enabling the identification of optimal methodologies that result in measurable outcomes in advancing responsible and sustainable practices within the industry. Researchers may conduct longitudinal studies to examine the development of ethical considerations in the realm of e-commerce over an extended period. Such studies may also assess the lasting impact of strategies and regulations on this industry.

Academics have the potential to deepen our understanding of ethical considerations in the realm of electronic commerce by identifying and resolving existing limitations, as well as exploring potential avenues for future research. The phenomenon has the potential to lead to the development of effective strategies and policies that aim to promote responsible and sustainable practices within the industry.

The implications of the study have extensive ramifications for various stakeholders, underscoring the importance of ethical considerations in e-commerce for businesses, consumers, policymakers, and researchers. This statement emphasizes the importance of maintaining ethical principles in the field of e-commerce. Through the analysis of these findings and the promotion of diligent and sustainable methodologies, stakeholders possess the capacity to exert a significant impact on the establishment of a more ethical and unbiased electronic commerce landscape.

VIII. CONCLUSIONS

The findings of the study offer significant insights into the ethical dilemmas encountered by professionals in the field of e-commerce, as well as the effective strategies they utilize to tackle these issues, similar to the previous findings[16]. Through the assimilation and application of these optimal methodologies, businesses and consumers can collaboratively work towards establishing a more sustainable and socially responsible electronic commerce ecosystem. A potential avenue for future research in this domain may involve the examination of supplementary viewpoints, encompassing those of both end-users and governing bodies, with the aim of attaining a more all-encompassing comprehension of ethical deliberations within the sphere of digital trade.

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REFERENCES

[1] K. H. Leung, C.K.M Lee, and K.L. Choy. "An integrated online pick-to-sort order batching approach for managing frequent arrivals of B2B e-commerce orders under both fixed and variable time-window batching." Advanced Engineering Informatics. Vol. 45, p. 101125, 2020.

[2] Al. Mashalah, H., E. Hassini., A. Gunasekaran, and D. Bhatt. “The impact of digital transformation on supply chains through e-commerce: Literature review and a conceptual framework”. Transportation Research Part E: Logistics and Transportation Review, Vol. 165, p.102837, 2022.

[3] J. Collier, and R. Esteban.. “Corporate social responsibility and employee commitment”. Business ethics: A European review, Vol. 16, No. 1, pp.19-33. 2007.

[4] M.K, Kamila, and S.S Jasrotia. “Ethics in product marketing: a bibliometric analysis”. Asian Journal of Business Ethics, pp. 1-24, 2023. In press.

[5] S. S. Jasrotia, and S. Koul. “Do young consumers buy country made products? Evidence from India”. International Journal of Management and Enterprise Development, Vol. 19, No. 4, pp. 378-397. 2020.

[6] M. Petrescu, A. Krishen and M. Bui. "The internet of everything: implications of marketing analytics from a consumer policy perspective", Journal of Consumer Marketing, Vol. 37 No. 6, pp. 675-686. 2020.

[7] M.K, Kamila, and S.S Jasrotia. Ethics and marketing responsibility: A bibliometric analysis and literature review. Asia Pacific Management Review. 2023. In press.

[8] G. Agag, “E-commerce ethics and its impact on buyer repurchase intentions and loyalty: An empirical study of small and medium Egyptian businesses”. Journal of Business Ethics, Vol. 154, pp. 389-410. 2019.

[9] S. M. Tseng. (2009). “A study on customer, supplier, and competitor knowledge using the knowledge chain model”. International Journal of Information Management, Vol. 29, No. 6, pp. 488-496.

[10] J.L. Campbell, C. Quincy, J. Osserman, and O.K. Pedersen. “Coding in-depth semistructured interviews: Problems of unitization and intercoder reliability and agreement”. Sociological methods & research, Vol. 42, No. 3, pp. 294-320. 2013

[11] S.S. Jasrotia., P. Darda, and S. Pandey, "Changing values of millennials and centennials towards responsible consumption and sustainable society", Society and Business Review, Vol. 18 No. 2, pp. 244-263, 2023.

[12] S. Koul., S.S. Jasrotia, and H.G. Mishra. “Value Co-creation in Sharing Economy: Indian Experience”. Journal of Knowledge Economy, Vol. 13, pp. 387–405. 2022.

[13] S.S Jasrotia., M.K. Kamila, and V.K Patel. “Impact of Sustainable Tourism on Tourist’s Satisfaction: Evidence from India”. Business Perspectives and Research, Vol. 11, No. 2, pp. 173–189. 2023.

[14] J.G. York. “Pragmatic sustainability: Translating environmental ethics into competitive advantage”. Journal of Business Ethics, Vol. 85, pp. 97-109. 2009.

[15] O.K. Tam. “Ethical issues in the evolution ofcorporate governance in china”. Journal of business ethics, Vol. 37, pp.303-320. 2002.

[16] McNealy, J.E. “Platforms as phish farms: Deceptive social engineering at scale”. New Media & Society, 24(7), pp.1677-1694. 2022.

Digital Marketing Strategy and Application of Social Media in Crisis PR on Railways

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Abstract—This paper analyzes how the Infrastructure of Serbian Railways, using digital communication channels and social media, can influence public information, views and forms public opinion about railways. In the research, the authors specifically analyze the activities and measures released by the crisis PR in social media of the above mentioned company aiming to inform about railway accidents, and form public opinion. Also, the authors study and define the use of social media by crisis PR on railways as part of the digital marketing strategy in this railway company. The research aims to determine whether railways can reduce the negative consequences of the railway accidents in the public through social media. The authors conclude that the Infrastructure of Serbian Railways can reduce such negative consequences with quick and accurate information in social media and avoid inaccurate and sensational announcements by informing citizens promptly. Considering this, the paper also defines future digital activities by crisis PR in the event of railway accidents.

Keywords - crisis PR, railways, social media, digital communications

I. INTRODUCTION

Planned and organized PR activities in the Serbian Railways began in the nineties of the 20th century, intending to improve a degree and level of communication between the railways and the wider public. With the development of computerization in the Serbian Railways and the more significant presence of Internet communication in everyday business operations at the beginning of the 21st century, communication with the public has become faster, cheaper, and more efficient.

The first web presentation of the Serbian Railways (www.zeleznicesrbije.com) appeared in 2006, with an average annual visitation of about one and a half million visitors, which was an enviable number for that time. The official Internet presentation of Serbian Railways is becoming an important communication channel with the public, service users, and the media. In five years, from 2006 to 2011, 581 news items were published on the Serbian Railways website, with 1,228,828 views.

In the paper published at the 11th International E-Commerce Conference in 2011, the Internet as a function of improving relations with the public of the Serbian Railways [1], the authors stated that 75% of PR activities in 2010 were based on Internet communications.

The first railway presentation on Facebook was the page about the Railway Museum published in March 2011. On the first day after its publication, it was followed by about two hundred visitors, mainly railway enthusiasts.

As a result of the restructuring of the once unique railway company the Serbian Railways, since August 10, 2015, the railway sector in Serbia has consisted of four legally and commercially independent railway joint-stock companies wholly owned by the State of Serbia: Infrastructure of Serbian Railways, Serbia Voz, Serbia Cargo, and Serbian Railways. Each of these railway companies has developed a digital marketing strategy and social media application in accordance with their business and functional needs and specific characteristics.

II. BACKGROUND

The development of the Internet, mobile and other modern information technologies has contributed to the transformation of many industrial branches and the entire social life. Thanks to that, the broader social community got the opportunity to define problems and offer solutions for them in many areas of its activity [2] [3] [4]. One of those areas is railway traffic [5]. At the same time, in the last twenty years, modern information technologies and the Internet have dramatically influenced the implementation of practical activities in the field of public relations [6]. Many studies have accompanied the development of information technologies showing their importance and effects on improving the public relations [7] [8] [9].

The practice of public relations has been transformed to the greatest extent by social media [10], which now accounts for the majority of Internet traffic [11]. Both media and journalists have accepted them to find information and for news transmission, which allowed crises to spread around the world in a minute. The railway transport represents a sphere of potential risks in which there is always a possibility of various emergencies, so crisis communication in a railway company is a very sophisticated sphere of public relations [12]. Passengers increasingly use social media to communicate with railway operators, so these companies adopt social media to establish communication with users of their services [13].

The crisis communications theorists also investigated the measures that the Chinese government implemented in this area after a severe collision and a major train accident on the high-speed railway on July 23, 2011[14].

The Canadian Pacific Railway train derailment is one of five crises in the past decade. The authors analyzed how to communicate with the public and, based on that, defined basic guidelines for crisis communication [15]. The use of social media was also analyzed during the Metropolitan Transportation Authority train derailment in December 2013. Also, the analysis included the reaction of how the railway company, the general public, and the media reacted, how these groups used both traditional and social media to reach others with the story and how the news about the train derailment spread across the country thanks to social media [16].

The Ministry of the Railways of India also uses Twitter to share information and collect complaints and opinions on rail traffic issues [17]. The Indian Railways, with 118 thousand kilometers of tracks and 23 million passengers transported daily, face enormous challenges and dissatisfaction of service users on a daily basis. That is why this company has become highly active in the digital space of social media in order to respond to all problems and complaints in real-time [18].

The crises on railways can also arise due to infrastructure projects, so the authors also dealt with negative posts on Twitter regarding the United Kingdom project High Speed 2, stating that the inefficiency of conventional approaches can be improved by analyzing social media, as well as posting about infrastructure social media projects provide a large amount of data to evaluate public opinion [19].

The topic of the research was the communications of the Austrian Railways in the summer of 2015, when a large number of refugees was found in this country [20], but also the negative impact of the terrorist attack in China in 2014 on the Kunming Railway Station, on the urban development of this city [21].

The authors dealt with communication in crisis situations and other areas besides railways. Thus, the research topics were online crisis communication in Sweden from 2005-2011 [22]. The crisis communications in the USA on Twitter [23] and the role of Twitter during the devastating earthquake and tsunami in Japan in 2011 [24], crisis management in the UK rail industry and the steps needed to improve it [25] and the role of social media in the public transport sector in Singapore [26].

The EGCERSIS project, which aims to use virtual reality to improve the efficiency of crisis management, was demonstrated precisely by the crisis at the metro station [27].

III. METHODOLOGY

Based on the conducted quantitative research and qualitative analysis of the previous activities of the Infrastructure of Serbian Railways in crisis PR through social media and digital channels of communication, the paper establishes a cause-and-effect relationship between the activities that the company implements during emergency events on the railways through social media and informing the public, influencing public opinion and reducing negative consequences in those situations.

Also, based on the conducted research, the paper analyzes and defines the use of social media in crisis PR on railways within the digital marketing strategy of this railway company.

IV. RESEARCH RESULTS AND IMPLICATIONS

A. The Infrastructure of Serbian Railways on Social Media and the Internet

Joint-stock company for the management of public railway infrastructure, the Infrastructure of Serbian Railways performs activities of general interest, namely: maintenance of public railway infrastructure, organization, and regulation of railway traffic, provision of track access, and usage of public railway infrastructure to all interested railway operators and safeguarding of railway infrastructure.

The newly founded railway company Infrastructure of Serbian Railways since 2015 has had its institutional website and Facebook page. In 2019 the company opened its accounts on Instagram and Twitter to communicate with the public better and faster and to make its operations and functioning more open.

On March 13, 2023, the institutional presentations of the Infrastructure of Serbian Railways had the following number of visitors:

a. Facebook (facebook.com/inf.zel.srb) - 2,200 followers;
b. Instagram (inf.zel.srb) – 1,229 followers;
c. Twitter (@inf_zel_srb) – 119 followers;
d. Youtube (@infrastrukturazeleznicesrb6186) – 2,170 followers;

Official web presentations of the Infrastructure of Serbian Railways regarding the number of visitors did not have a significant presence on social media. However, unlike other commercial or promotional presentations on social media, for the Infrastructure of Serbian Railways, more than the number of followers is needed to succeed and realize the goals of activities on the Internet and social media.

Via social media, the Infrastructure of Serbian Railways addresses the following target groups: the most comprehensive external public, media, service users (operators – 1 user in passenger and 18 in freight rail transport), state bodies, state administration, and local government, international organizations, railway associations, and employees.

On the official company website and social media, Infrastructure of Serbian Railways had 173 posts in 2022. (Fig.1). This means that, on average, the Infrastructure of Serbian Railways had one post on the Internet and social media almost every other day. Out of 173 posts on the Internet and social media, 74 were related to the projects of modernization and reconstruction of railway infrastructure in Serbia. Last year was marked by the completion of works and the launching of the first Serbian high-speed railway line for 200 kilometers per hour Belgrade - Novi Sad, which had the greatest impact on many postings about the modernization projects of Serbian railways.

In addition, 50 posts were related to the functioning of railways, safety, and train traffic on Serbian railways, and 26 to the business policy of the Infrastructure of Serbian Railways. On social media, the Infrastructure of Serbian Railways published last year additional 23 other reports on topics aimed at the affirmation and promotion of railways, railway workers, and the railway professions, and also related to railway tourism, history, tradition, humanitarian causes, as well as participation in fairs and international activities (Fig.1).

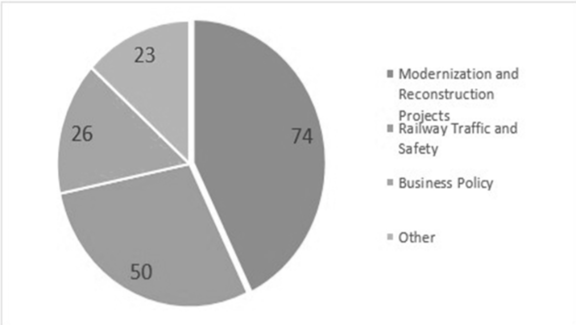

Fig. 1. Infrastructure of Serbian Railways' Posts in 2022

A large number of announcements on institutional social media and the website are significant for all target groups that are addressed in this way, starting from the general public, through state authorities and the media, to employees.

Through posts on the Internet and digital communication channels, the Infrastructure of Serbian Railways achieved the following effects: speed of information and information flow, efficiency in implementation, the establishment of two-way communication channels with the public, transparency in business, and development of internal relations within the company.

B. Development of digital marketing strategy in the Infrastructure of Serbian Railways

In a strategic and conceptual sense, the digital marketing strategy in the Infrastructure of Serbian Railways is determined annually, based on the annual Business Plan of this railways company, which defines its business and development policy.

The digital marketing strategy in the Infrastructure of Serbian Railways is based on the following:

- Presentation of the Infrastructure of Serbian Railways on social media and the Internet.
- Influence on public opinion and media creation and puic views on essential topics of railway business through social media and the Internet.
- Institutional representation of the company on social mia and the Internet.
- Presentation of projects of modernization, business, and functioning of the railway.
- Monitoring media coverage based on the company's digital marketing.
- Adequate "coverage" of users and target groups with the company's information and activities.
- Monitoring public comments posted on social media and the Internet.

The objectives of the activities implemented by the Infrastructure of Serbian Railways online on social media and using digital communication channels are:

a. Quick, accurate, and objective information to the media and the public about the functioning and business operations of the railway;
b. Creation of media and public opinions about the Infrastructure of Serbian Railways;
c. Raising awareness of the importance and advantages of railway traffic and its development;
d. Influencing the positions and opinions of target groups and the public, those groups that influence the adoption and implementation of appropriate strategic and financial decisions;
e. Creation of media and public views and opinions on the company's important business topics;
f. Improvement of business relations with different target groups;
g. Changing the image of and improving the reputation of the railways in the public;
h. Transparency in work;
i. Development of internal information within the company;

In the strategy of digital marketing in the Infrastructure of Serbian Railways, priority is given to the implementation of the following tasks: topicality of the topic (in accordance with the needs of the company or the demands of the public and the media), speed of reaction, accuracy, and timeliness of the information and the quality of texts and visual content (creation of video clips, graphs, images, etc.).

In order to accomplish these tasks, the Infrastructure of Serbian Railways should create and post ready-made media content on social media, which the media can easily and quickly take over completely, such as statements from representatives of the railway, recordings from events or the field, and others.

Next, the company should create and publish content on social media that can attract a wider audience and the public, such as interesting facts about the railway and railway workers, the history of railways, etc.

The content published on social media should be improved in a visual and technical sense. It should contain video clips, virtual railway tours, simulations of railways and facilities, graphs, photos, etc.).

C. Crisis PR – Extraordinary Traffic Events and Digital PR of the Railways

A special place and role in the digital marketing strategy in the Railway Infrastructure of Serbia are the activities of crisis PR on social media and the Internet in cases of extraordinary events and accidents in railway traffic.

The Infrastructure of Serbian Railways has a network of railways in Serbia with a total length of 3,348 kilometers. In 2022, 75,968 freight and 114,640 passenger trains operated on these lines. (Business Plan the Infrastructure Serbian Railways, 2023)

At the same time, around 500 extraordinary events, that is, accidents and incidents in railway traffic occur annually on Serbian railway lines. Thus, in 2022, there were 473 and in 2021, 518 accidents and incidents in railway traffic.

Out of 473 extraordinary events last year, 227 were accidents, and 246 were incidents in railway traffic. The category of railway accidents includes, among others: derailments of trains, accidents during the transport of dangerous goods by railway, accidents at level crossings, and the collision of a train with a railway vehicle or another obstacle on the railway line, traffic interruptions, and people run over on the railway or injuries due to electric shocks from the overhead contact line. The consequences of railway accidents are often interruptions of railway traffic and material damage, and in some cases, there are also human victims.

However, apart from the direct consequences, these crisis situations in railway transport always arouse the great interest of the public and the media and cause damage to the reputation of the Infrastructure of Serbian Railways.

At the same time, exceptionally extraordinary events with more prolonged traffic interruptions, more significant material damage or human casualties, such as derailment of freight trains with dangerous goods or accidents at level crossings, certainly weaken the position of the railways with the State authorities, as well as with the State administration and local governments. This is particularly important because these target groups make strategic business and financial decisions regarding railway traffic.

In rail accidents and crisis PR situations, digital communications and social media can positively and negatively affect existing circumstances (Fig.2.)

Fig. 2. Crisis PR on the company's account on Facebook

Social media users can quickly post on their profiles and share information about train accidents. For social media users, the speed of publishing information is more important than its accuracy, completeness, and reliability. Such announcements from social media are then taken over by certain media and spread without prior verification, uncritically and sensationally on their portals. This can harm the elimination of the consequences of an extraordinary event, and in certain situations, there is a danger of an unjustified spread of panic.

In such a situation, no matter how important it is to eliminate the consequences of an extraordinary event in railway traffic as quickly as possible, a quick, precise, and timely reaction in the field of public relations is no less important. The railway needs to overcome such crises as quickly as possible and reduce damage to a minor extent through truthful, efficient, and high-quality communication with the broader public.

In order to achieve this, the Infrastructure of Serbian Railways, with its activities on social media and the Internet, should prevent all misinformation that may appear on digital communication channels.

D. Operational Digital Activities of Crisis Management PR on Railways

The railway digital crisis management PR in such situations includes the implementation of the following operational activities:

1. Information receiving speed

Viber groups are constantly active in the Infrastructure of Serbian Railways, which includes the most responsible managers and participants in the organization of railway traffic, intending to enable the fastest flow and dissemination of information about extraordinary events;

2. Accuracy, precision, and reliability of information

Upon receipt of the first information from the field via Viber groups that an extraordinary event has occurred, the information obtained is checked and supplemented through hierarchical communication channels;

3. Information flow control

Control of the flow of information during extraordinary events is regulated by internal rules, and an authorized person can only perform the entire communication with the public in such situations;

4. The speed of publishing information on social media and the website

Expert services of the Infrastructure of Serbian Railways, in charge of public relations and cooperation with the media, already upon receiving the first information, prepare a statement about the extraordinary event, and after checking and receiving additional information, finally, publish the statement on the website and social media, and deliver it to the media.

5. Monitoring posts on social media and the Internet

The on-call teams of the company in charge of public relations and cooperation with the media, after publishing press releases regarding extraordinary events, monitor how the media will convey that information. At the same time, they monitor reactions and comments on social media.

6. Responding to comments from social media users

In case of need, the company responds to social media users' questions through digital communication channels.

By quick and efficient response, accurate and verified information published on social media and the website, and objective and truthful information to the public through digital communication channels, the company reduces PR damage and negative consequences of events in public relations. At the same time, sensationalism in the media and the potential spread of panic among citizens is prevented, whereas the company shows a proactive approach in crisis situations, and at the same time, it is possible to remediate the consequences of an accident without pressure from the media and the public (Fig.3)

In the paper "Digital marketing techniques for Promotion of Infrastructure of Serbian Railways [28], research results were published, which showed that in the period from April 15 to December 31, 2020, 80 percent of publications in the media with a negative connotation were based on announcements and official information. These were train derailments, accidents at level crossings, interruptions in train traffic, and other railway accidents.

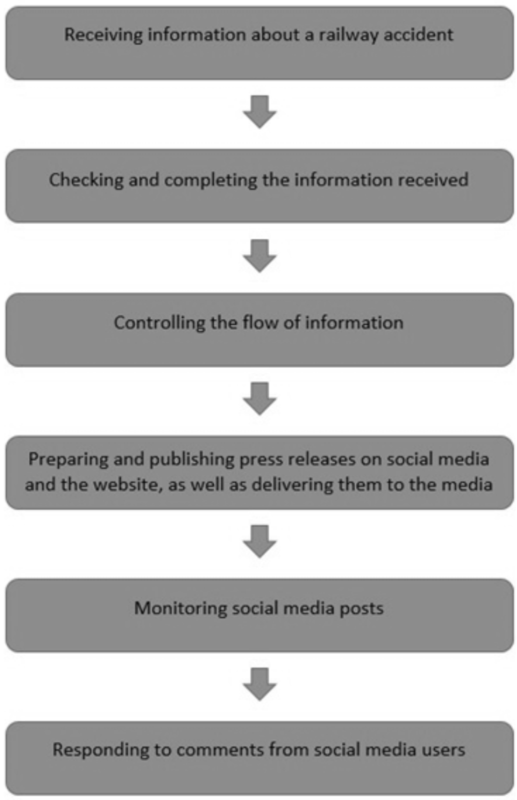

Fig.3: Operational Digital Activities of the Crisis PR on the Railways

E. Future Railway Crisis PR Activities on Social Media

Bearing in mind all of the above, the Infrastructure of Serbian Railways made a new step forward in 2023 when it comes to its activities on social media in cases of extraordinary events on the railways.

The infrastructure of the Serbian Railways publishes a recorded statement of the company's authorized person about the railway accident via social media. This way, the media can download a timely and precise (Fig.4.)

As part of the crisis PR of the Infrastructure of Serbian Railways on social media, the primary task in the coming period is the reaction speed. The goal of such activities is for the Infrastructure of Serbian Railways to publish appropriate information through digital communication channels before any other social media user, including the media.

Along with that, the task of the Infrastructure of Serbian Railways is to develop the habit of the media and social media users to immediately search for the most up-to-date information on the company's official social media accounts.

At the same time, students of the fourth year of the Faculty of Organizational Sciences of the University of Belgrade this school year will offer, through digital marketing techniques, but also open innovations, marketing, and technical-technological solutions that could be applied in crisis PR on the railways in some of the characteristic extraordinary events in traffic [29].

Fig.4: Crisis PR on the company presentation on Instagram

V. CONCLUSION

Using digital communication channels and social media, the Infrastructure of Serbian Railways can influence public information and views and form public opinion. This especially applies to the activities implemented within the digital crisis PR on the railways in cases of extraordinary events and railway accidents.

Organized, planned, and targeted engagement on social media can lead to more information, presence, and influence in the public than before. Through social media, the Infrastructure Serbian Railways can quickly and efficiently convey its information and views to the media and the wider public, thus influencing the formation of public opinion regarding railways.

In cases of extraordinary events, with quick and accurate information on social media, this railway company can reduce the negative consequences of such events in the public eye and avoid inaccurate and sensationalistic announcements on social media by informing citizens on time.

Digital marketing activities will be continued and intensified, enriched in terms of content and concept, and improved in visual and technical terms to achieve the set goals successfully.

REFERENCES

[1] D. Stojanović and N. Stanisavljević, “Internet u funkciji unapređenja odnosa sa javnošću ‘Železnica Srbije,’” in XI Međunarodna konferencija E-trgovina 2011, 2011, pp. 116–121.

[2] Z. Bogdanović, A. Labus, D. Barać, T. Naumović, and B. Radenković, “Challenging E-Learning in Higher Education via Instagram,” Rocha, Á., Reis, J.L., Peter, M.K., Cayolla, R., Loureiro, S., Bogdanović, Z. (eds) Marketing and Smart Technologies. Smart Innovation, Systems and Technologies, vol. 205. Springer, Singapore., pp. 479–491, 2021.

[3] D. Stojanović, Z. Bogdanović, M. Despotović-Zrakić, T. Naumović, and M. Radenković, “An approach to using Instagram in secondary education,” in The 14th International Conference on Virtual Learning ICVL, 2019, pp. 247–253.

[4] D. Stojanović, Z. Bogdanović, and M. Despotović-Zrakić, “IoT Application Model in Secondary Education,” in Reis, J.L., López, E.P., Moutinho, L., Santos, J.P.M.d. (eds) Marketing and Smart Technologies. Smart Innovation, Systems and Technologies, Springer, Singapore, 2022, pp. 329–338.

[5] B. Zhong, G., Xiong, K., Zhong, Z., & Ai, “Internet of things for high-speed railways,” Intell. Converg. Networks, vol. 2,

no. 2, pp. 115–132, 2021.

[6] P. Robson and M. B. James, “Not everyone’s aboard the online public relations train: The use (and non-use) of social media by public relations practitioner,” Prism, vol. 9, no. 1, pp. 1–18, 2013.

[7] R. Anderson and J. Reagan, “Practitioner Roles and Uses of New Technologies,” Journal. Q., vol. 69, no. 1, pp. 156–165, Mar. 1992.

[8] L. N. Hill and C. White, “Public relations practitioners’ perception of the world wide web as a communications tool,” Public Relat. Rev., vol. 26, no. 1, pp. 31–51, Mar. 2000.

[9] L. V Porter and L. M. Sallot, “The internet and public relations: Investigating practitioners’ roles and World Wide Web use,” Journal. Mass Commun. Q., vol. 80, no. 3, pp. 603–622, 2003.

[10] S. Lievrouw, L. A., & Livingstone, “Introduction to the updated student edition,” in Handbook of new media: Social shaping and social consequences of ICTs, 2006, pp. 1–14.

[11] B. Tancer, Click: What millions of people are doing online and why it matters. 2008.

[12] P. Daria, “Crisis communications in a railway company.” 2018.

[13] R. J. Golightly, D., & Houghton, “Social media as a tool to understand behaviour on the railways,” Innovative Applications of Big Data in the Railway Industry. IGI Global, pp. 224–239, 2018.

[14] Z. Chen and D. R. Becky Mcdonald-Advisor, “Crisis communication and reputation management : a content analysis of a Chinese high-speed rail accident.” 21-Jul-2012.

[15] S. R. Veil, K. E. Anthony, T. L. Sellnow, N. Staricek, L. E. Young, and P. Cupp, “Revisiting the Best Practices in Risk and Crisis Communication,” Handb. Appl. Commun. Res. Vol. 1 Vol. 2, vol. 1–2, pp. 377–396, Jan. 2020.

[16] M. Groover, “Crisis on the rails: An examination on the use of social media in the December 2013 Metro-North train derailment,” Regent University, 2015.

[17] N. Akhtar and M. M. S. Beg, “Railway Complaint Tweets Identification,” Adv. Intell. Syst. Comput., vol. 1174, pp. 195–207, 2021.

[18] S. Narayanaswami, “Digital social media: Enabling performance quality of Indian Railway services,” J. Public Aff., vol. 18, no. 4, p. e1849, Nov. 2018.

[19] R. YAO and A. Gillen, “Public Opinion Analysis on Social Media Platforms: A Case Study of High Speed 2 (HS2) Rail Infrastructure Project,” UCL Open Environ. Prepr., Jun. 2022.

[20] S. Einwiller, C. Ruppel, and C. Strasser, “Effects of corporate social responsibility activities for refugees: The case of Austrian Federal Railways,” Corp. Commun., vol. 24, no. 2, pp. 318–333, May 2019.

[21] Y. Li and Y. Wu, “Research on the Impact of Crisis Events on Urban Development—A Case Study of Kunming Railway Station Terrorist Attack,” Proc. 20th Int. Symp. Adv. Constr. Manag. Real Estate, pp. 139–144, 2017.

[22] M. Eriksson, “On-line Strategic Crisis Communication: In Search of a Descriptive Model Approach,” Int. J. Strateg. Commun., vol. 6, no. 4, pp. 309–327, Oct. 2012.

[23] M. Eriksson, “Lessons for Crisis Communication on Social Media: A Systematic Review of What Research Tells the Practice,” Int. J. Strateg. Commun., vol. 12, no. 5, pp. 526–551, Oct. 2018.

[24] A. Acar and Y. Muraki, “Twitter for crisis communication: Lessons learned from Japan’s tsunami disaster,” Int. J. Web Based Communities, vol. 7, no. 3, pp. 392–402, 2011.

[25] S. Beamon, “Caught out in a Crisis,” Apr. 2010.

[26] K. R. TULI, C. DULA, and S. MITTAL, “Planes, trains and social media,” Mar. 2017.

[27] A. Conges, A. Evain, O. Chabiron, J. Graham, F. Benaben, and F. B. Virtual, “Virtual Reality to Train for Crisis Management,” no. 174940, p. p.1100-1112, May 2020.

[28] D. Stojanović, N. Stanisavljević, and E. Jovičić, “Digital marketing techniques for promotion of ‘Infrastructure of Serbian Railways,’” in E-business technologies, 2021, pp. 44–46.

[29] N. Stanisavljević, D. Stojanović, and Z. Bogdanović, “Fostering crowd-based open innovations in Serbian railways - preliminary readiness assessment,” in Sustainable Business Management and Digital Transformation: Challenges and Opportunities in the Post-COVID Era, Cham: Springer International Publishing., 2022, pp. 278–297.

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BIG DATA AND ARTIFICIAL INTELLIGENCE

Big Data-driven Architecture for Crowdsensing Systems in Smart Cities

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Abstract—The subject of this paper is the development of a crowdsensing system with a big data architecture that aims to efficiently collect, process, and analyze data from various sensors deployed in smart cities. The primary goal of this research is to propose an architecture that enables real-time data collection, processing, and analysis for noise, vibrations, healthcare, and pollution monitoring. The proposed architecture is presented in detail, highlighting its components and their interactions. By leveraging asynchronous event-based communication and integrating Apache Kafka and Apache Spark, the proposed system offers improved decision-making capabilities and resource management for urban sustainability. This research contributes to the field of smart cities and crowdsensing by proposing a big data architecture that enables effective collection of data, processing, and analysis for noise, vibrations, healthcare, and pollution monitoring.

Keywords - Event driven architecture, Apache Kafka, Apache Spark, crowdsensing, smart city

I. INTRODUCTION

Smart cities are rapidly evolving to tackle environmental and health challenges posed by urbanization [1]. Smart cities integrate physical and virtual worlds, providing ordinary objects with intelligence and achieving high levels of integration, coordination, and cooperation to increase quality of life, minimize environmental impact, and optimize resource usage. The effects are more noticeable in urban areas and mega cities, and are achieved by integrating environmental sensing and automatic behaviour to objects to capture and analyse data from the real world for a better virtual operation [2]. In smart cities, crowdsourcing systems generate a vast amount of data that are crucial for providing quality services and improving citizens' lives. However, to make the best use of this data, it is necessary to develop appropriate architectures that can effectively manage large amounts of data and discover insights within them. To achieve this, a combination of Big Data, EDA, and microservice concepts are utilized for efficient data processing, analysis, and visualization. This combination enables fast and accurate execution of complex analyses over vast amounts of data, which provides better understanding of urban processes and improves citizens' lives. In recent years, big data-driven architecture has gained attention as a viable solution for building scalable and robust crowdsensing systems in smart cities. EDA is an architectural pattern where systems are designed to respond to events or messages asynchronously, rather than following a traditional request-response model [3]. This allows decoupling of components, enabling them to work independently and in parallel, resulting in improved scalability, flexibility, and responsiveness.

One of the key components of an big data-driven architecture based crowdsensing system is the data streaming platform, which is responsible for collecting and processing sensor data in real-time. Apache Kafka, a distributed data streaming platform, has gained popularity due to its scalability, fault-tolerance, and high-throughput capabilities, making it suitable for handling large volumes of sensor data in smart cities [4]. The use of Apache Kafka as the data streaming platform in this system enables efficient data collection from diverse devices, such as noise, vibrations, healthcare, and pollution sensors, and ensures reliable and timely delivery of data to Apache Spark for processing, thus contributing to the overall effectiveness and performance of the crowdsensing system [5][6].

The real-time collection and processing of sensor data is critical for addressing environmental and health challenges in urban areas [7]. For example, monitoring noise and vibrations can help in identifying areas with high noise pollution and taking appropriate measures to mitigate the impact on public health. Similarly, monitoring healthcare parameters such as heart rate and blood pressure can enable early detection of health risks and timely interventions [8]. Additionally, monitoring pollution levels can help in identifying pollution hotspots and implementing effective pollution control measures.

The proposed architecture aims to effectively monitor the environment for air pollution, noise, and vibrations in order to derive insights and conclusions about the impact of these factors on different parts of the city during specific times of the day. This architecture is designed to handle the massive amounts of data generated by crowdsensing applications and leverage it to derive meaningful insights about the parts of the city that may be problematic during specific times of the day due to air pollution, noise, or vibrations. The architecture will focus on developing efficient mechanisms to collect, analyse, and store large amounts of data from crowdsensing applications. Additionally, efforts are made to notify people in a timely and relevant manner about information that is pertinent to their specific needs, such as individuals with health concerns related to air pollution, noise, or vibrations.

The main goal of the proposed architecture is to effectively monitor the environment for air pollution, noise, and vibrations in order to derive insights and conclusions about the impact of these factors on different parts of the city during specific times of the day.

II. RELATED WORK

Data-Driven Knowledge Management Systems [9] focus on the knowledge management process, including knowledge exploration and exploitation, and the capture and organization of explicit and tacit knowledge in organizational memory. Knowledge components which are critical to the workings of such systems, can be stratified into different levels and shared through various knowledge conversion processes.

The proposed architecture is the further refinement of the research done in [10], and is focused on the development of a mobile crowdsensing system for monitoring noise pollution in smart cities. The system is comprised of several elements such as a crowdsensing mobile application, cloud and big data infrastructures, a web application for monitoring and data analysis, and REST web services for communication between components. The system supports three scenarios for mobile device calibration: full calibration using certified sound calibrators in a laboratory, calibration based on the model of the mobile phone using calibration data of other devices of the same model in the database, and no calibration which is the most common approach in crowdsensing contexts but provides lower accuracy of individual measurements. Overall, the developed mobile crowdsensing system offers a comprehensive approach for monitoring noise pollution in smart cities, leveraging mobile devices and cloud-based infrastructure for real-time data collection, analysis, and decision-making, with flexibility in calibration methods based on accuracy requirements and practical considerations.

Apache Kafka is a distributed streaming platform designed to handle high-volume, real-time data streams. It provides a publish-subscribe model where producers write data to topics, and consumers subscribe to those topics to receive and process the data. Kafka is known for its high throughput, fault-tolerance, and scalability, making it a popular choice for building data pipelines, event-driven architectures, and real-time streaming applications [4].

Apache Spark, an open-source distributed data processing engine, is another crucial component that can be integrated with Apache Kafka for processing and analysing sensor data in real-time. Apache Spark provides various powerful features such as batch processing, machine learning, and graph processing, making it suitable for advanced data analytics tasks in smart cities [11]. The use of big data-driven architecture can enable efficient data collection and processing in large-scale smart city environments, where data from a diverse range of sensors need to be integrated and processed in real-time. Big data-driven architecture allows for decoupling of components, making it possible to add or remove sensors without disrupting the entire system [12]. This provides scalability and flexibility, allowing the system to adapt to changing sensor deployments and data processing requirements in a dynamic urban environment.

III. BIG DATA-DRIVEN ARCHITECTURE FOR CROWDSENSING SYSTEMS IN SMART CITIES

In this part of article will be presented architecture for crowdsensing systems in smart cities designed to efficiently collect, process, and analyse diverse data from multiple sources in real-time. The architecture consists of five layers: data sources, data streaming, data structure, data analytics, and monitoring processes.

On the Fig. 1, first layer includes IoT sensors and mobile phone sensors, existing databases, and files. Data collection works similarly to edge computing and can perform some data modification and analysis on the device itself before sending it to the database. Mobile phone sensors can include a wide range of sensors, such as GPS, accelerometer, gyroscope, magnetometer, ambient light sensor, proximity sensor, and microphone, among others. These sensors can provide valuable data on location, motion, orientation, light levels, proximity to objects, and ambient sound, among others.

IoT sensors, on the other hand, can be deployed throughout the city and can be both static and mobile in nature. Static IoT sensors can be installed at fixed locations, such as on street lamps, buildings, or other infrastructure, and can include sensors for monitoring environmental parameters such as temperature, humidity, air quality, noise levels, and pollution levels. Mobile IoT sensors, on the other hand, can be attached to moving vehicles, drones, or other mobile devices, and can provide real-time data on road conditions, weather conditions, and other dynamic parameters. Additionally, data can also be collected from mobile phones using specialized applications. In some cases, citizens can install Raspberry Pi stations in their homes to collect data, while in other cases, professional stations can be installed by citizens or companies to collect data in more specific locations such as yards or parking lots.

In addition to mobile phone and IoT sensors, the data sources layer can also include data from existing databases and files. These can be data from municipal databases, open data sources, social media, or other relevant sources. Such data can provide additional context and metadata for the crowdsensing data, such as location information, historical data, or other relevant information that can enrich the overall understanding of the urban environment.

Overall, the data sources layer of the proposed crowdsensing architecture encompasses a wide range of sensors and data sources, including mobile phone sensors, IoT sensors (both static and mobile), and existing databases and files, all of which contribute to the collection of diverse and rich crowdsensing data for analysis and insights in smart city applications.

The second layer, data streaming, plays a crucial role in transmitting the crowdsensing data to a private cloud for further processing and analysis. This layer utilizes the MQTT (Message Queuing Telemetry Transport) protocol, a lightweight messaging protocol designed specifically for efficient and reliable communication between devices in IoT applications [13]. MQTT ensures that the data is transmitted in real-time, allowing for timely updates and insights. Likewise, it provides secure and efficient communication, making it suitable for handling the large volumes of crowdsensing data generated from IoT sensors.

Real-time data processing in Apache Kafka is performed using Kafka Streams, a powerful and lightweight stream processing library that is part of the Kafka ecosystem. This allows for processing and decoupling of sensitive user/mobile data and sensor values, ensuring that they are separated and processed independently to maintain data privacy and security.

To achieve this, data from different sources, such as user/mobile data and sensor values, are ingested into separate Kafka topics using Kafka producers. Kafka topics act as channels that hold the data streams in a distributed and scalable manner, allowing for parallel processing. Kafka Streams then consumes these topics and performs real-time data processing operations, such as filtering, aggregation, transformation, and enrichment, using a stream processing topology defined by the application logic.

Data processing layer, after data is processed in Apache Kafka using Kafka Streams, it will be sent to Apache Spark for further analysis in real-time or batch mode, depending on data structure. Apache Spark is a popular distributed data processing framework that provides advanced analytics capabilities for large-scale data processing [14]. The processed data from Apache Kafka will be transformed and organized into a unified and structured format using data structuring techniques.

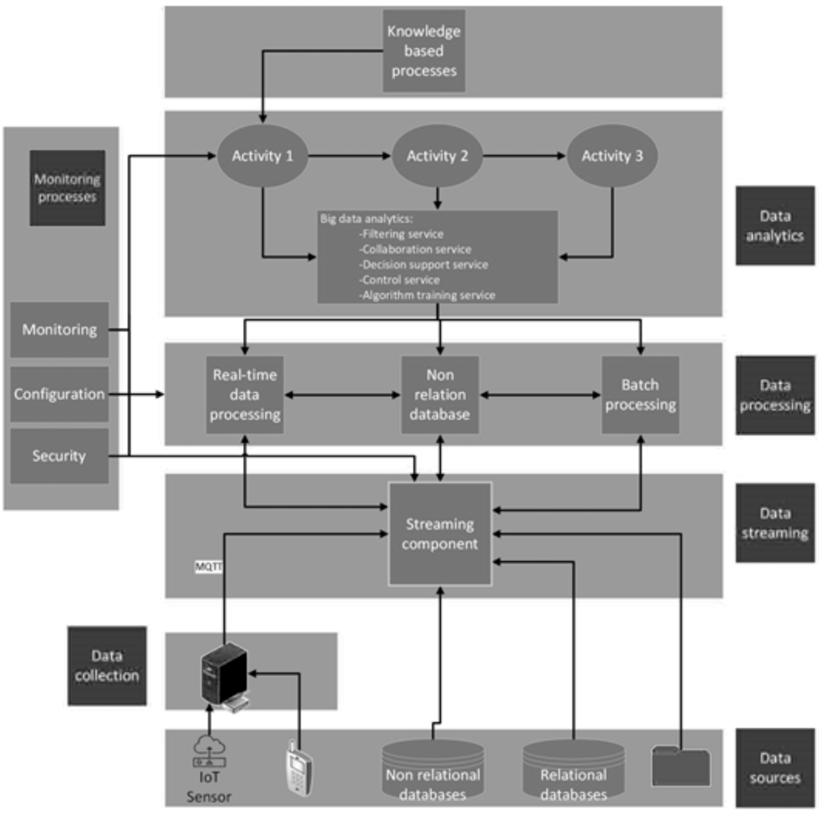

Fig. 1 - Event-driven architecture for crowdsensing systems in smart cities

In the proposed architecture, Apache Spark can consume the processed data from Kafka topics and perform various data analytics operations, such as data aggregation, machine learning, and graph processing, to gain insights and extract valuable information from the data. This enables efficient data analysis in Apache Spark and ensures that the data is stored in a suitable database for further retrieval and analysis.

The fourth layer of the proposed architecture involves interactive services that allow users to further interact with the processed data and take appropriate actions. These services include:

1. The Filtering service enables users to apply filters and settings to the data for tailored analysis and decision-making. Filters can be set by location or time.
2. The Collaboration service promotes real-time collaboration among users, facilitating information sharing and feedback exchange.
3. The Decision support service provides tools for data visualization, analytics, and predictive modeling to support evidence-based decision-making.
4. The Control service allows remote management and control of devices or systems based on processed data, enhancing system responsiveness.
5. The Algorithm training service supports continuous training and refinement of algorithms for improved system performance.

These interactive services empower users to further interact with the processed data, collaborate, make informed decisions, take actions, and continuously improve the system's performance, leading to a more effective and user-centric solution for monitoring environmental pollution and healthcare in smart cities.

The final layer, monitoring processes, involves monitoring and tracking the performance and effectiveness of the entire architecture. For that will be utlized tools such as Prometheus and Grafana. Also thay will ensure the timely and accurate processing of crowdsensing data. Configuration involves managing the various components of the architecture, such as sensors and databases, to ensure they are working together smoothly and efficiently. Security involves implementing measures to protect the data being collected and processed, as well as ensuring the overall security of the architecture itself.

IV. IMPLEMENTATION REMARKS

In this part will be presented technologies and why are they chosen for implementation of the proposed architecture.

Kafka is an asynchronous messaging system that provides a messaging system with a broker for broadcasting messages and storing them for as long as needed, making it suitable for streaming and fire-and-forget messaging [3]. Unlike traditional messaging systems, Kafka is distributed and provides high availability, storage, and linear scale-out across a cluster. Some people compare Kafka to a database due to its storage capabilities, support for large data volumes, SQL interface for querying data, and transaction support. Kafka's Connect interface allows for data integration with various interfaces and datastores, and its streaming APIs enable data manipulation in-flight [3].

Apache Kafka is capable of accepting data from various sources through Kafka Connect, which allows data to be pulled from IoT sensors through the MQTT protocol, mobile applications, as well as databases and files.

Apache Kafka and Apache Spark are an ideal combination for processing and analysing large-scale data in real-time.[15] Spark, with its fast and general-purpose cluster computing framework, can process data in parallel across a cluster of machines, enabling scalable and high-performance data processing. The integration between Kafka and Spark allows for easy data ingestion and real-time data processing in Spark Streaming applications [15]–[17]. Kafka's ability to store and retain data for a configurable period of time enables Spark Streaming to perform analytics on both historical and real-time data. This makes the combination suitable for a wide range of use cases, from real-time data analytics to processing of large-scale data streams.

Grafana and Prometheus are likewise a powerful combination for monitoring distributed systems. Prometheus provides reliable and scalable monitoring and alerting capabilities, while Grafana offers rich visualization and dashboarding features [18], [19]. Together, they enable users to gain insights into the performance and health of their systems through customizable visualizations and interactive dashboards.

In the proposed architecture, the Kafka cluster will be deployed on a private cloud infrastructure and managed using Kubernetes, a popular container orchestration platform. If a Kafka broker pod fails, Kubernetes will automatically detect the failure and initiate a rescheduling process to restart the failed pod on a healthy node.

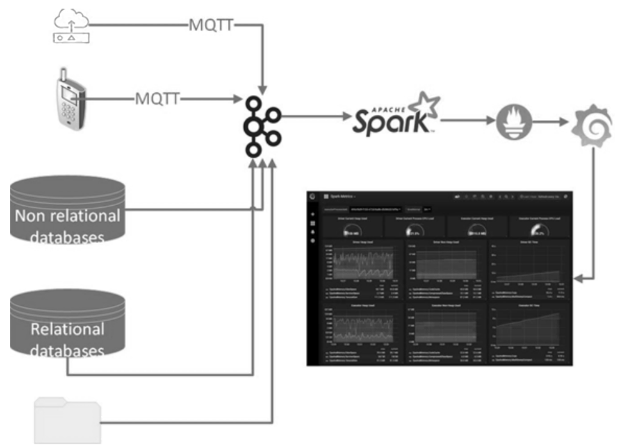

Fig. 2 Event-driven architecture for crowdsensing systems in smart cities

V. CONCLUSION

The proposed architecture, implemented in smart cities with a mobile app for monitoring noise, vibration, air pollution, and healthcare, offers several benefits. The most notable benefit lies in its enables real-time data processing, which allows citizens to receive timely and accurate information about pollution levels in their vicinity. This empowers citizens to make informed decisions regarding their health and well-being. The system also offers the ability to decouple sensitive data, ensuring the privacy and security of user information. Additionally, the use of Prometheus and Grafana for monitoring provides real-time insights into the performance and effectiveness of the system, enabling proactive management and troubleshooting. Furthermore, deploying the system on a private cloud with Kubernetes ensures high availability and scalability, making it suitable for large-scale deployments in smart cities. Overall, this system offers a valuable tool for citizens to monitor environmental pollution and healthcare in their localities, leading to improved quality of life and informed decision-making.

Lastly, the integration of Apache Kafka and Apache Spark as data streaming and processing platforms, respectively, can provide powerful capabilities for real-time data analytics in smart cities. Apache Kafka can efficiently collect and stream data from sensors to Apache Spark, where data processing tasks such as filtering, aggregation, and analysis can be performed on the collected data, enabling real-time insights and decision-making in smart cities. The combination of Apache Kafka's high-throughput capabilities for data collection and Apache Spark's robust data processing capabilities can contribute to the effectiveness and performance of crowdsensing systems that deal with diverse data types.

REFERENCES

[1] M. P. Rodríguez-Bolívar, “Transforming city governments for successful smart cities,” Transform. City Gov. Success. Smart Cities, pp. 1–185, Jan. 2015, doi: 10.1007/978-3-319-03167-5/COVER.

[2] O. Alvear, C. T. Calafate, J. C. Cano, and P. Manzoni, “Crowdsensing in Smart Cities: Overview, Platforms, and Environment Sensing Issues,” Sensors 2018, Vol. 18, Page 460, vol. 18, no. 2, p. 460, Feb. 2018, doi: 10.3390/S18020460.

[3] B. Stopford and S. Newman, “Concepts and Patterns for Streaming Services with Apache Kafka Designing Event-Driven Systems,” 2018, Accessed: Apr. 23, 2023. [Online]. Available: http://oreilly.com/safari

[4] A. Zelenin and A. Kropp, “Apache Kafka,” in Apache Kafka, 2021, pp. I–XVII. doi: 10.3139/9783446470460.fm.

[5] A. Miletić, P. Lukovac, B. Radenković, and B. Jovanić, “Designing a data streaming infrastructure for a smart city crowdsensing platform,” E-bus. Technol. Conf. Proc., vol. 2, no. 1, pp. 61–64, Jun. 2022, Accessed: Nov. 19, 2022. [Online]. Available: https://ebt.rs/journals/index.php/conf-proc/article/view/128

[6] A. Miletić, M. Despotović-Zrakić, Z. Bogdanović, M. Radenković, and T. Naumović, “WorldCIST’23 - OpenConf Abstract Submission, Peer Review, and Event Management System.” http://itmasoc.org/wcist23/modules/request.php?module=oc_program&action=summary.php&id=240 (accessed May 10, 2023).

[7] M. G. Alvarez, J. Morales, and M. J. Kraak, “Integration and Exploitation of Sensor Data in Smart Cities through Event-Driven Applications,” Sensors 2019, Vol. 19, Page 1372, vol. 19, no. 6, p. 1372, Mar. 2019, doi: 10.3390/S19061372.

[8] E. Roth, “The Internet of Medical Things: What is it and What is its Role in Healthcare.” https://www.productiveedge.com/blog/the-internet-of-medical-things-what-is-it-and-what-is-its-role-in-healthcare (accessed May 03, 2023).

[9] T. Le Dinh, T.-C. Phan, and T. H. Bui, “Towards an Architecture for Big Data-Driven Knowledge Management Systems”, Accessed: Apr. 12, 2023. [Online]. Available: https://www.researchgate.net/publication/314047241

[10] I. Jezdović, S. Popović, M. Radenković, A. Labus, and Z. Bogdanović, “A crowdsensing platform for real-time monitoring and analysis of noise pollution in smart cities,” Sustain. Comput. Informatics Syst., vol. 31, Sep. 2021, doi: 10.1016/J.SUSCOM.2021.100588.

[11] A. Bansal, R. Jain, and K. Modi, “Big Data Streaming with Spark,” Stud. Big Data, vol. 43, pp. 23–50, 2019, doi: 10.1007/978-981-13-0550-4_2/COVER.

[12] F. Ten Sythoff, “The Advantages of Event-Driven Architecture (EDA),” May 11, 2022. https://www.greenbird.com/news/event-driven-architecture-eda (accessed Apr. 23, 2023).

[13] D. Soni and A. Makwana, “A survey on MQTT: a protocol of internet of things (IOT) Prediction of Telemetry data using Machine Learning Techniques View project Analysis and Survey on String Matching Algorithms for Ontology Matching View project a survey on MQTT: a protocol of inter,” 2017, Accessed: Apr. 23, 2023. [Online]. Available: https://www.researchgate.net/publication/316018571

[14] I. Pointer, “What is Apache Spark? The big data platform that crushed Hadoop | InfoWorld.” https://www.infoworld.com/article/3236869/what-is-apache-spark-the-big-data-platform-that-crushed-hadoop.html (accessed Sep. 17, 2022).

[15] G. M. D’Silva, A. Khan, Gaurav, and S. Bari, “Real-time processing of IoT events with historic data using Apache Kafka and Apache Spark with dashing framework,” RTEICT 2017 - 2nd IEEE Int. Conf. Recent Trends Electron. Inf. Commun. Technol. Proc., vol. 2018-January, pp. 1804–1809, Jul. 2017, doi: 10.1109/RTEICT.2017.8256910.

[16] L. Hall, “How to process streams of data with Apache Kafka and Spark.” https://cloudblogs.microsoft.com/opensource/2018/07/09/how-to-data-processing-apache-kafka-spark/ (accessed Apr. 24, 2023).

[17] “Apache Kafka - Integration With Spark.” https://www.tutorialspoint.com/apache_kafka/apache_kafka_integration_spark.htm (accessed Apr. 24, 2023).

[18] M. Chakraborty and A. P. Kundan, “Grafana,” Monit. Cloud-Native Appl., pp. 187–240, 2021, doi: 10.1007/978-1-4842-6888-9_6.

[19] “Get started with Grafana and Prometheus | Grafana documentation.” https://grafana.com/docs/grafana/latest/getting-started/get-started-grafana-prometheus/ (accessed Apr. 24, 2023).

Benefits and Risks of Artificial Intelligence in Cybersecurity and Phishing Attacks

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Abstract—With the development and expansion of artificial intelligence, there is a growing need for protection and security in the market. We can observe both positive and negative applications of artificial intelligence in phishing attacks, which are becoming increasingly complex and difficult to detect. Currently, artificial intelligence assists us in effectively and safely filtering incoming emails. The primary objective of this article is to raise public awareness about potential new, more sophisticated threats, as well as easier methods for detecting potential threats in cyberspace. Attackers utilizing artificial intelligence can more easily exploit audio and visual information to deceive users and gain access to desired information or data.

Keywords - artificial intelligence, phishing attacks, cyberspace, social engineering

I. INTRODUCTION

With the development of IT and the emergence of the first computer networks, criminals have moved from the streets to cyberspace. This trend has continued with the appearance of advanced software solutions, communication devices, smartphones, and laptops. Artificial intelligence is currently experiencing its full expansion and is spreading into all spheres of society. It is known that no development in the world is exclusively positive, and there is a justified fear that cybercriminals will start using artificial intelligence to achieve their goals.

Artificial intelligence did not just emerge recently, it has been developing for several years and has been mostly associated with specific business forms such as e-commerce, e-government, e-banking, and others. Currently, there is an opinion that artificial intelligence will take over all business processes in society. This claim is theoretically possible, but it also requires a significant amount of resources for the idea to have a chance to succeed in the real world.

Artificial intelligence engenders an immense amount of content every day that is increasingly difficult to differentiate from human-generated content. In this article, we focus on the „Phishing" method of cyber attack, which is becoming more sophisticated the complex to detect, while on the other hand, artificial intelligence enables attackers to create and execute attacks on an organization or individual in a very short time.

II. THE CONCEPT OF ARTIFICIAL INTELLIGENCE (AI)

The paradigm of artificial intelligence was developed in the recent past when shows, movies, and series depicting the struggle between modern humans and advanced intelligence in the form of robots were aired. Today, artificial intelligence has experienced complete expansion, but what is less known is that it has been present in our lives for some time now. Artificial intelligence has been applied in areas such as e-banking, e-commerce, e-government, and others. The main task of artificial intelligence in this regard was to assist users in searches, mark user behavior, suggest information, and more. With the emergence of Chat GPT and the expansion of artificial intelligence, questions related to security, integrity, rights, ownership, management, and more have arisen. In this paper, our main goal is to examine how artificial intelligence affects phishing attacks in cyberspace. Why were phishing attacks chosen? The answer, in this case, is very clear – artificial intelligence can simulate the behavior of one user or person who wants to obtain important information from another, in this case, a real person. What is known from previous attacks is that human usually makes a mistake in hacking attacks, not the computer system or application. The deceived person believes in some software solution and allows it access to their computing device, after which the attack develops, information is collected, distributed, processed, sold, exported, and other forms of violence occur in cyberspace.

In this section, we can briefly describe artificial intelligence using the Turing test. The Turing test states that artificial intelligence is so intelligent that a user communicating with it via computer terminals cannot know whether they are communicating with a computer system or a real person. Alan Turing presented this theory in his classic article in 1950 (Turing, 1950). From the Turing test, we can obtain basic information to understand the primary goal of artificial intelligence and where it will move in the future. The answer is self-evident, the basic goal of artificial intelligence is to mimic human behavior, i.e., to make decisions, evaluate, suggest, and communicate with the other party in an open forum.

This section is of great interest to cybersecurity experts because it is extremely easy to manipulate users in this way and obtain information that can be abused. Similarly, if we use artificial intelligence to detect attacks, we can alert users that malicious software or algorithms may be hiding behind certain content, which can cause harm to the organization or user.

III. AI AND CYBER ATTACKS

There are several cyber-attacks through which artificial intelligence can be used for illicit purposes. One such attack is phishing attacks.

A. Phishing Attacks

These attacks appeared with the first commercial appearance of the Internet and were a serious problem because they used social engineering to obtain client data. The main goal of these attacks is for the user to share their personal information with the attacker, believing the attacker's legitimacy[4]. In this regard, the attacker can use the brand of a reputable company, or an individual's brand, or persuade the user to obtain information. There are several types of phishing attacks, the most famous is:

- Email phishing attacks,
- HTTPS phishing attacks,
- Whaling attacks,
- Vishing,
- Smishing,
- Pharming[1].

1) Email Phishing Attacks

These are the most popular phishing attacks that organizations or individuals receive daily. Phishing attacks are well-crafted attacks that require obtaining adequate information. Attackers often gather information from the internet and falsely present themselves to increase their chances of success. The email contains information about someone and emphasizes the urgency of solving a problem. These attacks are extremely popular because they mostly use social engineering to successfully execute the attack [9].

2) HTTPS Phishing Attacks

Attacks involve sending a link in an email that the user is supposed to click on, downloading malicious software, or going to another website with compromised content. The attacker uses tools to shorten the link or to set up a link that appears to be secure and contains all the necessary security elements. Users can recognize these links by hovering their mouse over the link, and they should see a display of the link with suspicious content that contains several letters, characters, and symbols.

These attacks are highly popular, and there are several tools available that allow users to protect themselves successfully from these attacks[9].

3) Spear Phishing Attacks

Spear attacks represent more sophisticated attacks that require additional effort from the attacker. These attacks are executed deliberately and planned. The attacker collects information through social networks, the Internet, presentations, and seminars. After collecting the data, the attacker selects the target and, based on the collected information, falsely presents themselves and requests a service from the victim. It is not uncommon for the attacker to use things such as phone numbers, emails, pictures, or some other place for storing data.

The danger of these attacks is that they are aimed at individuals and smaller groups of users, so reporting the attack can go unnoticed[9].

4) Whaling Attacks or CEO Fraud

An attack that is also organized using publicly available information about organizations or individuals. The specificity of these attacks is that the attacker poses as the CEO of the organization and asks their subordinates (usually in finance) to transfer a certain amount of money to other accounts. The attacker creates the email to look as similar as possible in design and spelling to the real person and thus gains the victim's trust to perform the requested actions. The email usually also contains specific information such as job position, travel, and location information that is real.

An example of an attack that involves urgency and impersonation, is where the user is not given time to verify the information provided, but is asked to take action immediately[9].

```
Jim, i am currently stuck in a meeting, but we need to do a wire transfer as soon as possible for a payment Laura want us to get done today.

Can you get that done this morning? Let me know and I wil get you the infor you neeed. Thanks. David.
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5) Vishing Attacks

Vishing attacks use voice effects to enhance the importance and urgency of the operation. The attacker prepares and, in this case, calls a responsible person requesting information or malicious actions based on publicly available information, such as a phone number. These attacks need to be identified now with special attention and control. Currently, there are artificial intelligence tools that can replicate the sound and create new content based on given audio information. In this way, there is a justifiable fear that attacks will become more concrete and targeted.

Attackers can use the voice of the organization's director, for example, who stated on a forum, TV, or radio station, as the source[9].

6) Smishing Attacks

Smishing attacks, as well as Vishing attacks, use publicly available information about individuals, groups, and organizations, and then attack their victims using SMS[9]. Here, prize games, discounts, purchases, and other ways of presenting themselves to the victim are popular. In exchange for a benefit, the victim provides their personal information or performs the requested action.

Several Smishing attacks currently exist in cyberspace, these are the most popular:

- Notification of delivered mail or package – the attacker falsely poses as a postal and package delivery service and requests users to confirm their order by entering confidential information into a form,
- Banking service – the attacker creates an SMS message where they pose as a bank and informs the user that there have been changes to their account and requests data entry from the user to complete or stop an action on their bank account[6],
- Winning a prize in a sweepstake – the attacker sends a message to the victim via SMS and requests that they confirm their identity as the winner of a sweepstake,
- Password management – the victim receives information that there has been a malicious takeover of their account (email, social media, website) and is asked to enter a two-factor authentication code. After gathering information about the victim, the attacker executes the „forgot password“ action and then asks the victim to send them their authentication code for account recovery in this way[6].

7) Pharming

An extremely sophisticated attack that unlines previous attacks, in addition to social engineering, must also contain technical knowledge. In these attacks, the attacker takes over DNS servers and, by controlling the server, redirects requests to malicious websites. Here, deviations between pages are possible, but sometimes the attacker hides grammatical errors, photos, font types, and other elements that may indicate that the website is malicious. After the user enters access data or assigns management rights, the attacker has completed his task.

IV. Analysis of the Cyber Space

This section represents an analysis of the current state of cyberspace. The analysis contains information on the advantages and disadvantages of artificial intelligence in the current battle between attackers and cyber experts[2].

INTERPOL's report published for 2022 states that, on all continents, in addition to other criminal activities, cybercrime using phishing attacks is the biggest problem[2]. The attacker's goal is to collect information about the victim and later indirectly or directly gain access to financial resources. Phishing attacks have become very popular during the COVID-19 pandemic when the real world has moved into the digital realm. Attackers saw this transfer as an opportunity for additional earnings and further sophisticated and disguised their attacks. INTERPOL has recorded increased attacks on organizations, resulting in financial losses, data misuse, data leakage, and other negative activities.

A. Risks of AI in Cybersecurity and Phishing Attacks

According to The Guardian, the identification of phishing emails is currently more difficult because attackers can use popular chatbots to prepare emails and avoid detection by filters on SMTP (Simple mail transfer protocol) servers. Until now, it was possible to identify malicious phishing emails if they contained spelling or grammatical errors.

Using chatbots, attackers can create an email containing all the necessary information without any grammatical errors and in the specified language.

Cybersecurity experts used to be able to analyze email based on these parameters to determine if it was spam, but identification is currently difficult due to the content of the email[8].

Attackers can use artificial intelligence to create more comprehensive content and convince the victim that they know a lot about the topic they are writing about. Essentially, the content is mostly created by artificial intelligence for the attacker's tasks. Previously, attackers had to invest a lot of time to successfully create a phishing email, but now, using chatbots, it takes much less time and resources to create a successful phishing email. In the future, we can expect an increase in email phishing that will bypass controls on mail servers. Cybersecurity experts should conduct a more detailed analysis of which organizations they are working with and limit communication with unreliable partners or clients for organizations.

A new challenge that experts will face is voice cloning using artificial intelligence. This phenomenon could escalate because it allows attackers to prepare and execute an attack in an extremely short period. The attacker will use the voice of a person close to you and, using the Vishing method, will demand that you make a payment, purchase, or provide data. The additional concern is that artificial intelligence can mimic the thinking of the person it clones, their habits, vocabulary, and approach to information. Of course, these attacks would be much more difficult to carry out and would require a certain database of information about the victim or a person close to them. These attackers can become very dangerous if you have victims who are constantly exposed in public or have a large number of their video and audio content available online. In this example, the attacker is only as strong as the information they have about victims.

The problems that are coming will be increasingly difficult to solve in traditional ways, so additional surveillance of systems, information, and material that can be compromised is needed.

B. Advantages Of Artificial Intelligence In Cybersecurity And Phishing Attacks

Artificial intelligence's advantage in digital system protection lies in the fact that it will be able to connect events and thus detect malicious software or spam emails. The first task where artificial intelligence will significantly advance is the detection of unwanted messages.

The detection of unwanted messages currently works in such a way that the administrator or responsible person implements a filter that, if they contain defined keywords or come from marked unwanted addresses, transfer that mail to spam. By using artificial intelligence in this step, it is possible to connect similar words or expressions that are not listed but are naturally related to the previously mentioned keywords and inform the user that it is possible to spam.

Detection of phishing attacks is a more dangerous and complex way of attack where the attacker tries to persuade the user to deliver their data to the attacker. Artificial intelligence has existed in this part for some time and is supported by popular email service providers. What we can expect from the development of artificial intelligence is a deeper analysis provided, brand or person linking with a real brand or person, code checking (HTML, Javascript, delivered files), and other email features.

Detection of other attacks will be carried out in more detail based on the current knowledge possessed by artificial intelligence. Email should make rapid progress in machine learning and recognizing unwanted mail because a large amount of data passes through mail servers every day and artificial intelligence could quickly detect and mark them as malicious through learning[4].

V. CONCLUSION

In this field, we can expect an expansion in the coming years. Artificial intelligence's development and application are increasingly permeating all spheres of modern human life. If modern humans do not adapt to the new circumstances that are becoming more certain, we can expect significant problems, such as changes in the economy, marketing, growing social inequality, and other negative aspects of technological development.

In the future, AI will create increasingly persuasive messages and more complex algorithms in conversations with humans.

The advantage of artificial intelligence in this domain compared to humans lies in its ability to process a large amount of high-quality data quickly, and most importantly, it easily adapts to changes and new information. Through the use of extensive knowledge, AI is moving towards developing effective manipulation algorithms to obtain desired information from users. Personalized attacks will become more frequent in the future, as attackers will use artificial intelligence to gather all publicly available information about a specific person and, through misuse, attempt to achieve financial or material gain.

Automatization of attacks is another negative aspect of artificial intelligence development. Attackers can use artificial intelligence to make attacks more convincing and automated, allowing them to collect data and reiterate their attacks for each user.

This part is particularly dangerous. The user may be unaware that they are currently under attack, unknowingly providing prompts to artificial intelligence about their private or social life. We can observe this in popular "Love" applications, where attackers exploit the victim's passions to obtain information or financial gain.

In the upcoming period, individuals and organizations must invest significant effort and knowledge to protect users on their applications, social networks, or business environments. Investing in security technologies should be a goal for all organizations to safeguard their operations and enable further development through the use of new technologies.

Security should focus on social engineering, specifically developing mechanisms for recognizing malicious emails.

Attackers often employ this method to obtain information or request financial services from individuals and organizations.

Checking web addresses should become our new reality if it hasn't been so far. Attackers clone addresses of popular brands by setting up prize games and actions to attract the attention of victims. After the initial interaction, they ask victims to enter their personal information and provide more details about themselves. If a user submits their data to the attacker, it doesn't necessarily mean that the attack will immediately follow upon receiving the information. Attacks are often prolonged for some time and then carried out massively toward multiple victims. In this way, attackers avoid constant pressure from protection agencies and do not expose themselves to risks.

After gathering and planning the attack, the attacker executes it within a defined timeframe, after which they destroy all the equipment they used to hide the evidence.

Research in this field will be highly interesting in the future. If we critically analyze the current situation, we can observe emerging trends in phishing attacks that we are currently experiencing.

The development of artificial intelligence has both positive and negative aspects, as is the case with any advancement in human history. However, it is crucial to conduct a comprehensive review of existing security systems and prepare users for potential new trends. While we cannot predict the exact direction of these trends, we can provide general information and guidelines to ensure the safety of everyone involved.

The security tools currently available in the market are adapting to new challenges, and it is necessary to constantly update the data to minimize the risk as much as possible.

Ahead of cybersecurity researchers lies an exciting period filled with challenges. The development of new methodologies is necessary to enhance existing knowledge and safeguard against future threats.

Security will become the most valuable resource in the future, as ensuring it for all users on a global scale will be challenging. Every individual should focus on personal growth and the establishment of ethical and responsible standards to effectively and positively utilize the advantages brought by artificial intelligence.

REFERENCES

[1] Duplico.io. Phishing napadi: koje sve vrste postoje i kako ih prepoznati?.https://duplico.io/phishing-napadi-koje-sve-vrste-postoje-i-kako-ih-prepoznati/. 2021.

[2] INTERPOL. 2022 INTERPOL global crime trend summary report. https://www.interpol.int/content/download/18212/304202/file/2022_Interpol_Global_Crime_Trends_Summary_Report.pdf. 2022

[3] J. T.Minkus and N. Memon. Leveraging Personalization to Facilitate Privacy.https://papers.ssrn.com/sol3/papers.cfm?abstract_id=244802. 2014.

[4] The Guardian. AI chatbots making it harder to spot phishing emails, say experts. https://www.theguardian.com/technology/2023/mar/29/ai-chatbots-making-it-harder-to-spot-phishing-emails-say-experts. 2023.

[5] Help net Security. Sophistication of phishing emails. https://www.helpnetsecurity.com/2023/03/08/sophistication-of-phishing-emails/. 2023.

[6] Terranova, M. Smishing Examples: What They Are and How to Stay Safe. TerraNova Security. https://terranovasecurity.com/smishing-examples/. 2022.

[7] F. Enos, S. Benus, R. L. Cautin, M. Graciarena, J. Hirschberg, and E. Shriberg. Personality Factors in Human Deception Detection: Comparing Human to Machine Performance. INTERSPEECH – ISLP, 2006.

[8] EUROPOL. Digital skimming. https://www.europol.europa.eu/crime-areas-and-statistics/crime-areas/cybercrime. 2019.

[9] IT Governance. The 5 most common types of phishing attack. https://www.itgovernance.eu/blog/en/the-5-most-common-types-of-phishing-attack#:~:text=Smishing%20and%20vishing&text=One%20of%20the%20most%20common,link%20to%20prevent%20further%20damage. 2019.

The Application of ChatGPT for Identification of Microservices

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Abstract—Identification and definition of microservices is one of the most important aspects of systems based on the microservices architecture. There are many approaches for proper identification of microservices and their boundaries. However, these approaches are usually carried out by software architects, meaning that the overall success of the system design depends on their skills, abilities and understanding of the entire system. This comprehensive task can be quite demanding, which leaves room for oversights and errors. Luckily, new technologies emerge daily, as well as new uses for those technologies, which make such difficult tasks a little bit easier. In this paper, utilization of the popular ChatGPT large language model for analyzing software requirements and identifying microservices is explored. Three different examples are presented along with recommended solutions, showing that usage of GPT for analyzing software requirement can be useful, but used with caution because of its drawbacks.

Keywords - chatgpt, microservices architecture, artificial intelligence, large language model

I. INTRODUCTION

Microservices architecture is a distributed software system architecture which is consisted of highly cohesive and loosely coupled services. [1][2] Microservices architecture can be very complex for designing and implementing. One of the first challenges faced when designing systems with this architecture is defining boundaries of microservices. Poorly designed microservices can have a negative impact on system performance [3], which may lead to high interdependence, system not being fault tolerant, overlapping of responsibilities and other. Determining boundaries of microservices demands knowledge and understanding of the system, which can be difficult having in mind that these systems are usually very complex. Studies from the practice shows that this process is prone to error, and usually needs several iterations in order to get it right. This work is usually done by software architects and domain experts, meanings the quality of the solution depends of their skill and understanding of the customer's needs. One of the technologies that appeared recently and left deep impact is ChatGPT. New ways to utilize this technology are discovered daily. Capabilities of ChatGPT are explored in different areas of software engineering such as debugging[4], generating[5] and testing code, improving code quality[6], refactoring, software design[6], etc. In order to maximize effectiveness, different prompt engineering techniques and prompt catalogues are suggested [6]. Reference [7] examines ChatGPT's capabilities in the software development cycle, where in requirement analysis, it was able to successfully separate functional and non-functional requirements and generate detailed use case specification. In domain modeling, it was able to identify domain concepts, its attributes and relationship. In design modeling, it provided a well-detailed design class and sequence diagram.

The goal of this paper is to explore could large language models, such as ChatGPT, be used to analyze requirements and provide usable designs for microservices architecture. Here it will be explored whether GPT can be used for identification of microservices and for making suitable recommendations depending on system needs and given instructions.

ChatGPT is a large language model (LLM) developed by OpenAI. [8]. Currently ChatGPT is based on GPT-3.5 architecture (Generative Pre-trained Transformer) which is a natural language processing model that is trained on an enormous amount of text data. It is available free use since the 22nd November of 2022. ChatGPT has reached 100 million users in about two months. [9]

Large language models are probabilistic models which are designed to learn statistical pattern in natural language. These models are pre-trained on a large amount of available text data. Their architecture is based on artifical neural networks, specifically on Transformer model which was invented in 2017. Transformer models have proved to be good in natural language contextual understanding.[10] Transformer-based models employ an encoder-decoder archtecture. While encoder endcodes text in a numerical representation, the decoder takes in such representation and decodes it back into text. The Generative Pre-trained Transformer (GPT) is a decoder, which generates a new text.

In order to determine capabilities of GPTs to understand and identify microservices based on description of needed functionalities, description of three different systems will be provided to the chatbot. Afterwards, each solution will be analyzed.

II. EXAMPLES

In this section, several examples will be presented. For each example several additional instructions will be given to the Chat GPT, and results will be presented and analyzed.

Two chats are made for each example – in one the whole description of the system was given at once and GPT was instructed to identify potential microservices, and in the other the description of the system was given partially, in pieces. The goal of making these two chats was to determine whether the way of conducting the conversation will affect the result. Also, for the same purpose, additional descriptions involved not only providing additional functionality but also changing some of the existing ones. In order to assess GPTs overall understanding of the system several questions were asked: to identify the interdependency between microservices, to identify the most critical service and service which will have to be scaled.

A. Example 1: Online car parts store

In the first chat, ChatGPT was given the whole description about the system for online car parts store:

The software system is used for online car parts store. The customers can select the model of their car, and after that all available parts for the chosen car are displayed in categories. The available quantity of parts is updated automatically after successful order or it can be updated manually by authorized administrator user. In order to create an order or purchase car parts, customers must create a new user using an email, or they can log in using an existing user. When creating a user, customer must provide personal information, including first and last name, telephone number, and residence address. After the user has been created, a verification email containing a verification link is sent to the customer. The customer user is verified after the customer clicks on the verification link in the sent email. In order to purchase parts, customer must have a verified user in the system, and must create a purchase order. An order contains chosen car parts and quantity of chosen parts. Personal customer information is loaded from customer's user, and customer is given an option to ship the order to the residence address, or to specify another shipping address. After choosing an address, total price of the order is displayed and customer is given an option to use a discount by providing a discount code. If the customer provides it, the discount code is verified to check if it has expired or if it has already been used. If the code is valid, the price of the order is reduced by the amount specified by the discount code. Lastly, the customer chooses the payment method. They can choose to pay in cash on delivery, or to pay online using a credit or debit bank card. If they choose to pay using a bank card, the customer is redirected to the online payment page, where they are required to specify card information, after which the system communicates with the bank to realize the payment. The system has two types of users: customer users and administrator (employee) users. Both log in the system using the same login form. Administrator users can modify the quantity of existing car parts or they can add new car parts and new categories of parts, and also modify orders which have not yet been realized. While shopping for parts, customers can use shopping cart, where all chosen parts are placed. After choosing all desired parts, customer can review their shopping cart and modify it is necessary, after which they are forwarded to the page for creating of the order. Every customer can get a recommendation discount, when they recommend the application to the new user. In this case, it is necessary to track the list of the recommended users for given customer, since after certain number, the customer who gave recommendations will get an increase in the discount amount.

From this description, following services were identified by GPT[1]:

1. User Service: This microservice handles the creation, authentication, and verification of user accounts. It is responsible for storing and managing user data, sending verification emails, and tracking recommended users.
2. Inventory Service: This microservice is responsible for managing the inventory of car parts available in the online store. It handles the addition, modification, and deletion of car parts and categories of parts, as well as updating the quantity of parts available after successful orders.
3. Order Service: This microservice handles the creation, modification, and processing of purchase orders. It retrieves personal information from the user service, calculates the total price of the order, and verifies discount codes. It also handles payment processing through communication with the bank.
4. Cart Service: This microservice manages the shopping cart functionality of the online store. It allows customers to add and modify their chosen parts before creating an order.
5. Recommendation Service: This microservice tracks recommended users for each customer and calculates the discount amount based on the number of recommended users.
6. Authentication Service: This microservice handles authentication and authorization of both customer and administrator users. It is responsible for ensuring that only authorized users can access and modify data in the system.
7. Shipping Service: This microservice handles the selection and verification of shipping addresses for orders.
8. Notification Service: This microservice handles sending notifications to customers about order status updates, shipping information, and other relevant information.
9. Discount Service: This microservice manages the creation and verification of discount codes for customers.

In further conversation it was determined that the User Service is the most likely to be changed, while the most crucial part is the Order Service, and the Inventory Service

[1] Names and description of the services are generated by ChatGPT.

is the most likely to be scaled. ChatGPT was instructed to determine interdependencies between these microservices, in order to establish overall understanding of the system. At Fig. 1, identified microservices and their relationship is shown.

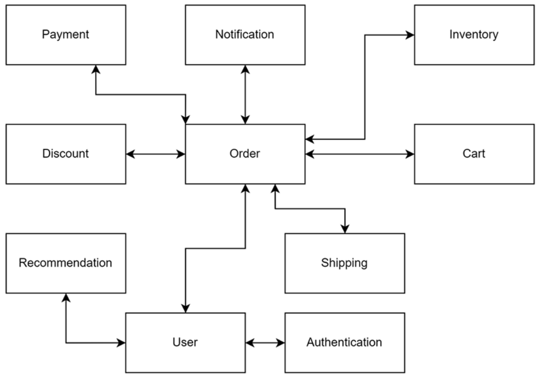

Fig. 1. Online car parts store I

As it can be seen, the Order microservice is placed in the center of the architecture, with many other services depending on it, and also having many dependencies. This might be seen as problematic and as a flaw in the design, and is determined by the nature of the system. However, it is what was provided in the description of the system, and ChatGPT provided faithful model to the description. Whether it is suitable description of the system, and whether changes need to be made to it, is up to the software architect to analyze. By asking further questions, and providing more information about the system, these potential flaws can be eliminated.

In the second chat GPT was asked to identify and define microservices based on the part of the full description. For the given description, GPT has identified six microservices: User Service, Catalog Service, Order Service, Payment Service, Admin Service and Notification Service, which was not immediately identified, but later in the conversation. Afterwards, ChatGPT was given an additional description of the system and was asked whether more microservices will be necessary. Two more services were identified for implementing these changes:

1. Recommendation Service,
2. Payment Gateway Service: This microservice would integrate with payment gateway APIs to enable customers to pay online using a credit or debit bank card. It would handle the payment transaction and update the order status once the payment has been completed.

The User Service is identified as critical and highly dependent microservice, as it serves as a central point of authentication and user information. The Order Service is also likely to be highly dependent, as it manages the core functionality of the system, while the Payment Service, Payment Gateway Service, and Recommendation Service are more specialized and have narrower dependencies. The most likely parts of the system to be changed in the future are the discount and recommendation system and the user interface. Discount and recommendation may need to be updated to include new rules or conditions and recommendations based on user behavior or business needs.

Conducting several chats with ChatGPT, it did reference services which were not previously identified, but turned out to be necessary. At Fig. 2, identified microservices and their relationships are shown.

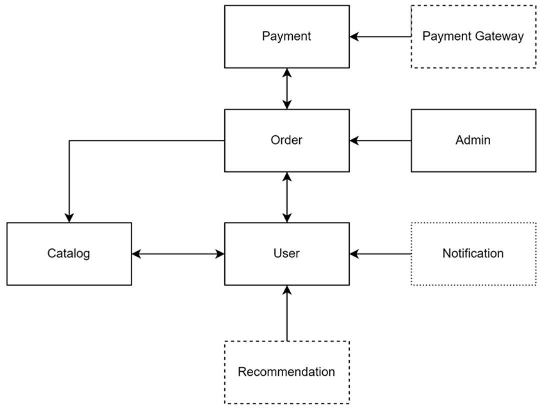

Fig. 2. Online car parts store II

It is obvious from Fig. 2 that Order microservice in this case is less dependent and has less other services depending on it, which might be seen as better solution. Hence, it can be concluded that the way the system was described to ChatGPT and the level of details provided affects the quality of the solution provided.

These two recommended designs are somewhat similar, while there are some differences in identified services. Giving more detailed instructions about the desired design, one can influence the complexity and quality of the solution. Instructions such as “make as many microservices as possible”, or “try not to make more than 5 microservices” can guide ChatGPT in providing a more desirable solution.

B. Example 2: A veterinary clinic

In the first chat, GPT is given the full description:

The software system is used for a veterinary clinic. The system allows scheduling pet examinations and interventions, as well as documenting them. The examinations are scheduled by customers through a form on a website. They should fill all the needed data and choose available date and time. It is expected that there will be short periods with high frequency of requests, and periods with rather low frequency. After the examination or intervention has been conducted, it is documented by the vet who conducted it. Vet can choose a pet if it has already been recorded, or can add it in the system if it does not exist in it. A vet does this by logging in with a dedicated user and inserting data describing the procedure through the dedicated form. Another type of users are admin users who manage the content of the website, providing and managing the available services which the clinic provides. They also manage the promotional part of the system, which consists of a blog with educational and professional articles and a gallery of videos and pictures of the clinic and pets who are treated there. One more part of the system is the chat which customers can use to contact available vet who can then answer their questions. Scheduling the examinations and using the chat doesn't require customers to have a registered user. However, customers should provide an email through which they will get updates on their questions asked in the chat. The vets respond to questions in chat using their dedicated user. Only one vet is on duty at the time for responding to the customer's questions in the chat, and all the questions should be forwarded to them.

Services identified by ChatGPT are[2]:

1. Appointment Service: This microservice handles the scheduling of pet examinations and interventions. It provides functionality for customers to submit appointment requests through the website form, choose available dates and times, and store the relevant appointment data.
2. User Service: The User Service manages user authentication and authorization. It handles user registration, login, and user profile management. It differentiates between customer users, vet users, and admin users.
3. Pet Service: This microservice handles the management of pet data. It allows vets to add new pets to the system if they are not already registered. It also provides functionality for vets to associate pets with examination and intervention records.
4. Documentation Service: This microservice is responsible for documenting examinations and interventions. It allows vets to log in, access the dedicated form, and insert data describing the procedure. It stores and manages the examination and intervention records.
5. Admin Service: The Admin Service provides functionality for admin users to manage the content of the website. This includes managing the available services provided by the clinic, such as adding, editing, or removing services.
6. Promotional Service: This microservice handles the promotional part of the system. It manages the blog with educational and professional articles, as well as the gallery of videos and pictures related to the clinic and the pets treated there.
7. Chat Service: The Chat Service enables customers to contact available vets and ask questions through the chat feature. It allows customers to initiate chats without requiring registered users. The service also ensures that questions are forwarded to the vet on duty, who can respond using their dedicated user.

The scheduling and the pet management services are identified as the core services of the system, while the promotional content management service is pointed out as the service which is likely to undergo frequent changes. At Fig. 3, identified microservices and their relationships are shown.

[2] Names and description of the services are generated by ChatGPT.

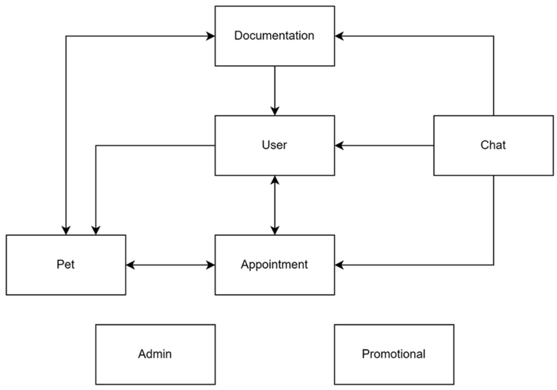

Fig. 3. The online system for the veterinary clinic I

As it can be seen at Fig. 3, the services are little less dependent on each other than in the previous example. However, there are two services (Admin and Promotional) which can be seen as isolated, which might be a sign that the model is not suitable for the system and that further changes are needed.

Given the partial description, followed by additional details these microservices are identified: Appointment scheduling microservice, Pet management microservice, Examination and intervention microservice, User management microservice, Content management microservice.

Additional microservices are: Promotional management microservice and Chat management microservice.

At Fig. 4, identified microservices and their relationships are shown.

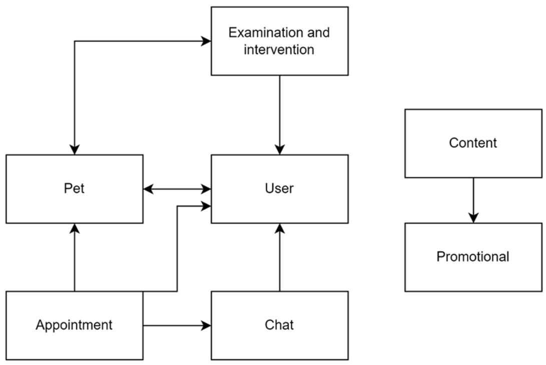

Fig. 4. The online system for the veterinary clinic II

In this iteration, there are no services which are isolated, but there are two services (Content and Promotional) which are connected with each other, but not with the rest of the system. Whether this is true for the described system is for the architect to analyze.

C. Example 3: An online music library and player

In the first chat, GPT is given the full description:

The software system is used for online music library and player. There are two types of users: regular and admin users. Admin users can add new songs, albums and artists to the library and modify existing ones, as well as create public playlists. Regular users should create new account in order to log in if they do not already have existing account. In order to create the new account, users should provide personal information as well as email address. After that, users are required to set up two-factor authentication using their mobile telephone. Once the account has been created, users are able to search the music library and find wanted songs. In the search, they can use various filters, such as genre, artist, decade, album, etc. Users can create their own custom playlists, and can also mark certain songs as their favorites. They can also rate songs, albums and artists, as well as leave written reviews. These reviews are in a form of a blog, where other users can comment on reviews and mark them as useful or not useful. The song player has customization options, such as volume adjustment, equalizer options, options to repeat songs and to randomize playlists, change the songs order, etc. In order to use the services of this system, regular customers should provide a payment method. They can use free two weeks trial period, after which they should select one of the payment subscription plans. These plans include monthly and yearly payment, and if a user stops paying or decides to stop using the application, their access to the application should be restricted. There is also an option for users to get subscription from their mobile services provider through their mobile service contract. In this case, the system should be able to check with the mobile service provider whether the user's contract allows for the such kind of subscription.

Seven microservices were identified, as it follows:

1. Account Management Microservice: This microservice handles the creation and management of user accounts. It includes the functionality to store and retrieve personal information and email addresses of the users. It also handles the two-factor authentication process using mobile phones.
2. Music Library Microservice: This microservice manages the songs, albums, artists, and playlists in the music library. It provides the functionality to add new songs, albums, and artists, modify existing ones, and create public playlists. It also provides the functionality to search for songs using filters such as genre, artist, decade, album, etc.
3. Playlist Management Microservice: This microservice handles the creation and management of custom playlists by users. It provides functionality to add, modify, and delete playlists. It also includes the functionality for users to mark songs as their favorites.
4. Review Microservice: This microservice handles the rating and review functionality of the application. It includes the functionality for users to rate songs, albums, and artists, and to leave written reviews. Other users can comment on reviews and mark them as useful or not useful.
5. Player Microservice: This microservice handles the functionality of the song player. It includes the customization options such as volume adjustment, equalizer options, options to repeat songs and to randomize playlists, change the songs order, etc.
6. Payment Management Microservice: This microservice handles the payment functionality of the application. It includes the functionality to store and retrieve payment information of users. It also handles the free two weeks trial period and the selection of payment subscription plans. It includes the functionality to restrict access to the application if the user stops paying or decides to stop using the application.
7. Mobile Subscription Microservice: This microservice handles the functionality to check with the mobile service provider whether the user's contract allows for the subscription to the application. It includes the functionality to retrieve information about the user's mobile service contract.
8. The User management microservice and the Music library microservice are likely to be the most crucial for the system. The Music library microservice and the Playlist microservice are likely to be the most likely to be scaled, as the system grows and more songs and users are added. The Music library microservice may need to be scaled horizontally to handle the increased load, while the Playlist microservice may need to be scaled vertically to handle the increased number of playlists. The Rating and review microservice and the Player customization microservice are the most likely to be changed as they involve user preferences, which can change over time.

At Fig. 5, identified microservices and their relationships are shown.

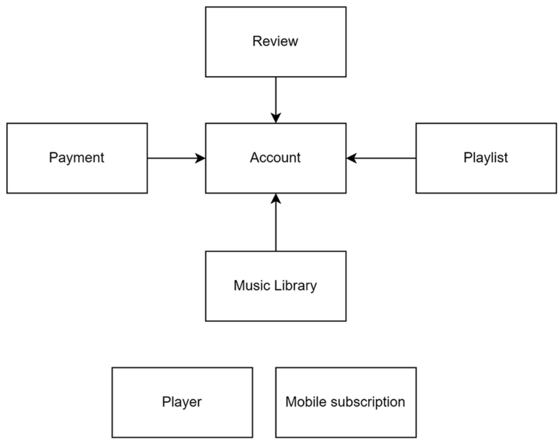

Fig. 5 The online music library and player I

At Fig. 5, a combination of previous examples can be seen. There is Account service which is placed in the center of the system, and there are two services which might be considered isolated. These might be signs that further analysis is needed.

Given the partial description, identified microservices are: User management microservice, Music library microservice, Playlist microservice, Favorites microservice.

Provided additional information, three more microservices were identified: Rating and review microservice, Player customization microservice, Payment management microservice.

At Fig. 6, identified microservices and their relationships are shown.

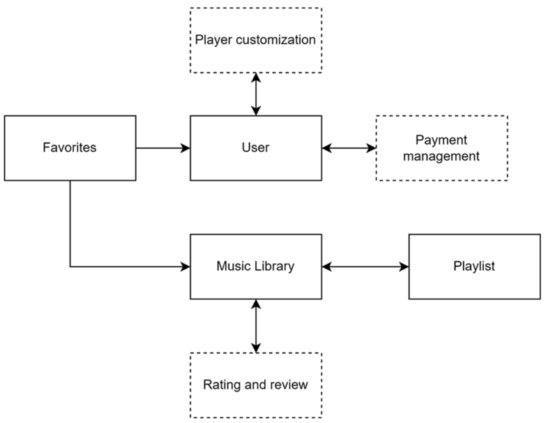

Fig. 6 The online music library and player II

After providing additional information, previous potential problems are resolved, since newly identified services connect the whole system and make it more granulated.

III. DISCUSSION

After analyzing previous examples and proposed solutions, it can be concluded that LLM GPT shows good understanding of microservices architecture and can provide solutions which make logical sense based on the given description of the system. Based on this, it can be used as an additional tool when defining microservices architecture. Being an LLM, GPT is capable of maintaining big amount of information about the system in the given context, while also allowing the changes and extensions of user requirements. Also, given additional instructions, GPT has proven to be able to adjust solution to the new requirements, and to steer solution to the desired one. This, of course, implies that the user of ChatGPT is competent and capable to recognize which solution is better, and to guide ChatGPT to it. Another important dimension is that the user should be careful to provide all of the relevant information. Otherwise, the proposed solution might not be as suitable to the actual system and might cause later problems.

Another positive side of using ChatGPT, is that it is capable of analyzing different characteristics of the solution, while showing the understanding of the most important features of the microservices architecture. Furthermore, it can predict which of the microservices are susceptible to change, which service provides the core functionality of the system and which service will probably have to be scaled. All that is presented above, along with the presented examples show that Chat GPT can be a useful tool for software architects. Having in mind its capability of understanding many details and complex topics, it is a good tool for determining context boundaries. Also, it is possible to influence the solution with providing additional details about the system, system requirements or other. Besides, as shown Chat GPT can recognize coupling between microservices and suggest improvements. Also, the number of microservices can be manipulated, while maintaining the most important principles of microservices architecture.

IV. CONCLUSION

With growing capabilities of GPTs, people are trying to utilize it in terms of automatization of many tasks. In this paper, utilization of this tool in terms of analyzing software requirements and identifying microservices which could be used to implement that system is presented. By providing additional instructions, user can quickly get many different solutions and have them automatically analyzed by GPT itself. The solutions provided by ChatGPT showed to be appropriate solutions for the given problem which made logical sense based on the given description. As seen, providing additional information or instructions can lead GPT to a different solution. Of course, the provided description must be correct and detailed, otherwise ChatGPT can overlook some important parts of the system, or some additional services may come up later in conversation.

One of the important things to note is that the solutions provided are only as good as provided input. From the analysis of the given examples, it is obvious that there are some details in the model which might be seen as problematic and not true to the system. Such things include one big service on which other services depend and the existence of the isolated services. It is up to the software architect to draw conclusions from this analysis and determine if model needs to be changed and in what direction. Hence, the user communicating with the tool should be well familiar with the concepts of microservices architecture and software design generally. The more experienced the person communicating with ChatGPT and the more they are familiar with the domain of the system in question and the system itself at all, the better the ending solution will be. This is the reason why it is highly unlikely that AI tools such as ChatGPT will ever be able to replace actual people when it comes to the design of software systems. Rather, it should be seen as a helping tool, one out of the many, that should help get to the optimal solution and to get to it faster. Using ChatGPT for identifying microservices can, without a doubt, be useful, in order not to overlook some important details, to save time working on initial solution and it can be practical to use for analyzing different parts of the system. The utilization of new technologies is not something that should be shied away from, but rather used to get better solutions.

For further research, it would be interesting to see if ChatGPT is capable of adapting existing solution to changes and determining whether existing solution have poorly designed architecture and how it could be improved.

REFERENCES

[1] S. Newman, Building Microservices - Designing fine-grained systems, O'Reilly Media, Inc., 2015.

[2] J. &. F. M. Lewis, "Microservices a definition of this new architectural term," 25 3 2014. [Online]. Available: https://martinfowler.com/articles/microservices.html.

[3] M. R. a. R. H. Dharmendra Shadija, "Microservices: Granularity vs. Performance," in In Companion Proceedings of the10th International Conference on Utility and Cloud Computing (UCC '17 Companion). Association for Computing Machinery, New York, NY, USA, 215–220. , 2017.

[4] Haque, Md & Li, Shuai. (2023). The Potential Use of ChatGPT for Debugging and Bug Fixing. EAI Endorsed Transactions on AI and Robotics. 2. e4. 10.4108/airo.v2i1.3276.

[5] Liu, Chao & Xuanlin, Bao & Zhang, Hongyu & Zhang, Neng & Hu, Haibo & Zhang, Xiaohong & Yan, Meng. (2023). Improving ChatGPT Prompt for Code Generation.

[6] White, J., Hays, S., Fu, Q., Spencer-Smith, J., & Schmidt, D.C. (2023). ChatGPT Prompt Patterns for Improving Code Quality, Refactoring, Requirements Elicitation, and Software Design. ArXiv, abs/2303.07839.

[7] Kim, Dae-Kyoo. (2023). Using ChatGPT to Develop Software Systems: Alert to Software Engineers?. 10.13140/RG.2.2.26388.78725.

[8] "Open AI," 30 11 2022. [Online]. Available: https://openai.com/blog/chatgpt. [Accessed 10 5 2023].

[9] K. HU, "ChatGPT sets record for fastest-growing user base - analyst note,"2/2/2023. [Online]. Available: https://www.reuters.com/technology/chatgpt-sets-record-fastest-growing-user-base-analyst-note-2023-02-01/.

[10] M. Ramponi, "AssemblyAI: The Full Story of Large Language Models and RLHF," 3 5 2023. [Online]. Available: https://www.assemblyai.com/blog/the-full-story-of-large-language-models-and-rlhf/. [Accessed 10 5 2023].

[11] "Identifying domain-model boundaries for each microservice | Microsoft Learn," 13 4 2022. [Online]. Available: https://docs.microsoft.com/en-us/dotnet/architecture/microservices/architect-microservice-container-applications/identify-microservice-domain-model-boundaries. [Accessed 10 5 2023].

[12] M. Fowler, "Microservices and the First Law of Distributed Objects," 13 8 2014. [Online]. Available: https://martinfowler.com/articles/distributed-objects-microservices.html. [Accessed 10 5 2023].

Fuzzy Logic Based Product Comparison for Different E-Commerce Websites

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Abstract— In recent times, there has been a surge in the number of e-commerce websites available online. This makes it difficult for a user to decide which website to use when purchasing a particular product. In addition, keeping track of the sale and offers going on in these platforms is an arduous task. Sometimes, these websites have contrasting reviews for the same product. Keeping a check on all these factors for multiple websites takes a lot of time as well as energy, and is laborious. Therefore, we have created a website that combines the results from various e-commerce platforms and showcases the result together on a single webpage. This not only helps the user to make better decisions related to their purchase but also saves their valuable time. Moreover, we have added functionalities such as email alerts that make our website a multi-purpose all rounded product.

Keywords - price comparison sites, web scraping, email alerts, rating comparison

I. INTRODUCTION

Online shopping has been trending a lot in today's times, and with this there has been a rise in the number of e-commerce platforms. This provides customers with great discount possibilities since every website would want to attract a large number of customers. However, this also makes it grueling for the customers to zero in on a website to purchase a particular product. The competition present among various platforms also creates confusion among the customers. Another significant issue is the authenticity of these platforms. Therefore, it helps to have results from all the platforms displayed in a single website. This makes it easier and less time-consuming to decide which platform to purchase a particular product from. Our website is primarily based on this utility. The increasing ease of access to online shopping websites may at times, result in the unavailability of products. An email alert system which sends an alert to the customer in the form of an email is one of the services we provide. This reduces the time spent on keeping track of the product on a number of websites simultaneously until it is available. Since the surge in e-commerce websites, there has also been a rise in sales, discounts, offers and discount coupons. This is done to attract more customers, as the prime aim of a customer is to purchase products at the cheapest price. However, keeping track of products on multiple websites and even searching for them is a tedious task. A single website where prices are compared and displayed in a simple format can improve the shopping experience. The proposed website not only provides this but also compares the ratings of a product on websites which could add to the decision making process. Visual data is far easier to interpret than seeing plain numbers. Taking this into account, we have also added a feature to display the price and rating comparison in the form of various charts and graphs. Thus, our price comparison website is not only restricted to comparing prices but also provides a variety of features to help users have a satisfactory online shopping experience while also saving money. This project is restricted to the popular ecommerce platforms, i.e., Amazon and Flipkart.

II. LITERATURE REVIEW

In [1], web scraping techniques are used to compare e-commerce websites. Take the product name as the input and this product name as a URL is passed to the comparator site. For each product displayed, scrap the product label, price, image and link and store it in a list. Compare the prices for various e-commerce websites and display the product with the lowest price. For scraping the data, use the Selenium python library.

A website is developed in [2] for the customers to find best product deals. The best offers will be prominently displayed. Collect detailed information using web crawling and web scraping methods to get the best prices from price comparison websites. Then offer online customers a way to purchase goods at a discount and save their precious time, effort, and money. Use web crawlers to get there, and once the crawler finds the right page and finds a match between the goods, scraping begins. Python tools like requests and beautiful soup are used to perform scraping. The client uses the search bar to find the needed goods, and a query is sent to the local database. Django web was used to create the website. Another feature offered is price alert, which enables users to instruct the website to notify them whenever an appropriate price is found.

[3] talks about various applications of web scraping in e-commerce websites. It can be used for Price-monitoring and Product Research, Online price comparison, Better Customer analysis, Market Analysis, Better advertisements, Influence Marketing and Sales Strategy and Brand monitoring. [3] uses web scraping for market analysis.

[4] The quick growth of e-commerce puts existing recommender systems under pressure to handle a lot of clients and products while maintaining high standards for recommendations. The extraction of product features, opinions, and categorization from online product reviews using IBM SPSS Text Analytics for Surveys is explored in the work with regards to the Ecommerce web interface and online reviews that are accessible online.The work computes the similarities and divide product features into various feature groups using the semantic knowledge similarity measures.

[5] The products from Flipkart and Amazon are suggested on an e-commerce portal based on user requests, and based on user preferences, the user can purchase the product from any site, which is entirely dependent on the user. In this research paper, data such as product name, price, reviews, and ratings related to suggested products from Flipkart and Amazon are scraped using a robotic process automation tool. For both Flipkart and Amazon, the RPA tool, i.e., UiPath, is used to develop a software robot. This bot is used to scrape data from both sites, execute cleaning operations, and dump the data into databases that can be used in the future. Additionally, the bot can be activated everyday to collect data for database updates. This work uses e-commerce for classifying and identifying product buying behavior as well as meeting end-user needs.

The e-commerce sector in certain wealthy countries has experienced phenomenal growth in a short amount of time—less than 10 years. To meet the complex and evolving needs of consumers, the e-commerce sector in developing nations like India is still lagging behind. E-commerce websites are regarded as the public face or representations of the associated businesses. A successful website is one that is well designed. It is created in a way that can accommodate user needs. For many E-Commerce businesses nowadays, having an optimized, current, and structured website is the ultimate goal. In this regard, [6] talks about improved mining techniques that are necessary to maintain optimized website architecture, which helps businesses grow their revenue, monitor the websites of competitors, compare various brands, draw in new clients, and keep hold of existing ones.

III. PROPOSED METHODOLOGY

The website is primarily built using python and python library Streamlit. The home page contains a search box where the user can enter the product name, the input. A text formatting function is employed to transform the input. This includes removing stop words like “the”, ”and”, etc., removing spaces, tags and punctuations and converting the string to lower case. After the text formatting, we obtain a keyword which consists of the most important words joined with a ‘+’ symbol. This keyword is used to scrap the products from amazon and flipkart. The scrapped products are stored in a local database. To differentiate between amazon and flipkart products, we use a variable “isprime”. The value of this variable is ‘Y’ or ‘N’ for amazon and ‘NA’ for flipkart. The website model is displayed in Fig. 1.

The output is divided into 5 modules as follows:

A. Best Match

This module identifies two products that are most similar to each other, from Amazon and Flipkart respectively. Here, most similar implies that the number of identical words in the product name is maximum. We find the best match using a distance matrix and a confidence score. The data stored in the distance matrix is a score. If the score between the amazon product and the flipkart product is greater than 0.5 then these two products will be considered and the website will display an output. This output will be the amazon product and the flipkart product having the highest score. If no two products have a score greater than 0.5, then the website will display “no best match”.

B. All Products

This module displays all the amazon and flipkart products that were scrapped. The first column comprises all the amazon products. The second column contains all the flipkart products. For this we use the mysql.connector.connect cursor to iterate in the database. All the products stored in the database will be presented in the web page. Using the sql commands and Streamlit we select and display the products.

C. Lowest Price

This module is one of the most useful for the user. Majority of the users visit multiple e-commerce sites to search for the cheapest product. This consumes time and energy. This lowest price module helps the user to save this time. It displays the lowest price product from amazon and flipkart. Extract all the amazon products using sql commands from the database and display the cheapest one. Similarly, for flipkart, extract and display the cheapest flipkart product.

D. Highest Rating

This module helps the user to find the best quality product from amazon and flipkart. We compare the product based on their stars and the product with maximum stars is displayed on the web page. This module can be used by the user if their focus is better quality. To implement this, extract products from the database using sql commands and display amazon and flipkart products with the highest rating.

E. Graphs

This module is used for data visualization. Here, we represent the extracted data in terms of graphs. We have a scatter plot and a bubble plot to find the correlation between price and ratings. To visualize the comparison between flipkart and amazon prices and ratings, we have drawn a line graph, bar chart and area chart. This graph will be updated for each search. To plot and display the graphs, we have used Streamlit and Plotly charts.

F. Email alert

This module alerts an user regarding a drop in the price of the product they wish to buy. The input is the product URL and the desired price for the product. If the price is equal to or less than the desired price, the user will be notified through email. Otherwise also, the user will be notified that the product price has not yet dropped.

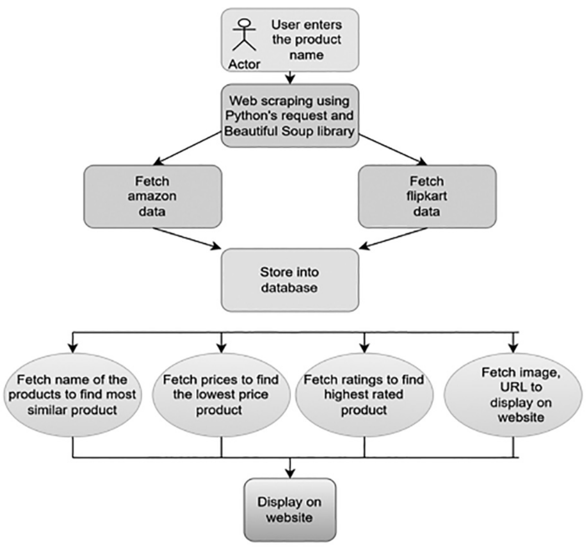

Fig. 1. Website Model

IV. WEB SCRAPING

Web scraping is a method for extracting data from the World Wide Web (WWW) and storing it in a file system or database for later access or analysis. It is also referred to as web extraction or web harvesting. [7]Unstructured data on the web is converted through web scraping into [8] structured data that can be saved and evaluated. Web data is frequently extracted from websites using HTTP (Hypertext Transfer Protocol) or a web browser. A user can do this directly, or a bot or web crawler can do it mechanically. Web scraping is widely regarded as an effective and powerful technique for gathering big data due to the enormous amount of heterogeneous data that is continuously produced on the WWW. Obtaining web resources and then extracting the desired information from them are the two sequential stages that make up the data scraping process. [9]

A web scraping programme specifically begins by creating an HTTP request to obtain resources from a selected website. This request can either be written as a URL with a GET query or as a portion of an HTTP message with a POST query. The requested resource will be retrieved from the website and then sent back to the web scraping programme after the targeted website has properly received and processed the request. The material can be in a variety of formats, including HTML-based web pages, XML or JSON data feeds, or multimedia data like image, audio, or video files. The extraction procedure continues to parse, reformat, and organize the web data in a structured manner after it has been retrieved.

An online scraping programme must have two core modules: one for creating HTTP requests, like Urllib2 or Selenium, and another for parsing and extracting data from raw HTML code, like Beautiful Soup or Pyquery. [10]The execution is done using the Python language. Here, the Selenium web browser wrapper constructs a web browser, such as Google Chrome or Internet Explorer, and enables users to automate the process of browsing a website by programming. The Urllib2 module defines a set of functions to deal with HTTP requests, such as authentication, redirections, cookies, and so on.

For scraping HTML and other XML texts, use Beautiful Soup. It offers simple Pythonic methods for navigating through, searching through, and changing a parse tree as well as a toolkit for breaking down HTML files and extracting desired data using lxml or html5lib. The encoding of the parsing being processed can be instantly detected by Beautiful Soup, and it can then be changed to a client-readable encode.[11]

The Urllib module offers a high-level interface for retrieving info from the internet. The request module of urllib can simply obtain and grab URL (Uniform Resource Locator) content. Urllib offers a number of functions for operating URLs. [12]

V. RESULTS

As part of this project, we have spent a lot of time testing the website. We have tried different types of inputs such as vague names, exact product names, etc. Depending on the confidence score, most of the searches displayed best matches, while there was no output for some of the searches.

However, the ‘Lowest Price’ and ‘Best Rating’ modules showed exceptional outputs for all the searches irrespective of the output of the ‘Best Matches’ module.

Moreover, based on the data obtained from these websites, charts and graphs were also accurately visualized.

Overall, the website gives promising results and is reliable enough for usage.

The output screenshots portraying some of the functionalities is displayed below:

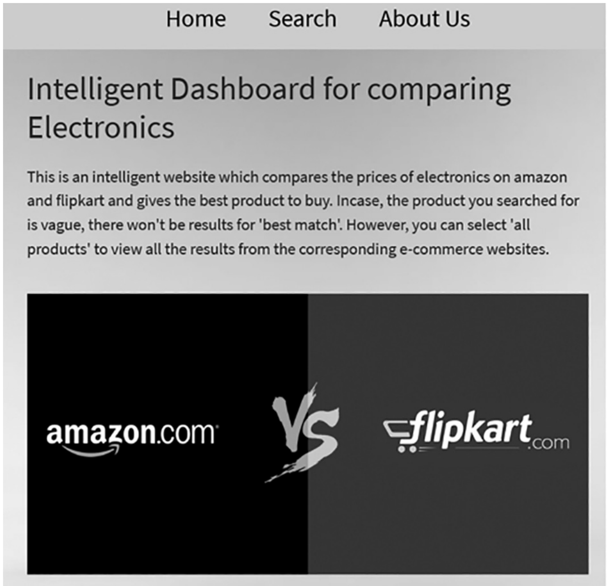

Fig. 2. Home Page

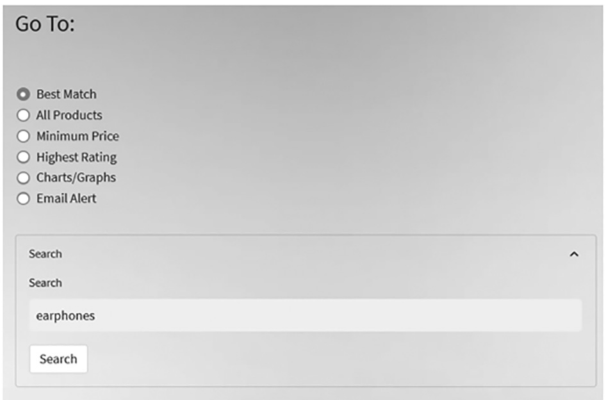

Fig. 3. Options and Search Box

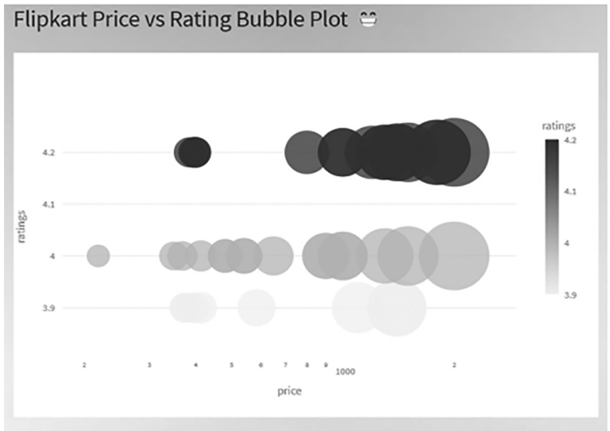

Fig. 4. Bubble Plot for Price vs Product

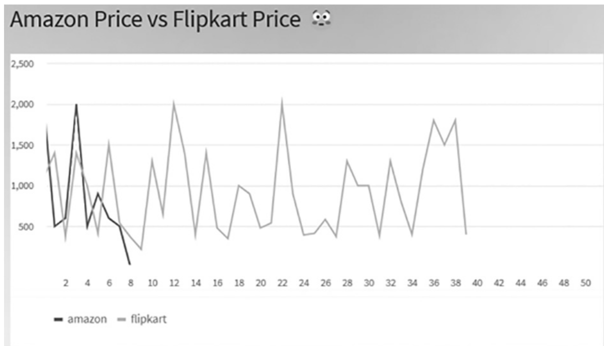

Fig. 5. Line Chart for Amazon Price vs Flipkart Price

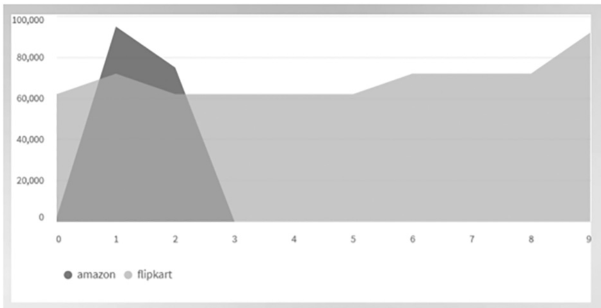

Fig. 6. Area Chart for Amazon Price vs Flipkart Price

VI. PERFORMANCE MATRIX

The ‘Best Match’ module identifies two products that are most similar to each other, from Amazon and Flipkart respectively. The criteria for this comparison is the product name.

The algorithm is based on fuzzy logic. [13]There are undeniable benefits to using fuzzy logic in retail as one of the multi-criteria decision-making alternatives.[14] In General, the employment of fuzzy logic might be helpful, for very complex processes, when there is no simple mathematical model (e.g. Inversion problems), for highly nonlinear processes or if the processing of (linguistically formulated) expert knowledge is to be performed. [15]The decision matrix's rules are articulated in plain terms.

We have tried various threshold values for our project and found that the best results are produced when this value is equal to 0.5. The pseudocode to determine the best match for the given user input is mentioned below:

STEP 1– Retrieve the list of products from Amazon and Flipkart from the database and store it in amazon_product and flipkart_product respectively.

STEP 2– Initialize a square matrix of size n with values equal to 0. Here n is the total number of products extracted from the database.

STEP 3– Take the first product from amazon_product as amazon, and split the string of words into a list.

STEP 4– Iterate through the list flipkart_product and convert the string of words into a list. The product name is stored as flipkart per iteration.

STEP 5– For each iteration, calculate the number of identical words in amazon and flipkart and divide it by the length of the smallest name.

STEP 6– For every amazon in amazon_product, the above value is stored in a list temp_score.

STEP 7– Repeat steps 3 to 6 for every item in amazon_product.

The final matrix, distance_matrix has a score for every pair of products in the lists amazon_product and flipkart_product, with the row numbers and column numbers representing Amazon and Flipkart products respectively. This score is a numeric representation of how similar the 2 product names are. Higher the score, higher the similarity.

Next, we use this distance_matrix to find the two products from Amazon and Flipkart that are most similar to each other as well as to the user input. The following describes the steps for the same.

STEP 1– Find out the rows and columns of the score which is greater than the confidence value, which is 0.5 for our case. These values are stored in the list s1.

STEP 2– Store the unique rows in list try1.

STEP 3– Initialize dictionary max_dict, where the rows are the keys and a list of score and columns form the values.

STEP 4– Initialize a dictionary con_dict that has the row number as the key and a list of corresponding columns containing the score higher than the threshold value.

STEP 5– Iterate through the s1 and store the highest score and its corresponding column number for each row in max_dict.

STEP 6– For each row in try1, iterate through s1 and store the column values in con_dict.

STEP 7– Iterate through max_dict and create a list pairs that contains a list of row and column numbers as its values.

Finally, the first values for Amazon and Flipkart in the list pairs is used to display the corresponding products. The rest of the products that were shortlisted and stored in con_dict are displayed for the module 'All Products'.

VII.FUTURE SCOPE

The project uses the syntactic approach to match the input keywords to products on the ecommerce platforms. This can be extended to a semantic approach which can prove to give more accurate results, particularly when the user is confused about the item he/she wants to purchase.

The database that we have used for this project stores data on an instantaneous basis, i.e., The table gets cleared when a new search is performed. Storing data for multiple searches and not clearing it can help depict charts that can compare the price and ratings for products throughout a particular category.

This website can be expanded to encompass other ecommerce platforms. This can broaden our service and help users get a better, thorough comparison. Not to mention, including many platforms in the comparison can also provide better price and rating comparison as the options increase.

VIII. CONCLUSION

To sum up, the website created by us provides a wide variety of features that yield multiple benefits for the user. Primarily, the user can compare products available on different websites in a single webpage. This makes comparison on numerous factors easy. Another viable feature our website provides is the price and rating comparison. The 'Least Price' module displays the cheapest available product which is the most similar to user input. This helps save money while being able to acquire the product. Similarly, the 'Best Rating' module identifies the product with the highest rating in each of the sites. The user can then make an informed decision and purchase the product he/she thinks is most suitable. This increases the chances of customer satisfaction while putting in minimum effort. Since fuzzy logic is used and the threshold is chosen with a lot of experimentation, the results are guaranteed to be accurate and can be trusted. In conclusion, although there is scope for a lot more improvement, currently our website offers more than satisfactory benefits and uses.

REFERENCES

[1] A.Shalini, Mr.R.Ambikapathy. E-Commerce Analysis and Product Price Comparison Using Web Mining.

[2] S. Rajendar, K. Manikanta, M. Mahendar, Assistant Prof. (Mrs.) K. Madhavi. Price Comparison Website for Online Shopping.

[3] Kasereka, Henrys. (2020). Importance of web scraping in e-commerce and e-marketing.. SSRN Electronic Journal. 10.6084/m9.figshare.13611395.v1.

[4] Daoud, M., Naqvi, S. K., & Ahmad, A. (2014). Opinion observer:

Recommendation system on ecommerce website. International Journal of Computer Applications, 105(14), 37-42.

[5] Sharma, D. K., Lohana, S., Arora, S., Dixit, A., Tiwari, M., & Tiwari, T. (2022). E-Commerce product comparison portal for classification of customer data based on data mining. Materials Today: Proceedings, 51, 166-171.

[6] Verma, N., & Singh, J. (2015, February). Improved web mining for e-commerce website restructuring. In 2015 IEEE International Conference on Computational Intelligence & Communication Technology (pp. 155-160). IEEE.

[7] Glez-Peña, D., Lourenço, A., López-Fernández, H., Reboiro-Jato, M., & Fdez-Riverola, F. (2014). Web scraping technologies in an API world. Briefings in bioinformatics, 15(5), 788-797.

[8] Khder, M. A. (2021). Web Scraping or Web Crawling: State of Art, Techniques, Approaches and Application. International Journal of Advances in Soft Computing & Its Applications, 13(3).

[9] Sirisuriya, D. S. (2015). A comparative study on web scraping.

[10] Zhao, B. (2017). Web scraping. Encyclopedia of big data, 1-3.

[11] Jin, D. (2021). Image Information Collection System Based on Python Web Crawler Technology. CONVERTER, 606-612.

[12] Thomas, D. M., & Mathur, S. (2019, June). Data analysis by web scraping using python. In 2019 3rd International conference on Electronics, Communication and Aerospace Technology (ICECA) (pp. 450-454). IEEE.

[13] Bezděk, V. (2014). Using fuzzy logic in business. Procedia-Social and Behavioral Sciences, 124, 371-380.

[14] Hellmann, M. (2001). Fuzzy logic introduction. Université de Rennes, 1(1).

[15] Dernoncourt, F. (2013). Introduction to fuzzy logic. Massachusetts Institute of Technology, 21, 50-56.

Factors Influencing Cloud Analytics Adoption in Indian Pharmaceutical Industry

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Abstract—Pharmaceutical firms have access to tremendous amount of data which they can use in order to gain insights to augment and accelerate drug development by employing analytics tools to make informed data-based decisions. This research aims to analyze the various factors on which the adoption of cloud-based solutions for analytics in the Indian pharmaceutical industry is decided. This research will help policy makers, key personnel and decision makers in various firms understand the factors that are required to be taken into consideration for adoption of cloud analytics solution. Data collected through an online survey have been analyzed by employing PLS-SEM technique which is a combination of confirmatory factor analysis and multiple regression techniques. The study uses an integrated framework based on the Extended Theory of Perceived Behavior (TPB) and Technology Acceptance Model (TAM) for determining the significant factors affecting the adoption of cloud computing software for analytics in Indian pharmaceutical industry.

Keywords - Technology Adoption, Cloud Analytics, Theory of Planned Behaviour, Pharmaceutical Industry

I. INTRODUCTION

To remain competitive in an ever-changing business world, many firms are under increasing pressure to build and scale up their business intelligence operations rapidly and at a minimal cost. Cloud computing is transforming the way organisations provide IT services and how businesses and users engage with IT resources [1]. It represents a paradigm change by introducing flexible service models to which businesses can subscribe on a pay-as-you-go basis.

Cloud Analytics is an amalgamation of cloud computing and big data analytics. The practise of storing and processing data in the cloud in order to get useful business insights is known as cloud analytics. Cloud analytics algorithms are used to analyse big data sets in a manner similar to on-premises data analytics to find patterns, forecast outcomes, and provide other data that is helpful to business decision-makers [2].

Cloud-based big data analytics is a service that provides aspects of the big data analytics process via a public or private cloud. It employs a variety of analytical tools and approaches to assist organisations in extracting information from vast amounts of data and presenting it in a way that is easily categorised and accessible via a web browser.

Large quantities of data is available as a result of the quick development of social networking, cutting-edge mobile technologies, e-commerce websites, search engines, and other new digital technologies. [1] This gives businesses the chance to produce and collect data that are characterised by the three Vs - Volume, Variety, and Velocity. [2] Volume describes the enormous amount of data that businesses gather in order to find hidden information, patterns in the data, and to get important knowledge. [3] Variety refers to the various data types, unstructured, semi-structured, and structured data.[4] It is difficult to manage these with traditional analytical systems. Velocity, on the other hand, represents the rate of data generation and real-time data analysis. [5] The advent of the digital age has led to a rise in different types of data with every passing day. Cloud computing provides an apt platform for big data analytics.

The focus of this paper is to examine the effect of various factors influencing the adoption of cloud analytics in Indian pharmaceutical industry using a combined framework of Technology Acceptance Model (TAM) [6] and Theory of Planned Behaviour (TPB) [7] extended with Cost and Trust as additional variables.

II. LITERATURE REVIEW & RESEARCH FRAMEWORK

Various approaches have been used in the existing literature for analysing the decision of adopting cloud based services including cloud analytics. Most of the studies have discussed cost as the basis of decision for adoption of cloud services and few others studied the effect of requirements like security and availability.

Menzel et al. (2011) shows a cost-oriented decision model approach by presenting a generic multi-criteria decision-making framework. [8] It shows a method for comparing cloud infrastructure providers based on cost, benefit, opportunity, and risk evaluations.

A multi-criteria decision model is also proposed by Saripalli and Pingali (2011) where the authors present a hierarchy of relevant criteria (e.g., suitability, economic value, usability, reliability, and security) and assign weights to the criteria using a wide-band Delphi method. [9] Martens et al.(2012) present a total cost of ownership (TCO) approach for cloud computing services [10] while Johnson and Qu (2012) propose an analytical decision model for cloud migration decisions that considers various business requirements such as security and availability. [11] Walterbusch et al. (2013) extend work presented by Martens et al (2012) by presenting a simple mathematical model and a Web-based application for evaluating cloud services from a total cost of ownership (TCO) standpoint. [12]

A study conducted in the United States by Parson (2021) examined IT specialists' decisions to implement big data analytics in SMEs using the TAM model. According to the study's findings, perceived usefulness and perceived ease of use had a substantial impact on BDA acceptance. [13]

Garrison (2018) tries to gain a better understanding of the reasons that motivate people to utilise cloud-based services despite the privacy and security risks. To explain user intents to use cloud-based services, the author created a research model that integrates the theory of planned behaviour (TPB) and constructs from past research. Their findings confirm the existence of links between predictor variables (attitude, subjective norm, perceived behavioural control, and information privacy) and outcome variables (behavioural intention). [14]

But there is a dearth of studies on adoption of cloud analytics that take into account the factors related to technology usefulness and ease of use along with behavioural aspects of the personnel involved in taking the adoption decision along with the cost factor. This paper is an attempt to fill this gap in the literature as it incorporates all these factors in an integrated multiple regression framework based on TAM and TPB extending the model with cost and trust as additional variables.

The model for this paper comprises of six independent variables namely – perceived usefulness, perceived ease of use (derived from TAM); subjective norm, perceived behavioural control (derived from TPB); and, cost and trust (derived from previous literature). The effect of these independent variables has been assessed on the dependent variable of behavioural intention to adopt cloud analytics.

Technology acceptance model [6] helps us in understanding how the user responds to a new technology which is introduced to him in terms of acceptance or rejection of the same. This model measures two variables perceived usefulness (PU) and perceived ease-of-use (PEOU). Perceived usefulness refers to the user's assessment of the technology in terms of its usefulness in accomplishing his job i.e., whether this technology is expected to help him in doing his job better than the previous system. Perceived ease of use refers to his judgement regarding how easy to use this new technology is for him.

Based on these two factors user can either accept the new technology or reject it. Therefore, the following two hypotheses are framed for the study:

H1: Perceived usefulness has a positive effect on cloud analytics adoption intention

H2: Perceived ease of use has a positive effect on cloud analytics adoption intention

Theory of Planned Behaviour [7] provides three major constructs which are Attitude towards a behaviour, Subjective Norms (SN) regarding the behaviour and Perceived Behavioural Control (PBC) in making of intentions to perform a behaviour. This paper considers attitude to be measured in a decomposed way through the TAM variables of PU and PEOU and combines them with SN and PBC proposed by Theory of Planned Behaviour.

Subjective Norm relates to an individual's belief of whether indulging in a behaviour would subject him or her to the likes or dislikes among his or her social group. [15] The intention to perform a certain behaviour would be strong if such behaviour is approved by or preferred by the social group of an individual. Contrarily, social disapproval will weaken the intention to engage in the behaviour.

The following hypothesis stems from the above discussion:

H3: Subjective norms have a positive effect on cloud analytics adoption intention

Perceived Behavioural Control refer to the circumstances where an individual has or does not have total control over the behaviour [6]. It refers to the easiness or difficulty of engaging in a behaviour considering the facilitators and inhibitors in performing the said behaviour and is influenced by an individual's cognitive capabilities, previous experiences and their expectations about ease or difficulty of engaging in the behaviour. If the individual perceives to have control over performing the behaviour, he is expected to have a higher intention to perform that behaviour.

The following hypothesis is thus framed for the study:

H4: Perceived behavioural control has a positive effect on cloud analytics adoption intention

Cost has been suggested to be a significant consideration in adoption of cloud based services including analytics [12]. For this study, cost is measured using the items for price value given by Venkatesh et al. (2012) [16] which measure if the users feel that the cloud analytics services are reasonably priced. In case the cost of these services is believed to be reasonable by the potential users, they tend to have a higher intention to adopt these services. Therefore, the following hypothesis has been tested:

H5: Cost perceived as reasonable has a positive effect on cloud analytics adoption intention

Trust on the cloud analytics provider or the vendor is an important aspect in decision to adopt the services as security of the data is a major concern.[9] Trust is comprised of the belief that the vendor will be able to fulfil the needs of the firm, will honour the commitments and will take care of the adopting firm's benefit. [17] Trust has thus been suggested to be a significant factor in influencing adoption intentions. [18]. Therefore, the following hypothesis is framed for the study:

H6: Trust on the vendor has a positive effect on cloud analytics adoption intention

The behavioural intention to adopt cloud analytics services has been taken as the dependent variable in the model. Intention is found to be significant in leading to actual behaviour [6] and hence by measuring intentions we can get an insight regarding the potential behaviour which in this case would be the actual adoption of cloud analytics.

III. METHODOLOGY AND ANALYSIS

A. Data & Methods

Purposive sampling technique was used to gather data from an online survey of middle and top level managers of pharmaceutical firms in India using a structured questionnaire based on 5 point Likert Scale. All scale items were adapted from prior literature with perceived usefulness and ease of use items adapted from Davis (1989) [6], Subjective norm and Perceived Behavioural Control items adapted from Taylor and Todd (1995), Trust items adapted from McNight et al.(2002) [19] and Cost items adapted from Venkatesh et al. (2012) [16]. Power analysis was used to ensure adequate sample size for the study. Sample size is determined by using G*Power software which employs the formula suggested by Faul et al. (2009) [20]. At 5% significance level and 95% power, a minimum sample size of 89 is required assuming medium effect size. Actual sample size used for the study is 180 which is well above the minimum required size for adequate power. Sample characteristics are presented in Table 1.

Table I. Sample characteristics

Characteristics	Frequency	Percentage
Gender		
Male	96	53%
Female	84	47%
Age		
25 to 35	50	28%
35 to 45	84	47%
45 to 55	42	23%
55 and above	4	2%

The analysis comprised of testing the construct reliability and validity through confirmatory factor analysis followed by multiple regression analysis employing PLS-SEM using SmartPLS software to estimate the effect of the six independent variables PU, PEOU, SN, PBC, COST, and TRUST on the dependent variable of cloud analytics adoption intention (INT).

Cronbach's alpha was calculated to check for internal consistency reliability of the constructs and convergent validity was established through the calculation of Average Variance Extracted (AVE) [21]. Discriminant Validity of the various constructs in the model was established through Fornell-Larcker Criterion.[22]

Before proceeding for multiple regression analysis, the data was checked for multicollinearity and heteroscedasticity and no issues were found pertaining to these assumptions.

B. Results

Table II presents the results for internal consistency reliability given by Cronbach's alpha and convergent validity given by AVE of the constructs. Internal consistencies of all variables are considered acceptable since the Cronbach's Alpha values exceeded .70, signifying acceptable reliability. The average variance extracted (AVE) of each construct was higher than the standard 0.5, which indicated good convergent validity for the scale.[25]

Table II. Reliability and convergent validity

Construct	No. of Items	Cronbach's Alpha	AVE
Behavioural Intention	3	0.791	0.62
Cost	3	0.755	0.67
Perceived Behavioural Control	4	0.902	0.78
Perceived Ease of Use	3	0.874	0.89
Perceived Usefulness	4	0.901	0.76
Subjective Norms	2	0.796	0.64
Trust	5	0.842	0.76

Table III gives the discriminant validity results based on Fornell Larcker criterion. The square root of the average variance extracted for each of the constructs was found to be greater than the correlation between all given constructs in the model, thus establishing the discriminant validity for all the constructs.

Table III. Discriminant validity

	INT	COST	PBC	PEOU	PU	SN	TRUST
Adoption Intention	0.888						
Cost	0.732	0.817					
Perceived Behavioural Control	0.553	0.452	0.921				
Perceived Ease of Use	0.766	0.748	0.424	0.881			
Perceived Usefulness	0.707	0.659	0.484	0.758	0.941		
Subjective Norms	0.789	0.657	0.411	0.733	0.803	0.858	
Trust	0.589	0.628	0.471	0.673	0.669	0.604	0.871

Result of the multiple regression analysis are shown in Table IV. All the independent variables except subjective norms have been found to be having a significant effect on intention to adopt cloud analytics.

Table IV. Multiple Regression Results

Independent Variable	Coefficient	T Statistics	P Values
Cost	0.437	2.047	0.041
Perceived Behavioural Control	0.289	2.227	0.026
Perceived Ease of Use	0.133	2.067	0.039
Perceived Usefulness	0.298	3.207	0.000
Subjective Norms	0.098	0.735	0.462
Trust	0.143	1.876	0.068
R Square	0.651		
R Square Adjusted	0.622		
SRMR	0.064		

Trust has been found to be significant but only at 10%. Reasonable cost has the highest weight among the independent variables with the perceived usefulness and perceived behavioural control being the next most important factors relatively.

R square and Adjusted R square were found to be greater than 0.6 exhibiting satisfactory explanatory power of the model with 65% of the variation in dependent variable being accounted for by the independent variables.

IV. CONCLUSION

The purpose of this study was to better understand the factors influencing the adoption of cloud analytics in Indian pharmaceutical industry by combining the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) extended with Cost and Trust variables.

Cost reasonableness, Perceived usefulness and perceived behavioural control are found to be major factors in affecting intentions followed by perceived ease of use. This implies that if cloud analytics is perceived to be relatively advantageous and is available in reasonable cost, the adoption would be higher.

It is also important to note that perceived behavioural control which refers to the self- efficacy of the personnel in use of cloud analytics and the resources they have at hand for its optimal usage are also significant in forming the adoption intentions. Therefore, companies which plan to adopt cloud analytics must train their employees well on its application and usage and provide them resources to fully utilize its potential.

The perceived ease of use will also result from proper trainings and awareness programs that should be conducted for the organizations where the cloud analytics vendors want to introduce their services. The trust on vendors will be developed subsequently as the clients in pharmaceutical industry become aware of the various features and usage of the cloud analytics through such training and awareness programs.

The findings of this study are significant for the cloud analytics service providers as well as the pharmaceutical companies which plan to incorporate cloud analytics and want their employees to be ready for its adoption. Further research may be conducted in different sectors and countries for establishing the generalizability of these results.

REFERENCES

[1] Surbakti, F. P. S., Wang, W., Indulska, M., & Sadiq, S. (2020). Factors influencing effective use of big data: A research framework. Information & Management, 57(1), 103146. https://doi.org/10.1016/j.im.2019.02.001

[2] Russom, P. (2011). Big data analytics. TDWI Best Practices Report, fourth quarter, 19(4), 1-34. https://vivomente.com/wp-content/uploads/2016/04/big-data-analytics-white-paper.pdf

[3] Ghasemaghaei, M. (2020). The role of positive and negative valence factors on the impact of bigness of data on big data analytics usage. International Journal of Information Management, 50, 395-404. https://doi.org/10.1016/j.ijinfomgt.2018.12.011

[4] Mohapatra, S. K., & Mohanty, M. N. (2020). Big data analysis and classification of biomedical signal using random forest algorithm. In New Paradigm in Decision Science and Management: Proceedings of ICDSM 2018 (pp. 217-224). Springer Singapore. https://doi.org/10.1007/978-981-13-9330-3_20

[5] Kuo, C. F. J., Lin, C. H., & Lee, M. H. (2018). Analyze the energy consumption characteristics and affecting factors of Taiwan's convenience stores-using the big data mining approach. Energy and Buildings, 168, 120-136. https://doi.org/10.1016/j.enbuild.2018.03.021

[6] Davis, F.D., (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340. https://doi.org/10.2307/249008

[7] Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

[8] Menzel, M., Schonherr, M., Nimis, J. and Tai, S. (2011) A generic decision-making framework and its application to cloud computing. http://arxiv.org/abs/1112.1851

[9] Saripalli, P. and Pingali, G. (2011) MADMAC: Multiple attribute decision methodology for adoption of clouds. Proceedings of the 2011 IEEE 4th International Conference on Cloud Computing, CLOUD 11, IEEE Computer Society, Washington, DC, 316–323.

[10] Martens, B., Walterbusch, M. and Teuteberg, F.(2012) Costing of cloud computing services: A total cost of ownership approach. Proceedings of the 45th Hawaii International Conference on System Sciences, HICSS 12, IEEE Computer Society, Washington, DC, 1563–1572.

[11] Johnson, B. and Qu, Y. (2012) A holistic model for making cloud migration decision: A consideration of security, architecture and business economics. Proceedings of the 2012 IEEE 10th International Symposium on Parallel and Distributed Processing with Applications, ISPA 12, IEEE Computer Society, Washington, DC, 435–441.

[12] Walterbusch, M., Martens, B., and Teuteberg, F. (2013) Evaluating cloud computing services from a total cost of ownership perspective. Management Research Review, 36(6), 613–638. https://doi.org/10.1108/01409171311325769

[13] Parson, G.K. (2021) Factors Affecting Information Technology Professionals Decisions to Adopt Big Data Analytics Among Small-and Medium-Sized Enterprises: A Quantitative Study. Ph.D. Thesis, Capella University, Minneapolis, MN, USA.

[14] Garrison, G., Rebman Jr, C.M. and Kim, S.H., (2018). An identification of factors motivating individuals use of cloud-based services. Journal of Computer Information Systems, 58(1), pp.19-29. https://doi.org/10.1080/08874417.2016.1180653

[15] Taylor, S., and Todd, P. (1995), Understanding the Information Technology Usage: A Test of Competing Models. Information Systems Research, 6(2), 144 –176 https://doi.org/10.1287/isre.6.2.144

[16] Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Quarterly, 36(1), 157-178. https://doi.org/10.2307/41410412

[17] Erkan, I., & Evans, C. (2016). The influence of eWOM in social media on consumers' purchase intentions: An extended approach to information adoption. Computers in Human Behavior, 61, 47-55. https://doi.org/10.1016/j.chb.2016.03.003

[18] Chang, Y. S., & Fang, S. R. (2013). Antecedents and distinctions between online trust and distrust: predicting high-and low-risk internet behaviors. Journal of Electronic Commerce Research, 14, 149-166. http://www.jecr.org/sites/default/files/14_02_p2_0.pdf

[19] McKnight, D.H., Choudhury, V. and Kacmar, C., (2002). The impact of initial consumer trust on intentions to transact with a web site: a trust building model. The Journal of Strategic Information Systems, 11(3), 297-323. https://doi.org/10.1016/S0963-8687(02)00020-3

[20] Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. Behavior Research Methods, 41(4), 1149-1160. https://doi.org/10.3758/BRM.41.4.1149

[21] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). Multivariate Data Analysis (7th Edition). Pearson Prentice Hall.

[22] Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 39-50. https://doi.org/10.1177/002224378101800104

Comparing Models for Analysing Database Pattern

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Abstract—In today's scenario, size of database is growing at a tremendous speed and analyzing such data for various purposes is of utmost importance. In this paper, we have applied our methodology to datasets of different sizes and discussed the experiment results in analyzing the pros and cons of various models. We have given an implementation model for knowledge discovery from huge unlabeled temporal databases by employing a combination of HMM and K-means technique.

Keywords - pattern analysis, HMM, KMM, KM HMM, recursive model

I.INTRODUCTION

With the huge growth of data [1], there has been a pressing issue to find tools and techniques to extract meaning information from this raw data and convert it into knowledge. For this, the data must be analysed by finding the patterns of the raw data and thereafter use these patterns to generate knowledgeable data.

These can be achieved through data analyses, which involve simple queries, simple string matching, or mechanisms for displaying data. The main aim of studying the various techniques of classification is the development of a tool or algorithm which can be utilized for prediction of the class of an unknown object, which is not labelled. This tool or algorithm is called a classifier while the objects in the classification process are represented by instances or patterns, where a pattern comprises of several attributes. The classification accuracy of any classifier is assessed by how many testing patterns it is able to classify correctly [2].

In general, unlabelled data is mined with the help of data clustering. Clustering, as a robust tool of Knowledge Discovery, aims to find hidden patterns in datasets by grouping data items together according to some criterion of closeness [3,5,13]. Grouping of objects is required for various purposes in various fields such as science and technology, social sciences, medical sciences, etc.

Studies have discussed various performance metrics and parameters are provided, and a comparative assessment of the corresponding aspects like cluster head selection, routing protocols, reliability, security, and unequal clustering [4].

The functionality and effectiveness of KM HMM [9,10] recursive model is first tested on one subset and its results are then backed up by different subsets of larger sizes. KM HMM [9] stands for the model-based clustering approach. It combines the power of K-means clustering with HMM, where K-means initializes the experiment by clustering the profiles. The resulting clusters are then used as an auto-labelling mechanism such that profiles that are grouped into the same cluster receive the same label.

The KM HMM model can group unlabelled data according to its underlying structure, i.e., patient's medical behaviours. The discovery is a data driven process which progresses through different hierarchical paths in unearthing the patterns in different age cohorts. Those patterns carry patient's medical information, and a proper interpretation could reveal some hidden but important knowledge such as a medical behaviour pattern of aged diabetics or abnormal medical behaviour pattern which could lead in fraud investigation. These are only few examples of application that can be achieved if some ground truth is made available.

We implement K-means clustering [11] and Hidden Markov model [6] approach, referred as KM HMM[13] recursive model, on smaller subsets in order to obtain a first insight into the effectiveness of the approach [13], and to serve as a basis for comparisons when subjecting the same method to the entire set of data. Then, the findings are then combined to produce the best performing approach which is then applied to the entire set of data.

II. LITERATURE REVIEW

Several clustering algorithms are proposed by various researchers, like Partitioning clustering algorithms, such as K-means [8] and CLARA [5] that assign objects into k clusters(predefined cluster number), that further iteratively reallocate objects to improve the quality of results obtained from clustering. Although K-means is a popular clustering algorithm [6] which is easy-to-understand also but at the same time it is very sensitive to the selection of the initial centroids and has no general solution to find the optimal number of clusters for a given data set.

Few authors have proposed Model-based clustering methods that are based on the assumption, that data is generated by mixture of underlying probability distributions and optimization with the help of models such as statistical approach, neural network approach and other AI approaches. The typical techniques in this category are AUTOCLAS [19], DENCLUE [7] and COBWEB [20] but they are facing a challenge of choosing a suitable one from the model-based candidates. Clustering, CH selection, routing, reliability and security aspects are addressed in review studies on clustering approaches [2,4]

These clustering-based approaches suffer from high computational cost, especially when the scale of data is very large. Another very commonly used model is the HMM model, the Hidden Markov Model (HMM) which is based on statistical modelling. Encoding of temporal pattern has made this approach very popular. Several variants of HMMs [7,8,9] exist like discrete HMM, continuous observation HMM, and input-output HMM, to name a few but they are also facing the challenge of heavy computational cost. To overcome these issues, we have proposed a recursive model which reduce the computational burden and to improve the quality of the model.

III. PROPOSED MODEL

In this section, our KM HMM approach is detailed through the application on one subset, then its functionality is further confirmed by applying the method on few other subsets. These preliminary experiments are important and necessary since they provide a vehicle to unfold the methodology. The step-by-step introduction of our method, the detailed discussions at the end of each step and the walk through of the sample profiles form the key in explaining the methodology.

3.1 Subset Selection

There are numerous ways in selecting reasonable subsets. What matters here is data quality: the selected subset has to be an unbiased representative of the data. We have divided the whole set of profiles into nine age cohorts, we decided to select one of the age cohorts to carry out our first experiment. Patients in age cohort 45-55 are well away from the female reproductive ages, and are still reasonably youthful as not to suffer from age related illnesses. Their profiles are not expected to be too complex to overly challenge the methodology. The data set is further downsized by constructing a rule-based selection e.g. particular illness based or gender.

IV. RESULTS

The experiment conducted for the study and the results of the experiment for comparing the accuracy of the models are presented in the following sections.

3.2 KM HMM Based Recursive Model

Using a fixed number of clusters for age cohort 45-55.

KM HMM [9] combines the power of K-means clustering with HMM, such that profiles that are grouped into the same cluster receive the same label, whereas profiles in different cluster receive a different one. Thus, the profiles are labeled according to the cluster membership. While these labels do not carry any meaning (other than cluster membership), it allows the application of a supervised learning scheme such as HMM.

By creating a model (HMM) for each cluster, HMM learns to detect patterns in given time series data which best describe the data in a given cluster. The result is a set of HMMs, one for each cluster. The procedure can then be applied recursively to each of the pattern classes in order to further segment a dataset into ever smaller classes. In practice, our methodology is unfolded through the following two steps:

Step 1: K-means Clustering

The first step of the proposed pattern discovery methodology addresses the clustering of data. In our case, the data subjected to the experiments are patients' profiles. K-means [11] clustering takes each profile as a 352-dimensional vector and calculates its distance towards centroids of each cluster, and eventually assigns the profile to the cluster where the distance between the profile and the centroid reaches minimum.to which a person believes that using a particular system would enhance performance.

K-means takes the initial parameters and performs data clustering. The cluster detected by K-means are then analysed, and clusters smaller than 200 are discarded (by assigning the patterns to the remaining clusters). The application of K-means algorithm results in 6 clusters. The patterns in each cluster are then uniquely labelled as Cluster1, Cluster2, ..., Cluster6 respectively. The benefit here stands for the total benefit paid for a patient throughout the year where the profile is drawn against

Table I. Basic information for k means clustering algorithm

Name of Cluster	Number of Profiles	Benefit Range in $
Cluster 1	28,608	8.15-1181.85
Cluster 2	9,427	124.95-2303.65
Cluster 3	1,447	357.25-7894.00
Cluster 4	1,199	393.60-7159.40
Cluster 5	1,216	505.10-9070.65
Cluster 6	903	645.60-8232.35

Step2: HMM Data Modelling and Recursive Mining

With HMM modelling [6], data is assessed according to contextual information embedded within the temporal sequence which we refer to as profiles. The process of estimating the values of these parameters is considered as the training of HMM models. For this experiment, a maximum 1,500 profiles are selected when the cluster size is over 2,000 (such as Cluster1 and Cluster2), otherwise 90% of the data from the cluster are subject to training (such as Cluster3 to Cluster6). Table II specifies the size of each training set.

Table II. Information of dataset in terms of its size in training hidden markov model

Name of Cluster	Number of Profiles	Size of Training Sample
Cluster 1	28,608	1,500
Cluster 2	9,427	1,500
Cluster 3	1,447	1,302
Cluster 4	1,199	1,079
Cluster 5	1,216	1,094
Cluster 6	903	812

For our experiments, we used the freely available, and well matured HMM software package known as HTK version 2.0. We customized the software package to allow the dealing with very large and zip compressed databases. This was necessary since HMM is not normally suited to deal with data mining tasks. One of the parameters that needs to be set when using the HTK 2.0 software package is the number of states in the HMM.

Following experiments are based on a left-right HMM with 3 states. Table III provides the training results of the 6 HMMs in terms of mean and variance of each HMMs. However, experiments on HMMs trained with more than one state were aborted due to lack of information.

Class1 is the largest which attracts 27,740 profiles while Class5 is the smallest with only 186 profiles. It is observed that the K-means clustering algorithm and the hidden Markov model grouped the profiles differently. Upon closer inspection of the K-means clustering results when compared to the HMMs classification results, it can be stated that the HMM classification makes more sense.

On a global scale the K-means clustering algorithm grouped the profiles as a whole profile, it works on the distance from the centroids to point of 352-dimensions. Hence at times it has grouped profiles which to the naked eyes appear to be quite different.

On the other hand, the hidden Markov model groups profiles together based on the time evolution of the profiles. The classification of profiles is the result of considering the context in which benefit is paid. For example, the hidden Markov model can assess whether a benefit paid is out-of-the-ordinary by considering the context within which the benefit was paid, this is an interesting observation given that the HMMs were trained on data labelled by K-means.

This process should keep on continuing recursively till further classification is possible. The process of Recursive mining allows the classes to be re-clustered into sub-clusters where the iterative mining will operate on each of the sub-clusters. The sub-clusters will then be modelled and iteratively mined by HMM so that new HMMs or patterns are discovered for each of the newly generated sub-clusters.

Table III. HMM training results: mean and variance of HMM

Name of Cluster	Number of Profiles	Size of Training Sample
HMM1	6.128910e+00	5.203418e+02
HMM2	2.477937e+01	3.275482e+03
HMM3	4.600096e+01	1.269653e+04
HMM4	5.877817e+01	2.111918e+04
HMM5	6.670536e+01	2.268726e+04
HMM6	7.352632e+01	2.508250e+04

Table IV. Classification result by the hmm model with comparison to k-means clustering

Cluster	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	TOTAL
HMM1	25.458	3,055	95	0	0	0	28,608
HMM2	2,274	6,005	1,003	82	10	53	9,427
HMM3	6	642	524	82	33	160	1,447
HMM4	1	246	501	123	56	272	1,199
HMM5	1	256	498	112	46	303	1,216
HMM6	0	92	377	95	41	298	903

Figure 1 shows the recursive process of our methodology. It demonstrates what has been done by the two processes of clustering and recursive mining: all the profiles in the data pool of a particular age group are sub divided and processed to get a further level with the help of clustering, modelling, and iterative mining as was described above.

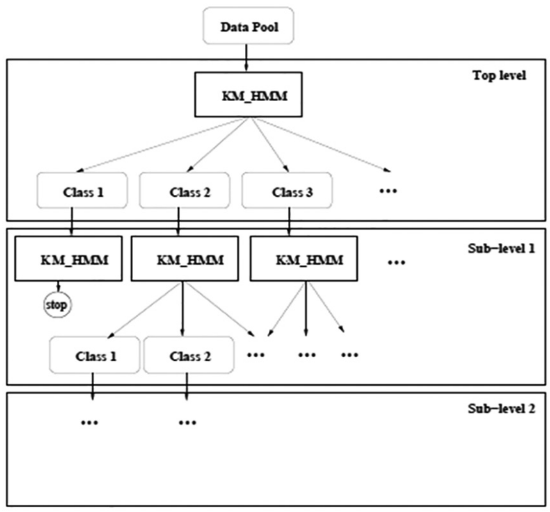

Fig. 1. Recursive refinement

All profiles of the above table of age cohort of 45-55 year are classified by the set of 63 HMMs generated for this cohort group. The classification is performed as follows: a profile is presented to all 63 HMMs, and the HMM which responds with the highest likelihood value wins. i.e., the profile is classified into the class represents by the winning HMM. Finally, at the end of this recursive modelling, we would like to re-visit the 36 profile which have been discussed in step 1 and step 2.

The 63 final HMMs are applied in classifying these 36 profiles in order to illustrate how these profiles are grouped at the end of the iterative training procedure. It is observed that the final HMMs provide a much finer classification to the profiles.

V. CONCLUSION

In this paper, we have implemented our analytical algorithm i.e. recursive KMM Model on a smaller subset and later on the complete set, in order to understand the effectiveness of KM HMM model. The distinctiveness of our model is the way the clustering KM HMM is applied on the dataset. Initially, to overcome the weakness of HMM on large datasets, we have applied the model iteratively. Also, in place of applying the model on entire dataset in one go by understanding all profiles of training set, we have done the mining iteratively in a controlled manner.

This helps to keep the training time in acceptable limits while keeping the model refined in each iteration. We analysed through the implementation model of KM HMM recursive model that we are getting more refined data as compared to K-means model. Thus iterative process makes HMM available for modelling a large set of data and maintains the known asset and the strength of HMMs. In our further study, we will take larger dataset and find the efficiency of this model and also compare it with other existing models.

The findings of this study are significant for the healthcare service providers as well as the digital marketing companies which may provide the technology and expertise for the same. By considering the various aspects of the factors that affect the attitude and actual adoption, detailed plans can be devised for effective implementation of these technologies. Further research may be conducted in different sectors for establishing the generalizability of these results and qualitative research can be conducted to explore further dimensions of the perceived usefulness and challenges constructs.

REFERENCES

[1] R. Chaiken, B. Jenkins, P. Larson, B. Ramsey, D. Shakib, S. Weaver, and Zhou, 2008, SCOPE: Easy and Efficient Parallel Processing of Massive Data Sets. PVLDB, 1(2):1265–1276. https://doi.org/10.14778/1454159.1454166

[2] Saxena, Saxena, A., Prasad, M., Gupta, A., Bharill, N., Patel, O. P., Tiwari, A., Joo, M., Ding, W., & Lin, C. T. (2017). A review of clustering techniques and developments. Neurocomputing, 267, 664-681.

[3] Zhang, Y. Yin, Y., Guo, D., Yu, X. & Xiao, L. (2014). Cross-validation based weights and structure determination of Chebyshev-polynomial neural networks for pattern classification. Pattern Recognition, 47(10), 3414-3428.

[4] Amutha, J., Sharma, S., & Sharma, S. K. (2021). Strategies based on various aspects of clustering in wireless sensor networks using classical, optimization and machine learning techniques: Review, taxonomy, research findings, challenges and future directions. Computer Science Review, 40, 100376.

[5] L. Kaufman and P. J. Rousseeuw, 1990, Finding Groups in Data: an Introduction to Cluster Analysis, John While & Sons.

[6] S. Kobayashi, T. and Haruyama.1997,Partly-hidden markov model and its application to gesture recognition. In 1997 IEEE International Conference on Acoustics, Speech and Signal Processing, Vol.4, pages 3081–3084.

[7] A. Hinneburg and D. Keim,1998, "An Efficient Approach to Clustering in Large Multimedia Databases with Noise", Proceedings of KDD-98 .

[8] R. Agrawal, J. Gehrke, D. Gunopulos, and P. Raghavan, 1998, "Automatic subspace clustering of high dimensional data for data mining applications", Proceedings of the ACM SIGMOD Conference, Seattle, WA., pp.94-105 .

[9] G. Sheikholeslami, S. Chatterjee, A. Zhang, 1998, "Wave cluster: A multi-resolution clustering approach for very large spatial databases", Proceedings of Very Large Databases Conference (VLDB98), pp.428-439.

[10] A. Panuccio, M. Bicego, and V. Murino, 2002,.A hidden markov model-based approach to sequential data clustering. In Proceedings of Joint IAPR International Workshops SSPR 2002 and SPR 2002, pages 734–743.

[11] M. P. Perrone and S. D. Connell, 2000, K-means clustering for hidden markov models. In Proceedings of the 7th International Workshop on Frontiers in Handwriting Recognition, pages 229–238.

[12] P. Smyth. 1997. "Clustering sequences with Hidden Markov Models" Advances in Neural Information Processing Systems, Vol.9:648–654.

[13] Babita, Paramjeet Rawat, Parveen Kumar, 2014, "An Approach to Analyze Pattern from Large Database of Healthcare" International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 1

[14] J. B. MacQueen,1967, "Some Methods for classification and Analysis of Multivariate Observations", Proceedings of 5th Berkeley Symposium on Mathematical Statistics and Probability, Berkeley, University of California Press, pp.281-297.

[15] L. Kaufman and P. J. Rousseeuw,1990 "Finding Groups in Data: an Introduction to Cluster Analysis", John Wiley & Sons.

[16] D. Jiang, A. K. H. Tung, and G. Chen., 2010, Map-join-reduce: Towards Scalable and Efficient Data Analysis on Large Clusters. TKDE, 23(9):1299–1311.

[17] S. Han, D. Chen, M. Xiong, and A. K Mok. 2008. Online Scheduling Switch for Maintaining Data Freshness in Flexible Real-Time Systems. In Proc. of RTSS, pp. 115–124. . https://doi.org/10.1109/RTSS.2009.36

[18] Y. Xiong and D. Y. Yeung., 2002, Mixtures of arma models for model-based time series clustering. In Proceedings of the 2002 IEEE International Conference on Data Mining (ICDM'02), pages 717–720. https://doi.org/10.1109/ICDM.2002.1184037.

[19] P. Cheeseman, J. Kelly, M. Self, J. Stutz, W. Taylor, and D. Freeman, 1998, "AutoClass: A bayesian classification system", Proceedings of 5th International Conference on Machine Learning, Morgan Kaufmann, pp. 54-64

[20] D. Fisher, 1987, "Improving Inference through Conceptual Clustering", Proceedings of 1987 AAAI Conferences, Seattle Washington, pp.461-465.

Evaluating the Performance of Some Statistical Location Difference Tests

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Abstract—This article shows the results of a simulation experiment evaluating the comparative effectiveness of the application of classical and new shift tests in the context of errors of the second kind using the example of the normal, lognormal, exponential, gamma and Weibull distributions. The experiment procedure is described in detail, based on the results of 100 simulations for each type of distribution; a "binary tree" algorithm is used to solve the classification problem. The result of its application made it possible to detect "areas of effectiveness" of tests depending on the parameters of the scenario. At the same time, the Wilcoxon test showed the best comparative effectiveness, the second - the modified Yuen-Dixon t-test. It is noted that in many cases, with insignificant values of the shift parameter, all tests gave an erroneous conclusion. The conclusion presents further prospects and directions for the development of this topic.

Keywords - statistical hypotheses, distribution, shift tests, simulation modeling, errors of the second kind

I. INTRODUCTION

The development of mathematical statistics, on the one hand, and exploratory data analysis, on the other hand, led to the active emergence of new tools for testing statistical hypotheses.

Today, statistical hypotheses are an important tool for data analytics. Improper work with them can lead to erroneous management decisions and company losses. That is why it is now extremely important to use accurate and effective statistical tests to test the relevant hypotheses.

This work covers only a small part of this area and focuses on shift tests.

II. MATHERIALS AND METHODS

Currently, the field of data science related to the application of statistical tests includes:

- direct application of statistical tests in the process of data analysis. Traditionally, they are actively used in medical and psychological research, but recently there has been a tendency to use statistical tests in solving machine learning problems - for example, in [1] an example of their use in the process of solving a pattern recognition problem is shown;

- a classic application, which is to check the significance of the obtained statistical indicators. With the passage of time, new ways of checking indicators in increasingly complex and difficult tasks appear - an example is work [2] on assessing the significance of the cross-correlation coefficient of time series or work [3] on comparing the effectiveness of optimization algorithms based on statistical tests;

- the use of statistical tests not as research tools, but as objects. There are more and more studies that compare the performance of various tests [4, 5, 6] to identify the “minimum optimal set” that should be used when testing a particular statistical hypothesis.

The presented work is a brief report on this topic.

Suppose that there are two independent samples of different sizes from one distribution, but the values of one sample are "shifted" relative to the other by some fixed value. Statistical tests testing a given hypothesis are called shift tests.

The null hypothesis in tests of this type is formulated as follows: the shift parameter is 0. An alternative hypothesis is most often formulated as follows: the shift parameter is not equal to 0.

The purpose of this work is to develop and test a methodology for evaluating the effectiveness of different shift tests for data subject to different distribution laws.

The following statistical tests were selected for analysis:

- Two-sample Fried-Dehling (1) test based on Hodges-Lehmann estimator.
- Modified [1] median test.

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- Test based on M-scores [2,3,4].
- Modified Yuen-Dixon t-test [5].
- Classic Mood's two-sample test.
- The classic Wilcoxon test.

This paper considers the comparative effectiveness of tests in the context of errors of only the second kind - when an incorrect null hypothesis about the equality of the shift parameter with zero is mistakenly accepted.

For this, the following methodology of the simulation experiment was applied:

- Values are randomly selected from the uniform distribution, which are defined as the center of the initial distribution, the shift parameter and the spread parameter.
- The number of observations in two samples (from 10 to 100) is determined randomly.
- Identify applicable funding agency here. If none, delete this text box.
- Two samples are generated and all the tests described above are performed.
- The obtained p-values of the tests are evaluated. The test with the smallest p-value is chosen as the best (the smaller the p-value, the more reliably the erroneous hypothesis of zero shift equality is rejected). If all tests have shown a p-value greater than 0.05, then it is noted that all tests were mistaken at this value of the incoming indicators.

Thus, for each distribution, a table with the following variables is obtained:

- Variables of the distribution parameters and the ratio of the shift to the central value.
- Sample size variables and their relationships.
- Best test number (0 if all tests are wrong).

Further, the classification problem is solved for the obtained data through the use of the binary tree method – this allows us to formulate some statements about the areas of comparative effectiveness of tests.

Simulation modeling was conducted for 5 types of distribution: normal, lognormal, exponential, Weibull distribution, gamma distribution.

The simulation results are displayed in tables that show the corresponding constructed tree. Simulation modeling included 100 different scenarios; and the criterion for stopping less than 10 observations in its separate branch was accepted for the tree.

All calculations were performed using the robnptests package of the R language.

III.RESULTS

Consider the evaluation of the comparative effectiveness of tests for normal distribution.

The value of the average value for the samples ranged from 0.1-1000.0, the value of the shift did not exceed 1/10 of the average, the value of the standard deviation ranged from 0.1-10.0. The evaluation results are presented in the Table 1:

Table I. Comparative evaluation of tests effectiveness in the case of normal distribution

Number of split	Parameters of split		
	Condition	**Best test**	**Percentage of scenarios with the best test selected**
1	Root	Wilcox	89.0
2	Location difference < 5.14	No test	56.3
3	Location difference > 5.14	Wilcox	100.0

According to Table 1, the Wilcoxon test shows the greatest efficacy on average. In this case, if the shift value is greater than 5.14, then this test gives the best evaluation in 100% of cases, in the opposite case, all the considered tests give the wrong result.

Consider the evaluation of the comparative effectiveness of tests for the lognormal distribution.

The logarithm value of average value for the samples ranged from 0.01 to 10.0, the shift value did not exceed 1/10 of the average, the standard deviation value ranged from 0.01 to 5.0. The evaluation results are presented in Table 2:

Table II. Comparative evaluation of tests effectiveness in the case of normal distribution

Number of split	Parameters of split		
	Condition	**Best test**	**Percentage of scenarios with the best test selected**
1	Root	No test	60.0
2	SD < 2.34	No test	37.8
4	Mean < 3.49	No test	47.6
5	Mean > 3.49	Wilcox	66.7
6	Ratio Delta on Mean < 0.05	No test	63.3
7	Ratio Delta on Mean > 0.05	Wilcox	92.3
3	SD > 2.34	No test	78.1

According to Table 2, we note that on average all tests gave incorrect results. However, an area of effectiveness of the Wilcoxon test was identified - if the simultaneous logarithm of the average value is greater than 3.49 and the shift value is greater than 1/20 of the logarithm of the average value. In other cases, all the tests considered were erroneous.

Consider the evaluation of the comparative effectiveness of tests for exponential distribution.

The value of the average value for the samples ranged from 0.2-100.0, the shift value did not exceed 1/10 of the average. The results are presented in Table 3:

Table III. Comparative evaluation of tests effectiveness in the case of exponential distribution

Number of split	Parameters of split		
	Condition	**Best test**	**Percentage of scenarios with the best test selected**
1	Root	Yuen-Dixon trimmed t-test	40.0
2	Mean < 2.38	Yuen-Dixon trimmed t-test	80.0
3	Mean > 2.38	No test	65.4
4	Elements on sample < 23	No test	84.8
5	Elements on sample > 23	Yuen-Dixon trimmed t-test	40.9

According to Table 3, Yuen-Dixon trimmed t-test showed the highest efficiency on average. If the mathematical expectation is less than 2.38, then the test is recognized as the best in 80% of cases. Moreover, if the mathematical expectation is greater, then with small samples of up to 25 elements, all tests give the wrong result.

Consider the evaluation of the comparative effectiveness of tests for the Weibull distribution.

The shape parameter for the samples was changed in the range 0.01-500.0, the shift value did not exceed 1/10 of the shape value, the scale parameter value fluctuated in the range 0.1-50.0. The results are presented in Table 4.:

Table IV. Comparative evaluation of tests effectiveness in the case of weibull distribution

Number of split	Parameters of split		
	Condition	**Best test**	**Percentage of scenarios with the best test selected**
1	Root	Wilcox	57.0
2	Shape < 6.94	No test	68.7
3	Shape > 6.94	Wilcox	67.8
4	Ratio Delta on Scale < 0.015	No test	81.8
5	Ratio Delta on Scale > 0.015	Wilcox	75.4

According to Table 4, the Wilcoxon test showed the greatest effectiveness on average. In this case, if the value of the form parameter is low (less than 6.94), all tests are mistaken. Accordingly, the area of effectiveness of the Wilcoxon test is the value of the shape parameter greater than 6.94, and the ratio of the shift value to the shape parameter is greater than 0.015.

Consider the evaluation of the comparative effectiveness of tests for gamma distribution.

The shape parameter for the samples changed in the range 0.01-500.0, the shift value did not exceed 1/10 of its value, the scale parameters fluctuated in the range 0.1-50.0. The results are presented in Table 5:

Table V. Comparative evaluation of tests effectiveness in the case of gamma distribution

Number of split	Parameters of split		
	Condition	**Best test**	**Percentage of scenarios with the best test selected**
1	Root	Wilcox	73.0
2	The shape parameter for the samples changed in the range 0.01-500.0, the shift value did not exceed 1/10 of its value, the scale parameters fluctuated in the range 0.1-50.0. The results are presented in Table 5	No test	53.1
4	SD < 30.6	No test	31.7
5	SD > 30.6	No test	84.1
3	Delta > 4.64	Wilcox	100.0

According to Table 5, the Wilcoxon test shows the greatest effectiveness on average. If the shift value is greater than 4.64, then it is effective in 100% case, otherwise all tests give an error.

IV. CONCLUSION

Evaluation of the results of the conducted experiments shows the comparative superiority of the classic Wilcoxon test for 4 of the 5 considered distributions.

The results obtained will be expanded in further researches - it is necessary to consider more diverse distributions and tests, complicate the experiment by introducing more variables characterizing the sample and more iteration.

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REFERENCES

[1] R. Zhu, F. Zhou, W. Yang, J.-H. Xue, "Statistical hypothesis testing as a novel perspective of pooling for image quality assessment", Signal Processing: Image Communication, 2023, vol. 114, 116942

[2] A.M. da Silva Filho, G.F. Zebende, A.P.N. de Castro, E.F. Guedes, "Statistical test for Multiple Detrended Cross-Correlation Coefficient", Physica A, 2021, vol. 562, 125285

[3] J. Carrasco, S.Garcíaa, M.M.Rueda, S.Das, F. Herrera, "Recent trends in the use of statistical tests for comparing swarm and evolutionary computing algorithms: Practical guidelines and a critical review", 2020, Swarm and Evolutionary Computation, 2020, vol. 54, 100655

[4] Y. Zhou, Y. Zhu, W. K. Wong, "Statistical tests for homogeneity of variance for clinical trials and recommendations", Contemporary Clinical Trials Communications, 2023, vol. 33, 101119

[5] R. Kochana, L. Kovalchuk, O. Korchenko, N. Kuchynska, "Statistical Tests Independence Verification Methods", 25th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems, Procedia Computer Science, 2021, vol. 192, pp. 2678–2688

[6] E. A. Luengo, M. B. L. Cerna, L. J. G. Villalba, J. Hernandez-Castro, "A new approach to analyze the independence of statistical tests of randomness", Applied Mathematics and Computation, 2022, vol. 426, 127116

[7] R Fried, H. Dehling, "Robust nonparametric tests for the two-sample location problem.", Statistical Methods & Applications, 2011, vol. 4(20), pp. 409–422.

[8] R. Fried, "On the online estimation of piecewise constant volatilities." , Computational Statistics & Data Analysis, 2012, vol. 56(11), pp. 3080–3090.

[9] R. A. Maronna, R. H. Zamar, "Robust estimates of location and dispersion of high-dimensional datasets.", Technometrics, 2012, vol. 44(4), pp. 307–317.

[10] B. Phipson, G. K. Smyth, "Permutation p-values should never be zero: Calculating exact p-values when permutations are randomly drawn." Statistical Applications in Genetics and Molecular Biology, 2010, vol. 9(1), Article 39.

[11] K. K. Yuen, W. T. Dixon, "The approximate behaviour and performance of the two-sample trimmed t." Biometrika, 60(2), 369–374

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SMART ENVIRONMENTS

Convolutional Neural Network Model in Human Motion Detection Based on FMCW Radar Signals

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Abstract—The detection of body movements is the essential step for sleep quality analysis. Contactless approaches for sleep motion recognition are unobtrusive and are easier to use in comparison to wearable technologies. In this paper, two contactless sensors based on Frequency-Modulated Continuous Wave (FMCW) radar technology were positioned on the side of, and underneath the bed on which the participant was lying. FMCW data from 10 participants were acquired during the experiment scenario that included the following three states: resting state, movement, and cough. Magnitude-phase coherency method was applied to FMCW data for finding optimal phase signals. Finally, a one-dimensional convolutional neural network was used for the classification based on optimal phase signals. The best classification results were obtained using only FMCW data from the radar positioned underneath the bed: 72% accuracy for differentiating between the resting state, movement, and cough class, and 89% accuracy for the resting state and movement class.

Keywords - frequency-modulated continuous wave radar, movement, cough, magnitude-phase coherency, classification, convolutional neural network

I. INTRODUCTION

Sleep quality can be measured using subjective methods (retrospective questionnaires and sleep diaries) and objective methods based on physiological and behavioral parameters [1]. Polysomnography (PSG) is the gold standard for sleep disturbance detection and is widely used in sleep clinics. Full PSG includes a multimodal measurement of electroencephalography (EEG), electrooculography (EOG), chin electromyography (EMG), electrocardiography (ECG), oronasal airflow, pulse oximetry, thoracic and abdominal movements and body position. The main disadvantage of the PSG approach is its complexity which makes it impossible for home usage without additional medical staff. For that reason, the research and business community invest efforts to offer a wide range of easy-to-use technological solutions suitable for home usage that combine machine learning approaches and that are validated using the standard PSG. These solutions are based on heart rate and heart rate variability features, as well as on actigraphy (body movement classification), on respiratory rate and respiratory rate variability features and brainwave features (distinction of low and high brain frequencies) [1]. Most of the commercially available sleep quality detectors for home usage are based on wearable technology. Recently, the advancement of microwave technology enabled non-contact approaches for monitoring vital signals (heart rate and breathing rate) and body motions. This moves the limits of technical solutions for sleep quality monitoring from wearable (contact) to contactless approaches. Several published solutions for sleeping scenarios use microwave technology based on Doppler radar technology [2-5], Ultra-Wide band (UWB) radar technology [6] or frequency-modulated continuous wave (FMCW) radar technology [7].

The FMCW radar is a device that generates electromagnetic signal that has linearly increasing frequency and transmits it into the propagation space via transmitting antennas. Also, the FMCW system receives reflected signals from objects via receiving antennas and extracts information about the reflective objects. FMCW detection of motion includes estimating the magnitude and phase signals by spectral decomposition of received signals as well as choosing the optimal range bin [8]. In the literature, the optimal range bin was chosen from either magnitude or phase signals. Munoz-Ferreras et al. [9] found the optimal range bin from the maximum averaged magnitude, considering the power of reflected signal from target, while Alizadeh et al. [10] selected the optimal range bin considering the highest variation of phase. Furthermore, traditional machine learning and deep learning approaches have proven to be effective tools for detection and classification of human motions from decomposed radar data [11-13].

In this paper, a convolutional neural network (CNN) approach was used for the movement recognition (differentiating the resting state, movement, and cough classes) based on FMCW phase data of ten lying down participants, while magnitude-phase coherency (MPC) algorithm was used for the selection of the optimal range bin.

II.METHOD

A. Theory FMCW background

FMCW radar is a device that works by frequency modulating the transmission signal. One FMCW radar contains transmitting and receiving systems. The main aim of FMCW radars is obtaining the high-frequently signal with a current frequency given by:

$$f(t) = f_c + \frac{BW}{T_{ch}} t = f_c + St \tag{1}$$

where fc represents the starting frequency for the linear modulated signal, BW bandwidth of the signal (difference between maximum and minimum frequency), Tch the period of the chirp signal, while S represents the slope of the ramp, i.e. division of bandwidth and period of the chirp signal [14].

The current phase of the transmitting signal is obtained by integrating the current angular frequency:

$$\phi(t) = \int 2\pi f(t)dt = 2\pi f_c t + \pi S t^2 \tag{2}$$

From previous relations, the final form of the transmitting signal $v_{tx}(t)$, TX in Fig. 1, is:

$$v_{TX}(t) = A_1 \cos(\phi(t)) = A_1 \cos(2\pi f_c t + \pi S t^2) \tag{3}$$

Fig. 1 illustrates that the received signal $v_{rx}(t)$, RX in Fig. 1, is a delayed version of the transmitting signal $v_{rx}(t)$and its final form is:

$$v_{RX}(t) = A_2 \cos(\phi(t-\tau)) = A_2 \cos(2\pi f_c (t-\tau) + \pi S (t-\tau)^2) \tag{4}$$

where τ is $2\frac{d}{c}$ and it represents delay time of the receiving signal vrx(t), relative to the transmitting signal vtx-(t) where d is the distance from the radar to the observed target and c is the speed of light.

Using the Fourier Fast Transform, magnitude signal M(t,rk) and phase signal P(t,rk) are calculated as:

$$M(t, r_k) = 2\left|\sum_{n=0}^{N-1} v_{RX}(t) e^{-j\frac{2\pi kn}{N}}\right| \tag{5}$$

$$P(t, r_k) = 2\tan^{-1}\frac{imag\left(\sum_{n=0}^{N-1} v_{RX}(t) e^{-j\frac{2\pi kn}{N}}\right)}{real\left(\sum_{n=0}^{N-1} v_{RX}(t) e^{-j\frac{2\pi kn}{N}}\right)} \tag{6}$$

where rk = $\frac{c}{2BW}k$, for k = 0, ..., N-1, N is the number of observed frames. [14]

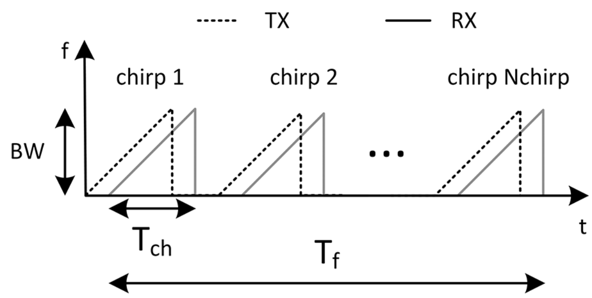

Fig. 1. One frame with duration Tf consisted of Nchirp chirps (Tch – duration of chirp signal)

B. Experiment setup and hardware description

During the experiment, two FMCW AWR1843 radars were used for data acquisition, including a board for evaluation AWR1843BOOST and a board for data collecting DCA1000EVM (Texas Instruments, USA). Number of receiving antennas, N_{rx} was 4 and number of transmitting antennas N_{tx} was 3.

The position of the radars was on the side of, and underneath the participant. Radar 1 was placed underneath the bed, directly under the chest of the participant. On the side, on the designed holder, Radar 2 was placed on the table at a height of 85 cm and 90 cm from the participants' chests, Fig. 2. The distance was measured by a laser rangefinder.

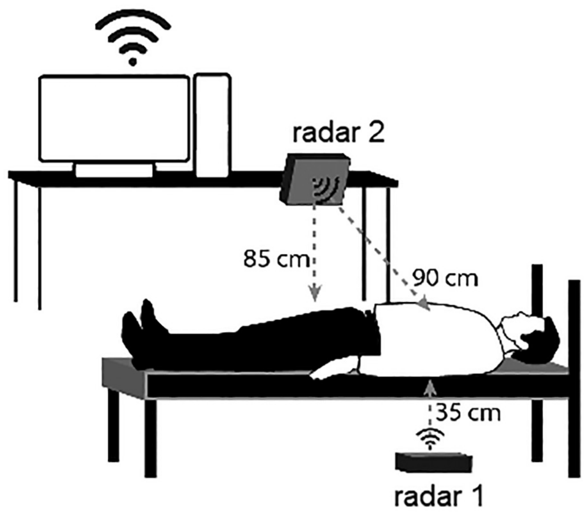

Fig. 2. Experiment setup with two FMCW radars, computer and subject in the lying position.

The configuration of both FMCW radars were set to the following values:

- Started Frequency of Chirp signal, f_c – 79Hz
- Idle Time, IT – 40 μs
- ADC sampling time, TADC – 8 μs
- Duration of Chirp signal, Tch – 75 μs
- Slope of Chirp signal, S – 30 GHz/μs
- Number of Samples per Chirp signal, N_{ADC} – 128

- The sampling frequency, f_s – 2000 kHz
- Number of Chirp signals per frame, N_{chirp} – 32
- Duration of one frame, T_f – 20 ms.

Data acquisition was performed by the mmWaveStudio software (Texas Instruments, USA).

The experiment was performed on ten healthy subjects: ages 26.7±5.23, 4 males and 6 females. They have signed the informed consent to participate in the study.

At the beginning of the experiment, the participant was lying on the back with the hands next to the body. Next, they were following the protocol of the experiment from the prerecorded audio file, when to turn over, and when to cough. The experiment had 5 phases, and the whole experiment lasts 14 minutes, Table I.

Table I. Experiment protocol

Phase No.	Phase description		
	Position	Breathing category	Duration [s]
1	Back	Normal	180
2	Right side	Normal	120
3	Stomach	Normal	120
4	Left Side	Normal	120
5	Back	Cough	5*
	Back	Normal	25*
Total duration			840 (14 min)

*This phase was repeated 10 times.

C. Algoritam description

Data was archived in .bin files with maximum file size of 1 GB. The total data SIZE per file was:

$$SIZE = N_{tx}N_{rx}N_{frames}N_{chirp}N_{ADC}4B \quad (7)$$

where Ntx is the number of transmitting antennas, N_{rx} the number of receiving antennas, N_{frames} the number of frames in one file, N_{ADC} the number of samples per chirp signal and 4B comes from the size of one sent or received data (2B for the real and 2B for the imaginary part).

Data were loaded and processed frame by frame in a 4D structure with dimensions N_{adc} x N_{chirp} x N_{rx} x N_{tx} =128x32x4x3.

The implemented algorithm includes the following steps, (Fig. 3):

- Fourier Fast Transform (1D-FFT, N_{fft}=128 points, Blackman windowing) of received signals. 1D-FFT coefficients are added to the buffer. The buffer size of 600 x N_{fft} x N_{chirp} x N_{rx} x N_{tx} was selected regarding the maximum breathing period of $T_{breating\_max}$=12 s [15] – the first dimension value 600 was calculated as $T_{breathing\_max}$ / T_{frame}.
- limiting N_{fft} dimension to the target bin range 10cm – 3m (limiting to the part where the target can be physically found)
- average buffer signals through all chirp signals, all transmitting and receiving antennas
- magnitude extraction within the buffer, M_{buffer} – applying of Eq. 5 to the averaged buffer signals
- phase extraction within the buffer, P_{buffer} – applying of Eq. 6 to the averaged buffer signals
- MPC algorithm for the optimal range bin detection (within the buffered data)(Section II C)
- creating the total phase signal, Ptotal of one .bin file
- total phase signal unwrapping of one .bin file, Ptotal_unwrapped, (Section II C2)
- CNN performance on $P_{total\_unwrapped}$ signals (Section II C3).

Data load, preprocessing and optimal phase detection were performed using the *Matlab* R2022a environment while neural network data preparation and experiment phase recognition were done in the *Python* environment version 3.10.11.

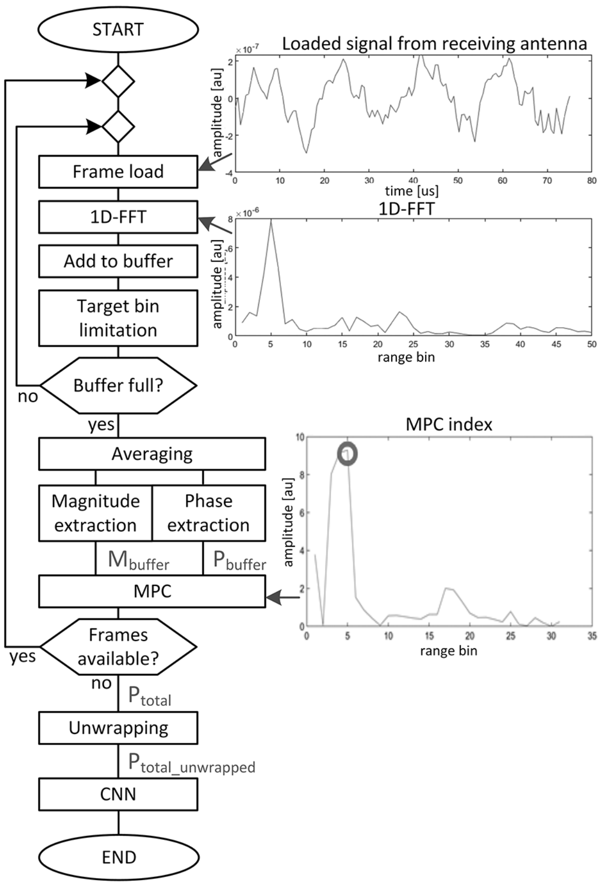

Fig. 3. Flow chart of the implemented algorithm

C1. Magnitude-phase coherency (MPC) method

An example of the magnitude signal for normal breathing and movement is presented in Fig. 4A.

It can be observed that targets existed at 25 cm to 60 cm (4-5 range bin) from the radar 1. Also, there are changes in the amplitude through bins that represent the target area because of the chest motion in those bins. The higher amplitudes represent the time when the subject inhales, so the chest is closer to the radar, and the smaller amplitudes represent the time when subject exhales, so the chest is further away from radar. Also, at the end of the figure, the amplitude is low because of the occurrence of body movement (red rectangle).

Fig. 4B, shows a magnitude signal for cough and normal breathing. A cycle of cough and normal breathing (phase 5, 5 s+25 s=30 s) is marked by a red rectangle. Higher amplitudes of signal represent cough, whereas smaller amplitudes with oscillations represent normal breathing.

MPC method uses magnitude and phase signals and considers that they are highly correlated and that the coherence between them is going to be high. Two signals are coherent if they have equal frequencies, polarizations and a constant phase ratio.

To describe the mentioned coherence, the concept of MPC index was used:

$$MPC(t,r) = \frac{\left|\sum_{s=t-t0}^{t} M(s,r)P(s,r)\right|}{\sigma_M(r)\sigma_P(r)} \tag{8}$$

where M(s,r) represents the magnitude signal, P(s,r) is the phase signal, from which the mean value is subtracted, σM(r) is the standard deviation of the magnitude signal through all frames (i.e. observed time slots), σP is the standard deviation of the phase signal through all frames. MPC(t,r) represents the obtained function – MPC index in the observed moment of time (frame) depending on the vector of range bins [16].

An example of MPC index was illustrated in Fig. 3. After forming functions of MPC indexes, it is necessary to find the position of the maximum (red circle in Fig. 3), and then declare this position for an optimal candidate for the chosen range bin. The position of the maximum in MPC indexes represents the range bin in which magnitude and phase signals are the most coherent. Observing Fig. 3, it can be obtained that the maximum MPC function is on fifth position (range bin), i.e. approximately 50 cm from the radar.

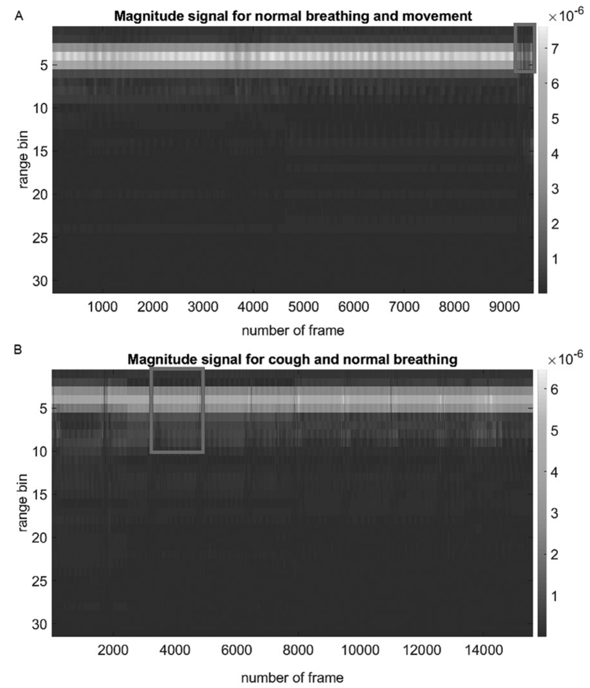

Fig. 4. A) Magnitude signal for normal breathing and movement (phase 1 of experiment protocol), B) Magnitude signal for cough and normal breathing, repeated 10 times (phase 5 of experiment protocol)

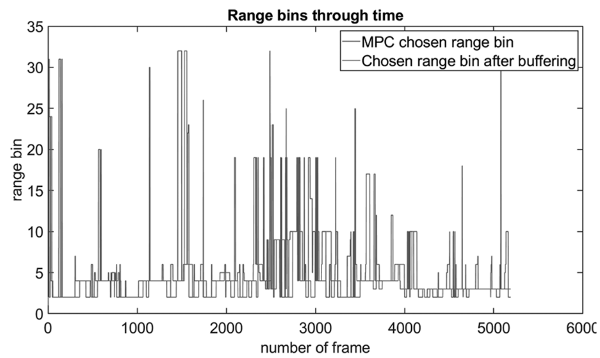

Fig. 5. An example of the range bin selection through time for normal breathing

After forming the candidate for optimal phase, it is necessary to store it in the buffer (buffer size 100). After filling the whole buffer, the most frequent range bin is found, which is going to be declared for optimal phase (i.e. range bin) in observed moment of time. Fig. 5 illustrates a graphic with obtained candidates for optimal phase through time for one .bin file, as well as the final chosen range bins after buffering which is going to be used for forming the phases.

C2. Phase unwraping

An example of selected optimal phase obtained by MPC is given in Fig. 6.

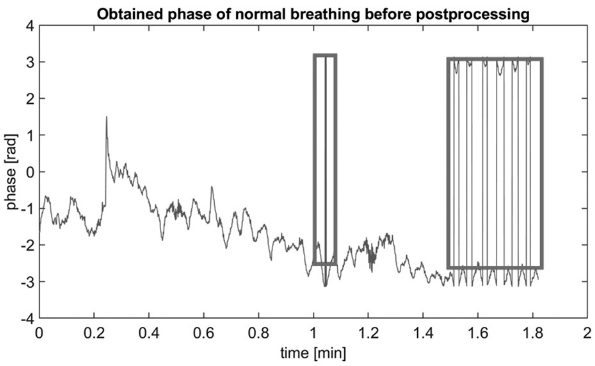

Fig. 6. An example of optimal phase signal Ptotal of normal breathing ("sudden jumps" – red rectangles)

"Sudden jumps" can be observed in the extracted optimal phase in Fig. 6 These "jumps" are a consequence of the application *matlab* function angle over magnitude signal and changes of the chosen range bin over time. It is necessary to use *matlab* function unwrap which removes "sudden jumps" from the signal (i.e. all changes in signal which are bigger than 2π). The result after the removal of "sudden jumps" is shown in Fig. 7.

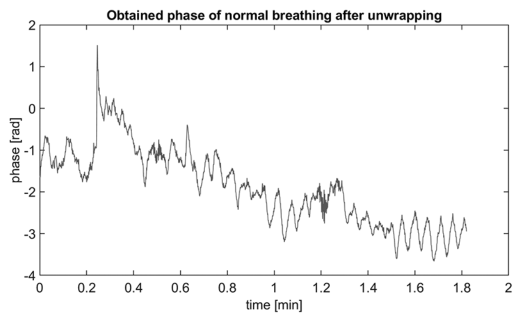

Fig. 7. Obtained phase signal of normal breathing after unwrapping, Ptotal_unwrapped

C3. CNN description

CNN was used for movement and cough detection with two evaluation scenarios. The first scenario included the classification of three states: movement, coughing and normal breathing state (three class recognition) and the second scenario included the differentiation between movement and the normal breathing state (2 classes recognition). The CNN architecture was the same for both evaluation scenarios, with the only difference being in the number of neurons in the output layer. The CNN architecture is presented in Table II. It consists of 1D convolutional (CN) and max pooling (MP) layers, dropout layers (DP), batch normalization layers (BN) and fully connected layers (FC). The network was implemented using the Python programming language version 3.10.11 with the TensorFlow library version 2.12.

For CN the strides were 1, for MP the strides were 2, DP rate was 0.5 and the activation function for all layers was the Exponential Linear Unit except for the final layer which had the Softmax activation function. All convolutional layers had l2 kernel regularizers with the l2 factor set to 0.01. The network was trained using an Adam optimizer with the initial learning rate set to 0.0001. The loss function of the network was a weighted categorical cross-entropy, with each class having a weight that is inversely proportional to the number of datapoints from that given class in the train set. The network was trained and evaluated based on the 5-fold subject-wise cross-validation (each fold contained data from two participants). Three folds were used for training, one for validation and one for testing. The maximum number of epochs was set to 300 and early stopping was implemented based on the loss function on the validation set, with the patience parameter set to 20. The network was evaluated using the F1 score, precision and recall for each class as well as the macro average for each metric and the overall classification accuracy.

III. RESULTS WITH DISCUSSION

An example of the obtained optimal phases by the MPC algorithm during the resting state, coughing and moving of subjects from the experiment are shown in Fig. 8–10.

Fig. 8–10 illustrate that it is possible, by visual inspection, to make the distinction between the resting state, cough and movement phase signals. In the cough scenario, the phase amplitude has higher values than in normal resting. Also, in the cough scenario, the higher variance of signal could be observed in comparison to the movement phase. This conclusion is expected because the subject made larger movements while switching between different sides than the movements they made during coughing.

Table III presents the CNN classification results for both classification problems: differentiating between the resting state, movement, and cough classes (three classes), and differentiating only between the resting state and movement classes (two classes recognition), for all radar

Table II. CNN architecture

	Layer number																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1/7	18
type	CN	CN	BN	MP	DP	CN	CN	BN	MP	DP	CN	CN	BN	MP	DP	FC	DP	FC
kernel size	50	50	/	2	/	50	50	/	2	/	25	25	/	2	/	/	/	/
filter size	64	64	/	/	/	64	64	/	/	/	32	32	/	/	/	/	/	/
FC size	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	40	/	2

configurations (only radar 1, only radar 2 and both radars).

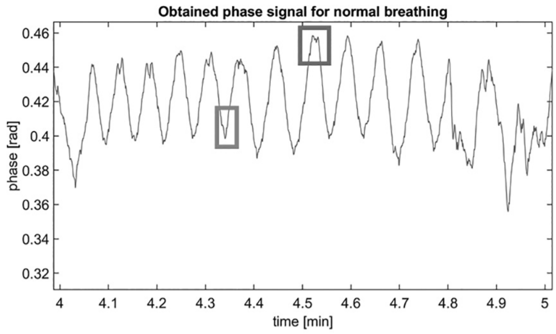

Fig. 8. An example of obtained phase signal for normal breathing – subject lying on the right side (one inhale – red rectangle, one exhale – green rectangle)

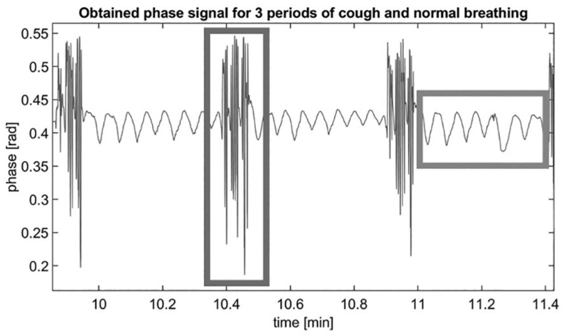

Fig. 9. An example of obtained phase signal for 3 periods of cough and normal breathing (cough – red rectangle, normal breathing – green rectangle)

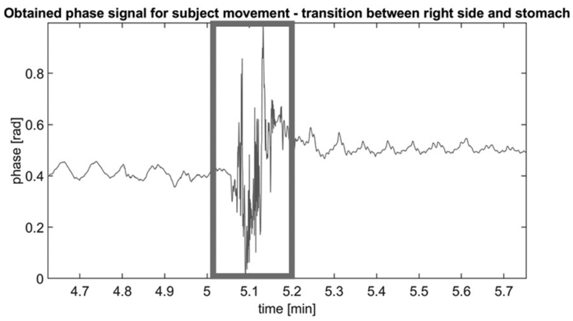

Fig. 10. An example of obtained phase signal for subject movement – transition between right side and stomach (movement – red rectangle)

It can be concluded that the maximum value of accuracy was 89 % for the two classes recognition (resting vs movement) for radar 1. Also, it can be concluded that higher values of accuracy are for radar 1 in comparison to the results for radar 2 or for both radars. The reason for these results is the small value of signal-to-noise ratio for radar 2, because of which CNN cannot detect the differences between the classes. Furthermore, observing the metric F1 Score for individual classes, it can be concluded that the best detected class was normal breathing. The imbalanced classes in combination with individual differences between the subjects and their movement and cough patterns could be the reason for the encountered accuracy detection barrier. However, with larger datasets containing more subjects, more complex CNN architecture and a combination of multiple radar phase signals from an adequately positioned sensor, further studies could further develop and improve the obtained results.

Table III. The CNN results for three classes recognition (radar 1)

Category	F1 score	Precision	Recall	Accuracy [%]
THREE CLASSES, RADAR 1				
Resting state	0.84	0.96	0.76	
Movement	0.40	0.33	0.54	
Cough	0.23	0.16	0.44	
Overall	0.49	0.48	0.58	72
THREE CLASSES, RADAR 2				
Resting state	0.80	0.96	0.69	
Movement	0.44	0.34	0.70	
Cough	0.24	0.16	0.49	
Overall	0.49	0.49	0.63	68
THREE CLASSES, BOTH RADARS				
Resting state	0.82	0.96	0.72	
Movement	0.46	0.39	0.59	
Cough	0.29	0.19	0.62	
Overall	0.53	0.25	0.65	71
TWO CLASSES, RADAR 1				
Resting state	0.94	0.99	0.89	
Movement	0.54	0.40	0.84	
Overall	0.74	0.69	0.87	89
TWO CLASSES, RADAR 2				
Resting state	0.90	0.94	0.86	
Movement	0.23	0.18	0.35	
Overall	0.56	0.56	0.61	82
TWO CLASSES, BOTH RADARS				
Resting state	0.92	0.98	0.86	
Movement	0.49	0.35	0.85	
Overall	0.70	0.67	0.86	86

IV. CONCLUSION

In this paper, an MPC method was applied to FMCW radar data for finding optimal phase signals in order to classify movement vs resting state and, in another scenario, movement, cough and resting state classes. Observing the results of the obtained phases, it can be concluded, by visual inspection, that there are distinctions between different states of the subjects. CNN results were better for radar 1 that was positioned underneath the bed than for the side radar 2 or both radars. Furthermore, CNN did not have enough data about the observed classes, because of class imbalance (resting state data being far more common than coughing or movement). For further investigations, there are possibilities for increasing the distance resolution in order to improve the implemented MPC algorithm. Also, it is necessary to record additional radar data for a larger number of subjects whereby it is expected that accuracy of CNN results would be improved.

ACKNOWLEDGMENT

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REFERENCES

[1] Crivello, A. Barsocchi, P. Girolami, M. and F. Palumbo, “The meaning of sleep quality: a survey of available technologies,“ IEEE Access, vol. 7, pp. 167374-167390, 2019.

[2] Hong, H. Zhang, L. Gu, C. Li, Y. Zhou, G. and X. Zhu, “Non-contact sleep stage estimation using a CW doppler radar,“ IEEE Journal on Emerging and Selected Topics in Circuits and Systems, vol. 8, pp. 260-270, 2018.

[3] Zakrzewski, M. Vehkaoja, A. Joutsen, A. S. Palovuori, K. T. and J. J. Vanhala, “Noncontact respiration monitoring during sleep with microwave Doppler radar,“ IEEE Sensors Journal, vol. 15, pp. 5683-5693, 2015.

[4] De Chazal, P. Fox, N. O’HARE, E. M. E. R., Heneghan, C. Zaffaroni, A. Boyle, P. McNicholas and W. T. “Sleep/wake measurement using a non-contact biomotion sensor. Journal of sleep research,“ vol. 20, pp. 356-366, 2011.

[5] Chung, K. Y. Song, K. Shin, K. Sohn, J. Cho, S. H. and J. H. Chang, “Noncontact sleep study by multi-modal sensor fusion. Sensors,“ vol. 17(7), pp. 1685, 2017.

[6] R. De Goederen, S. Pu, M. Silos Viu, D. Doan, S. Overeem, W.A. Serdijin, K. F. M. Joosten, X. Long, J. Dudink, “Radar-based sleep stage classification in children undergoing polysomnography: a pilot-study. Sleep Medicine, “ vol 81, pp. 1-8, 2021

[7] Turppa, E. Kortelainen, J. M. Antropov, O. and T.Kiuru, “Vital Sign Monitoring Using FMCW Radar in Various Sleeping Scenarios. Sensors,“ vol. 20, pp. 6505, 2020.

[8] M. He, Y. Nian and Y. Gong, „Novel signal processing method for vital sign monitoring using FMCW radar,“ School of Biomedical Engineering, Third Military Medical University, Chongqing, 400038, China, vol. 33, pp. 335-345, 2017.

[9] J. -M. Muñoz-Ferreras, J. Wang, Z. Peng, C. Li and R. Gómez-García, "FMCW-Radar-Based Vital-Sign Monitoring of Multiple Patients," 2019 IEEE MTT-S International Microwave Biomedical Conference (IMBioC), Nanjing, People’s Republic of China, pp. 1-3, 2019.

[10] M. Alizadeh, G. Shaker, J. C. M. D. Almeida, P. P. Morita and S. Safavi-Naeini, "Remote Monitoring of Human Vital Signs Using mm-Wave FMCW Radar," IEEE Access, vol. 7, pp. 54958-54968, 2019.

[11] Y. Ge, A. Taha, SA. Shah, K. Dashtipour, S. Zhu, J. Cooper, QH. Abbasi and MA. Imran "Contactless WiFi Sensing and Monitoring for Future Healthcare-Emerging Trends, Challenges, and Opportunities. IEEE Reviews in Biomedical Engineering,“ pp. 171-91, 2023.

[12] Y. Song, W. Taylor, Y. Ge, M. Usman, Imran MA, QH. Abbasi, „Evaluation of deep learning models in contactless human motion detection system for next generation healthcare. Scientific Reports,“ vol. 12, pp. 21592, 2022.

[13] A. Shrestha, H. Li, J. Le Kernec and F. Fioranelli, „Continuous human activity classification from FMCW radar with Bi-LSTM networks,“ IEEE Sensors Journal, vol. 20, pp. 13607-19, 2020.

[14] Skolnik I. Merril, „Introduction to Radar Systems,“ MacGraw-Hill, New York City, United States, 2001.

[15] A. De Groote, M. Wantier, G. Cheron, M. Estenne, and M. Paiva, ‘‘Chest wall motion during tidal breathing,’’ J. Appl. Physiol., vol. 83, pp. 1531–1537, 1997.

[16] Choi, H. Song and H. -C. Shin, "Target Range Selection of FMCW Radar for Accurate Vital Information Extraction," IEEE Access, vol. 9, pp. 1261-1270, 2021.

Fall Detection of Elderly in Ambient Assisted Smart Living Using CNN Based Ensemble Approach

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Abstract—In recent years, there has been a significant increase in ambient assisted living and smart environment homes that utilize a range of technologies to enhance the quality of life for elderly people. Fall detection is an essential service that smart home healthcare can provide as falls can pose a significant threat to the independence and health of individuals over 65 years old. This article introduces the ISBFD (Inertial Sensor Based Fall Detection) concept, which aims to identify elderly persons who fall and alert family members or carers right away. The proposed model employs data from the accelerometer sensor of a smartphone in real-time. This data is then processed by a fall detection system that can run directly on the device. In this study, an initial-level deep learning model for fall detection is deployed along with subsequent models using ensemble learners, and it is trained on the publicly accessible MobiAct dataset. A comparative analysis is drawn between initial (Convolution Neural Networks) and final predictors (Ensemble Learners). The health and well-being of elderly people can be considerably improved by the ISBFD model, which makes it possible to detect falls and promptly warn carers with accuracy upto 93% approximately.

Keywords— Smart homes, Fall detection, CNN, Ensemble, Inertial sensors.

I. INTRODUCTION

The risk of falls among people 65 and older is a major public health problem. A fall refers to an unplanned and sudden drop from a position of elevation to a lower one. According to the World Health Organization's assessment, falls account for as much as 40% of injury-related fatalities in the elderly population globally [1]. Consequently, falls rank as the second leading cause of death following automobile accidents. Furthermore, falls are responsible for 60% of head injuries and 90% of hip and wrist fractures among the elderly population. Elderly people's mental health might suffer from frequent falls, which can undermine their self-confidence and ability to live independently [2]. Given the circumstances, it is imperative that older people remain in their homes for as long as they can, unless they have a condition that necessitates hospitalisation and endangers their lives. However, an accurate system must be in place to allow for remote health checks before this can be accomplished. Smart home healthcare has recently been a successful method for remotely monitoring elderly persons who live at home [3]. The well-being of elderly individuals is tracked by this technology using a range of devices, including as infrared sensors, mouthpieces, cameras, pressure sensors, and wearable sensors [4-6]. Then, in order to promote better illness management and ensure the elderly's well-being while living at home, this information is disseminated to medical professionals and carers. One of the most essential services provided by assisted home care is fall detection. However, commercial fall detection systems have a limited field of view and are expensive to install and operate. In addition, privacy issues are raised by video-based fall monitoring systems. To improve care for the elderly, it is crucial to create a fall detection system that is more affordable, automated, flexible, and dependable. The use of smartphones with sensors like accelerometers and gyroscopes by elderly persons is on the rise. Using the information gathered from various sensors, this technique allows for the detection of falls. Smartphones with sensors, as compared to wearable sensors, are adaptable and convenient. Elderly persons may not feel comfortable wearing sensors, but since they are more likely to carry smartphones, fall detection on smartphones is an easy alternative.

This paper suggests the use of the ISBFD framework which uses a platform for smart home healthcare that is assisted to identify falls in real time and enable help requests. The framework makes use of accelerometer sensor data from a smartphone, which is then processed and examined by a fall detection system that can runs online on the phone. Smartphone-based fall recognition systems have been thoroughly investigated by researchers in earlier works [7-9]. In these research, falls were detected using features gathered from smartphone sensors using threshold-based decision algorithms [10]. Although developing threshold-based decision algorithms is easier and requires less processing, selecting the appropriate threshold values requires striking a careful balance between identifying all falls (true positives) and avoiding classifying routine actions as falls (false positives). Finding thresholds that reliably function for everyone is challenging. Support vector machines [7] and Artificial neural networks [8] are two machine learning techniques that have recently been utilised to categorise falls from daily activities. Cahoolessur et al. [11] created a machine learning model based on waist-worn wearable devices using the XGBoost algorithm and the Sisfall dataset. To forecast falls, the model makes use of acceleration data that has been preprocessed into features.

Although these methods have generated good results, deeper understanding can be attained by applying deep learning models that make use of the substantial quantity of data that can be gathered from mobile sensors. In the fall detection system, Wang et al. [12] proposed a multi-source CNN integrated structure where the data from the pressure sensor, acceleration sensor, and gyroscope are individually preprocessed and formatted. Another study in [13] presented experimental model to enhance the care provided to elderly residents using a context-aware sensor system (CARE) for nurses in nursing homes through an Android tablet application. Long short-term memory (LSTM) network [15] and a Convolutional neural network (CNN) [14] have been combined to create a deep CNN ensemble model, which is an ensemble based learning model that has been created in the proposed ISBFD framework. The accelerometer sensor in smartphones is used to derive localised features. A dropout method is used to arbitrarily neglect a few neurons during training in order to prevent overfitting. The suggested model is trained using offline data, and it can then be integrated with smartphones for online, real-time fall detection. Using accelerometer data gathered from the publicly available dataset MobiAct, the ISBFD framework is validated for real-time fall detection use cases [16]. According to experimental findings, the suggested framework can categorise falls and non-falls more precisely. The rest of this article is organized as follows. First, we will discuss the proposed framework for detecting falls in the elderly. Then, we go over each component of this structure in depth. Following that, we brief the proposed approach for real-time fall detection, which is based on deep learning and ensemble models. Finally, we give the experimental findings that indicate the effectiveness of the suggested deep CNN-based ensemble technique.

II. METHODOLOGY

The primary components of the ISBFD architecture are depicted in Fig. 1. This system operates by collecting live data from a smartphone's accelerometer, gyroscope, and orientation sensors, which are then analyzed and processed by an integrated real-time fall detection system. Subsequently, the smartphone can generate an auditory alert via a Wireless Application Protocol (WAP) to notify family members and an SMS alert to inform caregivers via a mobile network.

A. Data processing and Feature extraction module

In this module, a 200-record window size is used to analyze and normalize the signal of human activity detected by smartphone sensors in real-time. This window size is sufficient to analyze each activity. With respect to the accelerometer sensor, 15 features are calculated from each of its three axis, for a total of 45 features. Fig. 2 illustrates and lists all of the attributes computed, including maximum value, maximum absolute value, minimum value, and minimum absolute value.

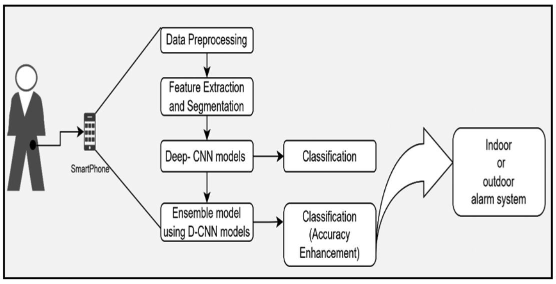

Fig. 1. ISBFD framework

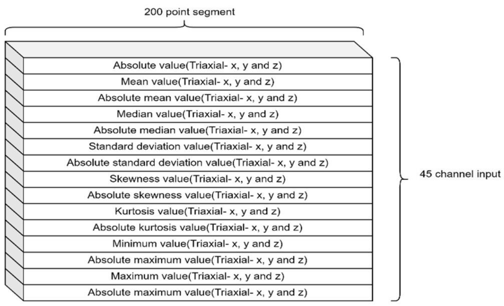

Fig. 2. 45-channel input feature set

B. CNN Architecture

In our model, we followed a typical Convolutional Neural Network (CNN) architecture. CNNs are basically group of three main components or layers: convolutional, pooling, and fully-connected layers. For experiments we fragmented data into segments having size 200 X 45, which contain 200 record points and 45 features. Convolution operations are used to create the convolution layers of CNN models, which are then followed by the max-pooling layer. Next layer of CNN is activation function, it takes inputs from previous convolution layer. Rectified Linear Unit (ReLU) activation function is used in this study. The last layer of the CNN is a Fully-Connected (FC) layer. The output from FC layer is then fed into a softmax function, which produces a categorization over the 2 classes, falling and non-falling activities of daily life. Our model's performance was evaluated using a dataset of 4000 samples.

The study evaluates four different CNN models for fall recognition. Model I has 1 convolutional layer and one fully-connected layer. Model II has 4 convolutional layers and 1 fully-connected layer, using 8 x 1 convolutional and pooling kernels. Model III is a wide neural network consisting of 5 convolutional layers and 1 FC layer. The first convolutional layer has 96 kernels having size as 8 and stride as 1 on a 200 x 45 input segment. The second layer has 256 kernels, and the third and fourth have 384 kernels each. The fifth layer has 256 kernels. A max-pooling layer of size 8 and a ReLU activation function are present in every convolutional layer. Both max-pooling and convolution kernels use the same amount of padding. This prevents differences in input and output size [17]. Model IV has six convolutional layers with 1 fully-connected layer and kernels of sizes 128, 256, 512, 1024, and 512. In all models, dropout is used to prevent overfitting.

The CNN models used in the study are thoroughly described in Table I.

Table I. CNN model architecture

<table>
<tr><th>Model name</th><th>1st Layer</th><th>2nd Layer</th><th>3rd Layer</th><th>4th Layer</th><th>5th Layer</th><th>6th Layer</th><th></th><th>Total Layers</th></tr>
<tr><td rowspan="2">Model I</td><td>4 kernels- conv 8</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td rowspan="8">Dropout and Fully Connected Layer</td><td rowspan="2">1+1=2</td></tr>
<tr><td>Max-pooling size=4</td><td>Max- pooling size=4</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Model II</td><td>4 kernels- conv 8</td><td>8 kernels- conv 8</td><td>16 kernels- conv 8</td><td>32 kernels- conv 8</td><td>-</td><td>-</td><td rowspan="2">4+1=5</td></tr>
<tr><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Model III</td><td>96 kernels- conv 8</td><td>256 kernels- conv 8</td><td>384 kernels- conv 8</td><td>384 kernels- conv 8</td><td>256 kernels- conv 8</td><td>-</td><td rowspan="2">5+1=6</td></tr>
<tr><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>-</td></tr>
<tr><td rowspan="2">Model IV</td><td>128 kernels- conv 8</td><td>256 kernels- conv 8</td><td>512 kernels- conv 8</td><td>1024 kernels- conv 8</td><td>1024 kernels- conv 8</td><td>512 kernels- conv 8</td><td rowspan="2">6+1=7</td></tr>
<tr><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td><td>Max- pooling size=8</td></tr>
</table>

C. Ensemble Models

The process of combining predictions from multiple machine learning models is known as an ensemble classifier. Such classifiers have potential of providing high accuracy results when their performance is compared against single classifiers. Some popular ensemble methods such as boosting, bagging and stacking are widely used. We have used stacking as one of our ensemble where we combine the outputs of a set of base learners and using another algorithm, known as the meta-learner, to make the final predictions. This approach can help improve the accuracy of the final predictions by combining the strengths of multiple models [18]. Ensemble methods are widely used in neural networks to improve the accuracy of predictions. Two commonly used ensemble methods are average voting and majority voting. The approach is to calculate the average or majority of the predicted probabilities from every model is used to generate a posterior label. Alternatively, the most common predicted label from all the models can be selected as the final prediction. Another method involves assigning weights to each model based on their performance, and combining their predictions using these optimal weights. After that using the weighted prediction from each model final prediction is made.

In summary, the study explores four different methods for combining the outcomes of multiple CNN models: majority, average voting, optimal weights, and logistic regression as meta-learner. The optimal weights are calculated by reducing the mean squared error function of the output coming from the base learners, and best-performing classifiers are assigned comparatively high weights. In order to improve the accuracy of CNN models further, ensembles are used. Here the CNN models are referred to as base learners (initial predictors) and the models used to make the resultant predictions are referred to as subsequent models.

III. EXPERIMENTS AND DISCUSSIONS

The proposed framework was evaluated on a laptop running on a Windows operating system, equipped with an i7-4510U CPU (2.0 GHz) processor and 8 GB RAM. The implementation was carried out using the Python programming language on Google Colab. The performance of the model was evaluated using the accuracy measure.

$$\text{Accuracy} = (TP + TN)/(TP + FP + TN + FN) \tag{1}$$

In equation (1), the accuracy measure is defined as the ratio of correctly recognized samples to all samples in the testing set. The measure includes true positive (TP) and false positive (FP) rates, as well as true negative (TN) and false negative (FN) rates. The next subsections provide information on the materials used in the experiments, such as the dataset, and the results are presented with comparisons and discussions.

A. Data Description

In our experiment, we utilized the MobiAct dataset to evaluate the proposed ISBFD framework. Biomedical Informatics and Health lab collected and published data publically for non-commercial research and educational purposes [16]. The raw data used in the study was collected from Samsung Galaxy S3 smartphones placed in the side pockets of participants. The data was gathered from accelerometers, gyroscopes, and orientation sensors. MobiAct dataset contains recordings from 67 subjects performing 4 types of falls, 11 types of daily living activities, and a lying activity after a fall. Both male and female subjects were included in the dataset, ranging in age from 20 to 47 years, height from 160 to 189 cm. For the case study, a portion of the raw accelerometer signal data was used, which included 4 different falls and 2 activities of daily life (viz. standing and lying) during the inactive period after a fall activity has been observed. Table III in the study provides more detailed information on the activities of daily life and falling acts included in the dataset.

B. Hyperparameters Used

In the initial experiment, we tested different types of CNN structures to see which ones works better for our task. We tried various combinations of layers, kernels, pooling size, optimization methods, stride size, batch sizes and activation functions. We found that for our problem Adam optimize works well when experimented with other optimizers such as gradient descent. Learning rate is set to 1e-4 for all the CNN models. We experimented with 50, 100, and 200 epochs, and we applied early stopping techniques and dropout technique to prevent model from overfitting. We provided varied batch sizes of like 16, 32, 64, and 128, and we concluded that a batch size of 64 provided better results. Finally, we compared three activation functions: 'tanh', 'Relu', and 'Leaky Relu', and we found that 'Relu' gave the best results. The initial predictors in this study consist of models I to IV (refer to Table I), which were developed using various CNN architecture types and their corresponding values used as hyper- parameter are indicated in Table II. Afterward, each method in the subsequent predictors is used to predict the final labels based on the output generated by the initial predictor models.

Table II. Hyperparameter values used

Hyper-Parameter	Value used	
Max- Pooling layer	Pooling size: 2, 4, 8	
Batch size	64	
Epoch Iterations	50,100,200	
Activation Layer-Output	Softmax	
Optimizer	Adam	
Conv Layer	Stride	1,2
	Activation function	ReLU
	Kernel size	2, 4, 8
	# kernels	4,8,16,32,96,128,256,384,512,1024

Table III. Activity Description of Mobiact Dataset

S.No	Activity	Description	Trails	Time Duration(sec)
1	Forward-lying	A forward fall from a standing position where the individual uses their hands to reduce the impact of the fall.	3	10
2	Front-knees-lying	Upon falling forward from a standing position, the initial impact is observed on the knees.	3	10
3	Back-sitting chair	A fall occurring during an attempt to sit on a chair, with a backward motion.	3	10
4	Sideward-lying	A sideways fall from standing position while bending legs.	3	10
5	Standing	Stationary stance with minor perturbations	1	300
6	Walking	Normal walking.	1	300
7	Jogging	Jogging.	3	30
8	Jumping	Continuous jumping.	3	30
9	Stairs up	Ascending a 10-step staircase.	6	10
10	Stairs down	Descending a 10-step staircase.	6	10
11	Stand to sit (sit on chair)	Transition from standing to sitting	6	6
12	Sitting on chair	Sitting on a chair with minor perturbations	1	60
13	Sit to stand (up from chair)	Transition from sitting to standing.	6	6
14	Car-step in	Stepping-in inside car.	6	6
15	Car-step out	Stepping-out of car.	6	6
16	Lying	An activity performed during the period of lying down following a fall.	12	NA

Fig. 3 shows the train and test accuracy as well as the loss function of Model IV. The train accuracy rises as the when we increase number of epochs, while the test accuracy reaches a stable point at around 100 epochs.

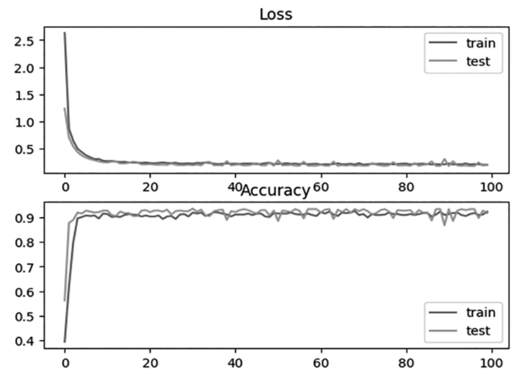

Fig. 3. Model IV Accuracy and Loss Curves (Train and Test)

C.Comparision with Ensemble Variants

Table IV illustrates the accuracy obtained by CNN models and their variations along with the performance of ensemble learners. With a prediction accuracy of 92.72%, the optimal weight technique outperforms even the best performing CNN model, Model IV. When Random Forest is used as meta-learner in stacking ensemble, highest prediction accuracy of approximately 93.51%, is obtained, indicating a better performance. Average voting ensemble did not perform well when compared with model IV but similar performance has been observed when compared with majority voting ensemble.

IV. CONCLUSION AND FUTURE WORK

It's critical to recognise falls accurately and immediately for ambient assisted smart living in healthcare, especially for elderly adults. This article introduces a fall recognition framework enabled by smartphones that identifies falls by continuously and automatically analyzing data from the smartphone's inertial sensors. In order to detect falls in real-time, we used a deep ensemble learning model that was trained offline on the publicly available MobiAct dataset. The proposed system can predict the activity into two categories namely non-falling act and falling act with more precision.

The ability of various convolutional neural networks (CNNs) to predict falls in elderly people has been subjected to the test. The raw sensor data was divided into 45 segments, each of which was of 200 points in size after pre-processing. To achieve high prediction accuracy, we studied different CNN architectures, combined the results using ensemble methods, and then looked into further CNN architectures. We used a number of CNN models in our ensemble model, each with different hyper-parameter values and configurations. Using "majority voting," "average voting," and each classifier's optimal weight, the outcomes of CNN models were combined. As a meta-learner, we also used Logistic Regression (LR). Different ensemble strategies that we tested all outperformed standalone CNN models. The ensemble methodology using LR as a meta-learner outperformed the other three methods as well, with an accuracy of 93.51%. Both the majority vote and the optimal weight techniques predicted percentages that were roughly in the range of 91-92%. In the future, we aim to integrate more sensor data, such as GPS data to track users' movements and integrate monitoring of other health related activities.

Table IV. Test accuracy of all experimented models

Model	Model I	Model II	Model III	Model IV	Ensemble Model (Average Voting)	Ensemble Model (Majority Voting)	Ensemble Model (Optimal weight)	Ensemble Model (LR as meta-learner)
Accuracy(%)	73.29	78.53	86.16	91.83	90.74	91.46	92.72	93.51

REFERENCES

[1] Todd, C., & Skelton, D. (2004). What are the main risk factors for falls amongst older people and what are the most effective interventions to prevent these falls?. World Health Organization. Regional Office for Europe.

[2] Fortino, G., & Gravina, R. (2015). Fall-MobileGuard: A smart real-time fall detection system. In Proceedings of the 10th EAI International Conference on Body Area Networks (pp. 44-50).

[3] Kvedar, J., Coye, M. J., & Everett, W. (2014). Connected health: a review of technologies and strategies to improve patient care with telemedicine and telehealth. Health affairs, 33(2), 194-199.

[4] Wan, J., Zou, C., Ullah, S., Lai, C. F., Zhou, M., & Wang, X. (2013). Cloud-enabled wireless body area networks for pervasive healthcare. IEEE Network, 27(5), 56-61.

[5] Hossain, M. S., & Muhammad, G. (2019). Emotion recognition using deep learning approach from audio–visual emotional big data. Information Fusion, 49, 69-78.

[6] Hossain, M. S., Muhammad, G., & Alamri, A. (2019). Smart healthcare monitoring: a voice pathology detection paradigm for smart cities. Multimedia Systems, 25, 565-575.

[7] Albert, M. V., Kording, K., Herrmann, M., & Jayaraman, A. (2012). Fall classification by machine learning using mobile phones. PloS one, 7(5), e36556.

[8] Kerdegari, H., Mokaram, S., Samsudin, K., & Ramli, A. R. (2015). A pervasive neural network based fall detection system on smart phone. Journal of Ambient Intelligence and Smart Environments, 7(2), 221-230.

[9] Hassan, M. M., Uddin, M. Z., Mohamed, A., & Almogren, A. (2018). A robust human activity recognition system using smart-

phone sensors and deep learning. Future Generation Computer Systems, 81, 307-313.

[10] Yu, D., & Li, J. (2017). Recent progresses in deep learning based acoustic models. IEEE/CAA Journal of automatica sinica, 4(3), 396-409.

[11] Cahoolessur, D. K., & Rajkumarsingh, B. (2020). Fall detection system using XGBoost and IoT. R&D Journal, 36, 8-18.

[12] Wang, L., Peng, M., & Zhou, Q. (2020). Pre-impact fall detection based on multi-source CNN ensemble. IEEE Sensors Journal, 20(10), 5442-5451.

[13] Klakegg, S., Opoku Asare, K., van Berkel, N., Visuri, A., Ferreira, E., Hosio, S., ... & Ferreira, D. (2021). CARE: Context-awareness for elderly care. Health and Technology, 11, 211-226.

[14] Hsieh, Y. Z., & Jeng, Y. L. (2017). Development of home intelligent fall detection IoT system based on feedback optical flow convolutional neural network. Ieee Access, 6, 6048-6057.

[15] Greff, K., Srivastava, R. K., Koutník, J., Steunebrink, B. R., & Schmidhuber, J. (2016). LSTM: A search space odyssey. IEEE transactions on neural networks and learning systems, 28(10), 2222-2232.

[16] Vavoulas, G., Chatzaki, C., Malliotakis, T., Pediaditis, M., & Tsiknakis, M. (2016, April). The MobiAct dataset: Recognition of activities of daily living using smartphones. In ICT4Ageing-Well (pp. 143-151).

[17] Dumoulin, V., & Visin, F. (2016). A guide to convolution arithmetic for deep learning. arXiv preprint arXiv:1603.07285.

[18] Ju, C., Bibaut, A., & van der Laan, M. (2018). The relative performance of ensemble methods with deep convolutional neural networks for image classification. Journal of Applied Statistics, 45(15), 2800-2818.

[19] Caruana, R., Lawrence, S., & Giles, C. (2000). Overfitting in neural nets: Backpropagation, conjugate gradient, and early stopping. Advances in neural information processing systems,

Mobile Application for People Suffering from Color Blindness

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Abstract—The article describes the method of developing a mobile application, including a comparison of analogues, an algorithm for writing the key function of the application, the principle, demonstration and explanation of the application. The relevance of this application and the scope of its application are also proved. A description of the characteristics of the application has been made, which can be individually configured for each user. The application modes listed in the paper are selected by the neural network based on the optimal and most suitable option for a given situation, and it can also combine them. The application also contains libraries of settings for each type of color blindness.

Keywords - mobile application, programming, color blindness, development, Java programming language, Android Studio

I. INTRODUCTION

Color blindness or color blindness is a pathology of vision in which a person loses the ability to fully or partially distinguish colors [1]. This problem is extremely relevant at the moment. Color blindness or color vision deficiency affects about 1 in 12 men (8%) and 1 in 200 women worldwide. There are about 300 million colorblind people on Earth (about 4.5% of the total population), most of whom are men. For a person diagnosed with color blindness, there are a number of restrictions that are imposed on the choice of profession. So, with a violation of color vision, it is impossible to master the specialty: chemist, surgeon, pilot, sailor, railway worker. A number of military specialties are banned. The vast majority of people with poor color vision have a genetic condition that is incurable.

The foregoing indicates the relevance of the problem under consideration, which has an engineering solution. This paper discusses in detail the development of a special mobile application aimed at solving this problem.

The relevance of the demand for mobile applications is due to the fact that almost half of the world's population already has smartphones, and the second half is likely to acquire them in the near future - therefore, the target audience of mobile application manufacturers will constantly grow [3].

Table I . Comparison of mobile applications "Vision of color" and "Color Blind Pal" [4], providing assistance to people suffering from color blindness

	Mobile app name	
	Vision of color	**Color Blind Pal**
Informing the user what the app is for	Available	Absent
Work stability	The application was created for the new version of Android, so it works stably on new devices, but may not work on devices with an old version of Android	Cannot work stably on new devices with new Android versions, app crashes suddenly, bugs occur that cause functions to work incorrectly
App support	The application is maintained, developed, updates are taking place	The application has been discontinued, last updated on March 8, 2017
Ease of use and ease of learning	The application has an intuitive interface that is easy to understand even for non-Russian-speaking users	The application has a complex confusing interface that is difficult to understand.

13.	Functionality	The functions of the application are performed with the highest quality. The application gives an accurate undeniable result. The result given out by application, practically does not depend on illumination of an object. It is possible to quickly switch from the mode of color perception of the world to the application cameras to capture the object of interest to the user. The application gives the result in real time, and the result is visual, that is, the user can see the object recolored by the application in real time in the part of the color spectrum visible to the user, so that the user can distinguish objects of one color from others in real time. The app has fewer features compared to Color Blind Pal.	The application has more features compared to Vision of color. The application does not allow you to get an accurate result, as it depends on the illumination of the subject. The operation of the application is structured as follows, the color of one pixel of the image is read from the camera, then the name of the color that this pixel has is displayed to the user on the screen. The disadvantage of this method is that if the object is poorly lit, it will be difficult to know the real color of this object, since its real color will be obscured by black. Also in the application there is a function for filling objects that have a red color with blue, but this filling is not transparent because of which the texture of the object is invisible, only its outline is visible, that is, the outline of the object and this mode can be turned on only for red, and for green and blue is not allowed. Just as importantly, the app lacks a feature that allows the user to take a photo of an item.

II. DESCRIPTION OF THE METHOD FOR SOLVING THE RESEARCH PROBLEM

The mobile application, the development of which is considered in this study, was given the name "Vision of color". This mobile application has an analogue - this is the Color Blind Pal application [4] developed by Vincent Fiorentini. Table 1 provides a comparison of these applications, taking into account the main functions that the application should perform. The uniqueness of the Vision of color application lies in obtaining accurate and visual results in real time, as well as in ease of learning, ease of use and the ability to photograph an object visible to the user.

For a mobile application, the development of which is considered in this study, the creation of color perception modes of the world using the example of a color perception mode for green will look like this.

Table II. Code of the mode of color perception of the surrounding world for green color with an explanation

Line number	Code	Code Explanation
1.	`imageAnalysis.setAnalyzer(ContextCompat.getMainExecutor(MainActivity4.this),`	Adding an analyzer class that contains the code of operations performed with the image received from the camera
2.	`new ImageAnalysis.Analyzer() {`	By entering this line, we create a new image analyzer. Entering this line creates lines 3 and 4
3.	`@Override`	We get an object of type "ImageProxy" from where we can extract image data
4.	`public void analyze(@NonNull ImageProxy image) {`	
5.	`Image img = image.getImage();`	Getting the image
6.	`Bitmap bitmap = translator.translateYUV(img, MainActivity4.this);`	We perform the conversion of the original image into a “Bitmap” pixel map, that is, an array containing the pixels obtained from the image with which you can perform various transformations
7.	`int size = bitmap.getWidth() * bitmap.getHeight();`	Set the size of the array with pixels
8.	`int[] pixels = new int[size];`	We get the pixels of the image into an array of the specified size
9.	`bitmap.getPixels(pixels, 0, bitmap.getWidth(), 0, 0,`	Copying an array with image pixels to a pixel map
10.	`bitmap.getWidth(), bitmap.getHeight());`	
11.	`for (int i = 0; i < size; i++) {`	Looping through an array

<table>
<tr><td>12.</td><td><code>int color = pixels[i];</code></td><td>Getting color</td></tr>
<tr><td>13.</td><td><code>int r = color >> 16 & 0xff;</code></td><td>Getting the red color from the image separately</td></tr>
<tr><td>14.</td><td><code>int g = color >> 8 & 0xff;</code></td><td>Getting the green color from the image separately</td></tr>
<tr><td>15.</td><td><code>int b = color & 0xff;</code></td><td>Getting the blue color from the image separately</td></tr>
<tr><td>16.</td><td><code>int red = r;</code></td><td>Assign the red color to the variable "red"</td></tr>
<tr><td>17.</td><td><code>int green = g / 0x999999;</code></td><td>We assign the green color to the variable "green", recolored to a shade of gray using the formula "g / 0x999999", where "0x999999" is a shade of gray. You can see color encodings in hexadecimal code on the website [12]</td></tr>
<tr><td>18.</td><td><code>int blue = b;</code></td><td>Assign blue color to "blue" variable</td></tr>
<tr><td>19.</td><td><code>int black = 0xff000000;</code></td><td>Assign the variable "black" the black color "0xff000000"</td></tr>
<tr><td>20.</td><td><code>pixels[i] = black | red << 16 | green << 8 | blue;</code></td><td>We write the result to the array with index "i". We write the black color "black" or "|" to the array red color "red << 16" or "|" grayscale recolored green "green << 8" or "|" blue color "blue" at the end of the line we put a semicolon, which indicates the end of the line ";"</td></tr>
<tr><td>21.</td><td><code>}</code></td><td></td></tr>
<tr><td>21.</td><td><code>bitmap.setPixels(pixels, 0, bitmap.getWidth(), 0, 0,</code></td><td rowspan="2">We write the transformed pixels of the image to the pixel map</td></tr>
<tr><td>22.</td><td><code>bitmap.getWidth(), bitmap.getHeight());</code></td></tr>
<tr><td>23.</td><td><code>preview.setRotation(image.getImageInfo().getRotationDegrees());</code></td><td>We send the resulting pixel map to the "imageView" element that displays the resulting image on the application screen. In order for the resulting image not to be inverted, enter the parameter "setRotation(image.getImageInfo().getRotationDegrees())" that sets the rotation of the resulting image</td></tr>
<tr><td>24.</td><td><code>preview.setImageBitmap(bitmap);</code></td><td>Displaying a correctly upside down image on the application screen</td></tr>
<tr><td>25.</td><td><code>image.close();</code></td><td>We finish working with this image and feed a new image to the analyzer input</td></tr>
<tr><td>26.</td><td><code>}</code></td><td></td></tr>
<tr><td>27.</td><td><code>});</code></td><td></td></tr>
<tr><td>28.</td><td><code>cameraProvider.bindToLifecycle(MainActivity4.this, cameraSelector, imageAnalysis);</code></td><td>We launch the written script of the analyzer for execution</td></tr>
</table>

III. APPLIED INTERPRETATION AND ILLUSTRATION OF OBTAINED RESEARCH RESULTS

Based on the results of the study, a mobile application was developed that can help people with color blindness.

The algorithm of the developed mobile application will look as follows.

After installing the application, its name and logo will be displayed on the smartphone screen.

Fig.1 Application name and logo

After entering the application, the main screen of the application will be displayed, welcoming the user and explaining to him the purpose of this application, which is shown in Figure 2. Then, after pressing the "START" button, the transition to the screen for selecting modes of color perception of the surrounding world is performed.

Fig. 2 App home screen

The mode selection screen displays the object received from the camera (Figure 3(a)). This function will allow the user to see the object that will be photographed using the "Camera" button in the camera application (Figure 3(b)) or view this object in the color perception modes, the function is implemented by the "R", "G" or "B" buttons. Under the names of the modes, that is, under the names of colors, there are colors corresponding to the names (R - red, G - green, B - blue). Below the names with colors, they are assigned shades of gray, in which red and green colors will be repainted. The blue color is assigned a shade of gray that only a person with color blindness will see.

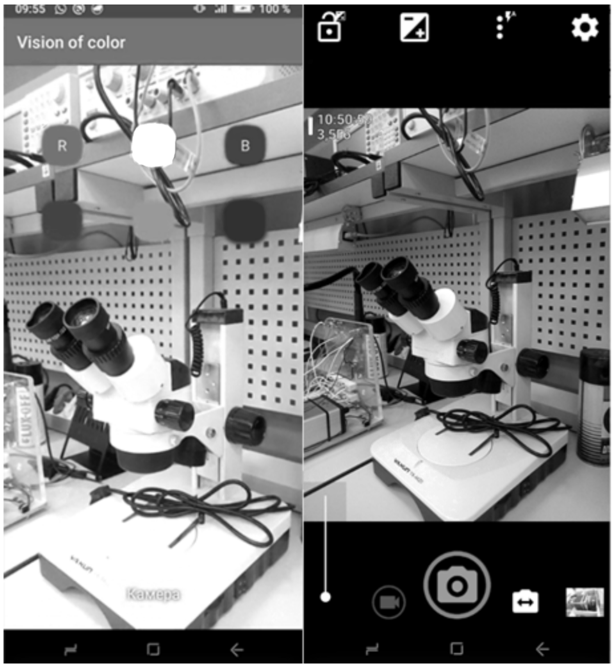

Fig.3 Displaying the object received from the camera

To explain how the modes work, the application "Sim Daltonism" was used, which allows you to see the world as people with color blindness see it.

In Figure 4, you can see how red and green colors on a laptop screen are seen by a person with healthy vision, that is, red is on the left, and green is on the right.

Figure 5 shows how these colors are seen by a person with color blindness, namely with protanopia, that is, not seeing red. That is, red, located on the left, a person with protanopia will see as green. Thus, it turns out that this person will not be able to distinguish red from green, since he sees both of these colors as green.

The question arises as to whether it is possible to distinguish these two colors from each other. It is this task that the mobile application “Vision of color” developed in this study solves, which helps people suffering from color blindness to distinguish colors that seem the same to them. In Figure 6, you can see how the application recolors the red on the left into a shade of gray, so that a person with color blindness can distinguish it from the green on the right.

Fig.4 Visibility of red and green in a person with healthy vision

Fig.5 Visibility of red and green in a person with protanopia

Fig.6 Recoloring red to a shade of gray

The color perception mode for green works in a similar way. Figure 7 - how a person with healthy vision sees this image (green box on the left, red on the right). Figure 8 - how a person suffering from color blindness sees this image, namely deuteranopia, that is, not seeing green (red box on the left and right). Figure 9 - how the application helps to distinguish colors from each other (on the left is a gray (recolored green) box, on the right is red).

Fig.7 Image of a person with healthy vision

Fig.8 Image of a person suffering from color blindness

The color perception mode for blue works a little differently. The application does not recolor the blue color into a shade of gray, but makes the blue color more vivid and saturated. It works this way because a person with color blindness, namely tritanopia, sees blue as a shade of gray, and so that the shades of gray that the application gives out and the person with color blindness sees differ, the application makes the blue color brighter and more saturated, which results in a lighter shade of gray than that shade of gray that a person suffering from color blindness sees in life. Figure 9 - how a person with healthy vision sees this image (blue case on the left, gray case on the right).

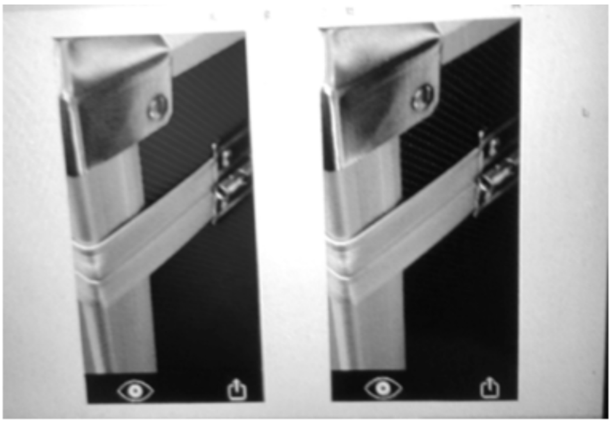

Fig.9 Image of a person with healthy vision

Figure 10 - how this image is seen by a person suffering from color blindness, namely tritanopia (gray case on the left and right). Figure 11 - how a person suffering from color blindness will see the image issued by the application and how he will be able to distinguish colors from each other. Based on the fact that the case on the left is light gray, we can say that it is blue, and the case on the right is gray.

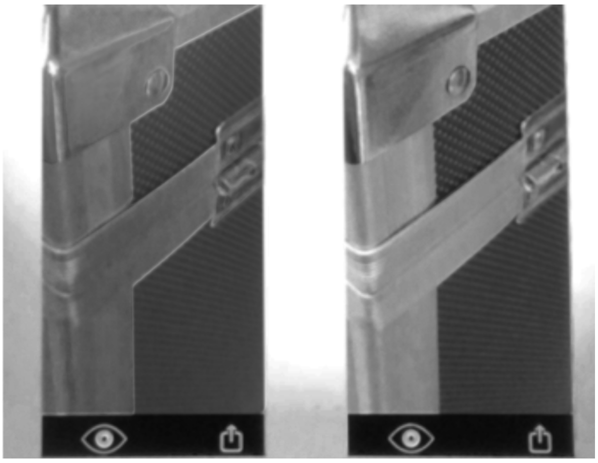

Fig. 10 Image of a person suffering from color blindness

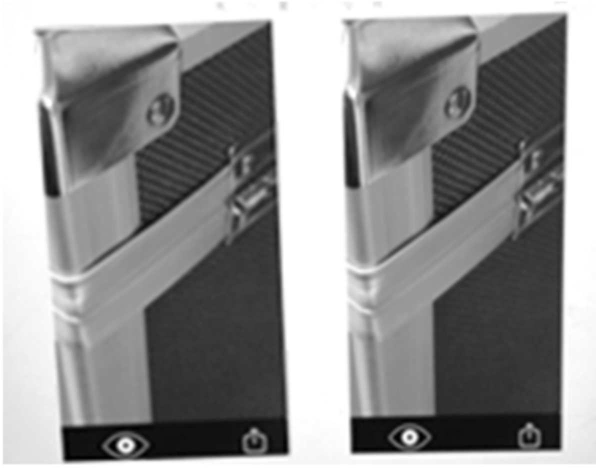

Fig.11 Differentiate colors for a colorblind person using an app

IV. CONCLUSION

Based on the results of the study, a mobile application "Vision of color" was developed in the Java programming language, which helps people with color blindness. This application can be used in various industries, such as: in the classroom at school (university) when performing tasks requiring work with illustrative material (maps, atlases); in the work of a graphic designer in the development of graphic design of sites (programs); in the work of a chemist, when mixing various substances; upon obtaining the right to drive a vehicle; in the work of an electrician; in robotics when creating robots from parts and wires of various colors that have their own semantic meaning on diagrams and in other areas.

Thus, the developed application allows to significantly improve the quality of life of people with color blindness, to navigate the world around them. As a result, favorable conditions are created for full-fledged professional realization in various spheres of human activity, as well as a socio-cultural aspect that allows them not to feel limited in their abilities, and to see the world as a person with healthy vision sees it.

REFERENCES

[1] Colorblind - causes, symptoms, diagnosis and treatment. Access mode: https://www.krasotaimedicina.ru/diseases/ ophthalmology/daltonism (Date of access: 16.01.2023).

[2] Faustova, J.P. and et al. COLORBLIND // Alley of Science. 2021. T.1. No.5. Pp. 165-167.

[3] Mobile Applications Market Outlook. Access Mode: https://artjoker.ua/ru/blog/perspektivy-rynka-mobilnykh-prilozheniy (Date of access: 07.01.2023).

[4] A unique application allows color blind people to see a colorful world. Access mode: https://www.ridus.ru/news/306556 (Date of access: 15.02.2023).

[5] 105+ Lessons Adobe Illustrator Training. Access Mode: https://videoinfographica.com/illustrator-tutorials/ (Date of access: 17.02.2023).

[6] Application Screen Resources and Layouts, ConstraintLayout in Android Studio. Access Mode: https://www.fandroid.info/urok-3-resursy-i-makety-ekrana-prilozheniya-constraintlayout-v-android-studio/ (Date of access: 18.02.2023).

[7] Android Studio Lessons. Access Mode: https://itproger.com/course/java-android/7 (Date of access: 10.02.2023).

IoT Enabled Software Platform for Air Quality Measurements

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Abstract—This paper presents an example of the IoT framework that is suitable for implementation into Smart City and environment system for air quality estimations. Framework consists of the web server application designed for IoT system in client-server mode, where hardware units present separate clients. Application is designed mainly using node.js tools and is accessible through web browsers. Framework is tested with appropriate ESP32 based measuring system being the client in the configuration. Measured data can be transferred, processed and shown to the users in real-time using graphs and images. Also, data is logged and stored for broader air quality assessments. Commercial capabilities and business approach is discussed.

Keywords - IoT, node.js, web application, air quality, ESP32

I. INTRODUCTION

Determining air quality remains a challenging task [1]. Air is perceived as a mix of different particles, and the structure of the air cannot be easily detected by humans. Presence of unwanted particles in the air is marked as air pollution. Likewise, air pollution often cannot be detected easily, until it is high enough to present a problem. Therefore, air pollution is often precisely measured with appropriate modules and devices. These modules are responsive to specific gases, where interaction between the module and the specific gases induces chemical reaction. Chemical reaction create changes in particular electrical parameter of the module (resistance or output voltage) that can be measured with microcontroller or similar controlling unit. Based on the magnitude of the change of the output voltage, concentration of unwanted gases in the air can be estimated. Upon these several eestimations, basic assessment of the air quality can be given [1, 2].

However, explained workflow has several flaws. Main flaw is that the measuring modules have limited reach, and area of air that modules can cover is fairly limited. Common misinterpretation of the results lies in the fact that single sensing module can give estimation for entire town or municipality. Modules can respond only if the targeted gases come in contact with the surface of the module. Natural air flow will, of course, bring more air to the module, but even then, the area where modules can detect presence of gases is limited [2, 3].

Therefore, in order to give more precise assesment of the air quality for a town, it is needed to increase the number of the measuring modules, and to position them in a various areas. In this manner, monitored area is far bigger, since more of the modules will contribute to the results with its measuring. With the increased number, it is needed to propose a technology that is able to monitor and to store the measured data as well as to present it to the multiple users in the same time. Internet of Things (IoT) technologies enable data aquistion from multiple points and simultaneous access to the measured data to multiple users [4, 5].

There have been many reports on IoT system that tackle air quality monitoring [4-10]. Khera proposed a system that can follow CO and CO_2 gases concentration [6]. This system also takes advantage of the LabVIEW, which is additional tool needed for the system. Kodali reported system where users can follow CO_2 concentration using MQTT protocol [7]. System is based on couple of common libraries and provides rather low-cost solution for some basic measurements. Munsadwala designed system that can also access the geographical location of the measuring unit [8]. System uses MQ gas sensor series that give elemental readings. This paper also tackles the ambiental conditions, mostly in securing optimal conditions for reliable measuring. Dhingra developed a system which is supplied with mobile application, where placing measuring units on vehicles is also discussed [4]. These approaches however suffer from the inconstant air pressure delivered to the measuring units, that can hinder the measurements. Đorđević presented a system where various data logging methods are discussed [9]. Data is sent using GSM communication, and can be easily stored to the external memory units.

Software framework presented in this paper presents sublimation of the reported solutions, developed in a different manner, with the goal to enable simple further implementation and addition into up-to-date technologies, mainly targeted at blockchain technologies. Framework is organized into client-server configuration where each measuring point, as well as each data observer is a separate client. Data recieved from separate clients can be encrypted and mutually dependent. Application for retrival and presentation of data is stored in a server. This approach present viable and confirmed solution for similar problems. In this paper, implementation of software framework for IoT system that is able to administer on multiple measuring points centered around measuring several gases concentration is presented. Framework does not rely on the existing commercial platforms, is independent of owned resources and is designed to be a groundwork for the implementation of the more advanced technologies that can

II. METHODOLOGY

IoT system generally consists of multiple measuring units on one side, and data processing and presentation control unit on the other side. Measuring units are using some of the wireless data transfer methods to communicate to the control unit, where data is processed and presented to the users of the system. In recent years significant development of different data transfer methods, as well as portable measuring devices that can measure different magnitudes is noted [4, 5, 10].

Measuring units can be connected to tens and tens of different measuring devices and can communicate with several wireless data transfer methods, while controlling web server applications should be able to ensure real time data presentation, high level of integration and simple data access. Measuring units and control unit can be integrated, beside others, into client-server configuration. General block concept of the proposed framework is given in the Fig. 1

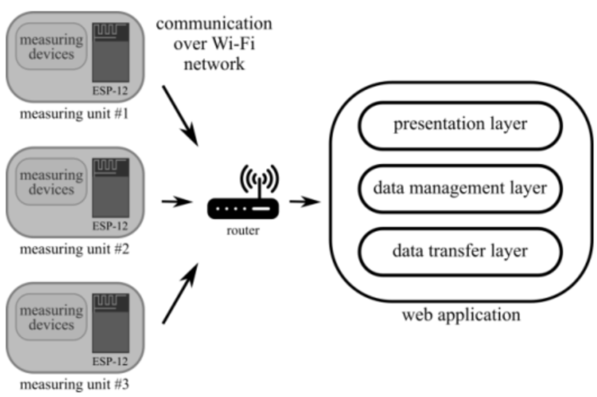

Fig. 1. Block schematioc of the designed web application.

Web server application that performs as a controlling unit for this IoT system demands three layers, data transfer layer, data management layer and presentation layer. It is based on node.js tool [11], designed to perform as a part of the client-server configuration in IoT system implementations, where clients are measuring units, as well as browsers following and accessing to the measured results. Application was developed locally at first, but also tested in real-time, with the usage of Heroku platform [12]. Parts of the developed framework are explained in more detail.

A. Data transfer layer

Data transfer layer deals with the transfer of the data to and from measuring units. Operation of this layer is most limited, since the same data transfer protocol should be used on both sending and receiving end. Designed web platform is set to communicate with the measuring units using WebSocket protocol. This protocol is chosen because of the widespread availability, low power demand and good usage support for various hardware architectures [13]. The WebSocket protocol enables full-duplex communication between a client running the code to a remote host that has opted-in to communications from that code, in a controlled environment, over single transfer control protocol connection. Developed application also supports data transfer through HTTP protocol, although WebSocket protocol is used as a primary transfer method.

B. Data management layer

Data management layer covers the processing of data. This layer of web application enables that needed calculations based on the data from the measuring units can be conducted in the controlling unit, that is often supplied with the stable voltage supply, rather than at the measuring unit, that is most often supplied through battery or similar limited supply [14].

In the designed software platform, data management layer is also used as the correction factor. If the received data is out of the anticipated range, platform can react with the appropriate notification to signal the user of the specific state. This layer of application is also very important for the future goal of the application, which is to implement blockchain technology to the framework [15]. This layer should cover process of addition of the processed data of the peer-to-peer organized blockchain nodes to the ledger.

C. Data presentation layer

Data presentation layer presents the measuring results to the user. Among many possibilities for data presentation, some of the appropriate for this type of usage are real-time graph that shows some of the recent measuring and a table that shows current measuring from the specific measuring unit. Interface of the designed software platform for air quality monitoring that follows the given concept is given in the Fig. 2.

Fig. 2. Interface of the designed web application.

Data presentation layer focuses around wide usage of the Chart.js module of the node.js based application that creates the appropriate graph in the center of the interface [16]. Data is expected to be presented on the graph as soon as received and processed, meaning, in real-time. Among other capabilities, data is shown can also be exported to the CSV file, where can be subsequently analyzed.

D. Measuring units

Important parts of the proposed framework are also measuring units. These units consist of measuring devices (sensors or similar sensing parts) and a wireless data transfer method enabled device, usually some type of a microcontroller or similar. Since the data transfer method between the controlling unit and the measuring unit is WebSocket method, measuring units incorporated microcontroller need to have the ability to use it.

Main measuring device that is the part of the measuring unit used for the development of the framework is MiCS5524 [17]. It is a micro-electromechanical system (MEMS) for carbon monoxide and natural gas leakage detection, that is able to measure concentration of CO in ppm. It comes with a simple interface for connection with other devices. Measuring of this MEMS are, according to the datasheet, as well as other reports [17, 18], heavily influenced by meteorological conditions. Therefore, output of this MEMS must be analyzed in the data management layer together with the value of the air temperature, air pressure and air humidity. These three magnitudes are measured using another measuring device, concretely BME280 [19], that is able to deliver it through I2C protocol.

Other part of the measuring unit is a Wi-Fi enabled microcontroller ESP12-E [20]. This module is the improved version of the commercially successful ESP8266 chip. It is characterized with even lower power consumption, especially in the sleep mode, and with increase in GPIO pins, meaning that is able to communicate with even more measuring devices. Implementation of WebSocket protocol on this microcontroller is done using Espruino [21, 22], programming and flashing JavaScript based tool.

Measuring unit is placed on a printed circuit board, so that it can be space effective and battery supplied. Designed PCB is presented in the Fig. 3.

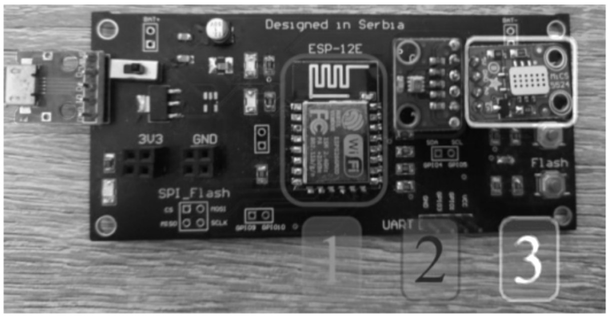

Fig. 3. Designed printed circuit board: 1) ESP12-E; 2) BME208; 3) MICS-5524.

III. FRAMEWORK TESTING

Testing of the framework, both application and measuring units is conducted with multiple ESP12-E based measuring units that are sending measured data using WebSocket protocol to the web server application. Tests were performed in the following manner.

Web application is activating one of the measuring units using WebSocket protocol. ESP12-E wakes from the sleep mode, and performs measurement from MiCS-5524 and BME280, and sends the measured data using WebSocket protocol back to the data transfer layer of the web server application. Upon receiving data, the application sends a message to the measuring unit that puts it into sleep mode until next wake-up signal. After sending the sleep signal, data transfer layer shares data with the data management layer. In this layer, measured values are processed according to the pre-calibrated values for the measuring devices. If the data is somehow corrupted, or there is an error in the reading, data transfer layer is reactivated with the goal to obtain the measurements again. If the data is in the range of expected, then, it is transferred to the data presentation layer and showed in the graph. During testing, measuring was performed in every hour, during one day, from three different measuring units, placed in different areas. Fig. 4 shows the results measured with professional equipment from the measuring devices itself. On the other hand, Fig. 5 and Fig. 6 present the data received through the software platform.

Measured results regarding CO concentration are in line with other investigations [1, 4, 6, 18]. As can be seen from the Fig. 4 and Fig. 5, developed framework shows pretty similar readings as the measurements made at the directly on the measuring units. However, another capability, presented in the Fig. 6 is noticed. For the readings from the measuring unit number 2, there is no line representing the ppm calculated values for the period after 10:00 AM. As can be seen from the Fig. 4, measurements from 07:00 AM to 10:00 AM show readings of 0 ppm of CO, where the real value is probably somewhere between 0 and 1 ppm. After receiving three successive zeros in this period of time web server application notifies the user of the measuring unit #2 using WebSocket method that the error is assumed and that operation of the unit should be checked. If the user checks that the device is operating reliably, reception of the data is continued, regardless of the values. If the user checks that device is not operating reliably, false measurement is prevented and the obtained results are, in overall, more reliable.

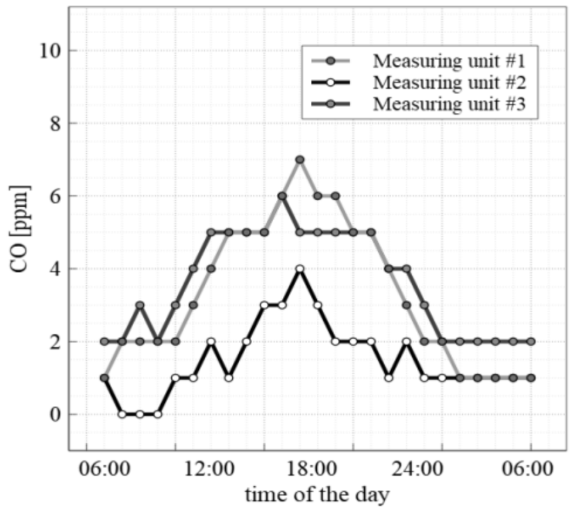

Fig. 4. Data measured directly from the measuring devices, using professional equipment.

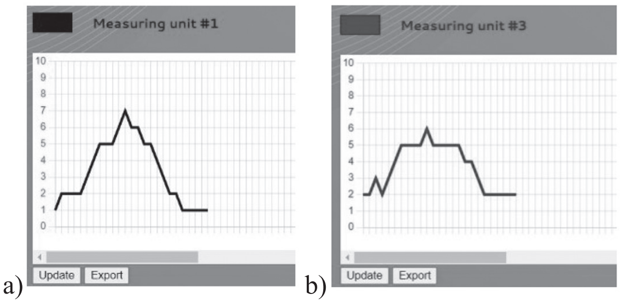

Fig. 5. Data from measuring units presented through the graph of the developed framework: a) measuring unit #1: b) measuring unit #3.

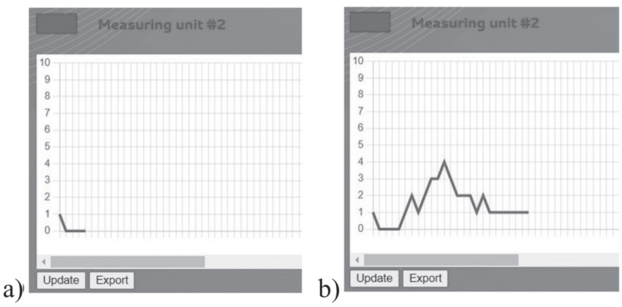

Fig. 6. Data from measuring unit #2 presented through the graph of the developed framework: a) receipt of succesive zeros; b) entire dataset.

IV. IMPLEMENTATION CAPABILITES

Presented framework offers a lot of commercial capabilites and potential for broad practical implementation. Software platform, together with its hardware counter part, provide good scalability and simple integration into installed systems. Number of measuring devices can easily be expanded with the goal to increase the number of measured magnitudes, or to increase the number of measurements related to the concentration of specific gases in the limited area. Hardware part of the system can be integrated with appropriate GPS modules, that will enable the users to have very precise knowing on the air quliaty in specific areas.

Beside broad capabilites that can be made use of from the hardware standpoint, amount of data collected from the devices allow basis for implementation of blockchain technologies in the management and processing of great amount of data. Blockchain's encryption technology and messaging protocol maintains data integrity, while enabling data sharing, as well as improve data processing efficiency. Developed framework can be also adapted to be compatible to Big data systems, if the number of hardware measuring units, as well as data obtained from them increases.

V. CONCLUSION

The paper present development and testing of the web application meant to be used as the software platform in IoT air quality system. Application is designed, realized and practically implemented. Presented framework offers a lot of commercial capabilities and potential for broad practical implementation. Software platform, together with its hardware counterpart, provide good scalability and simple integration into installed systems.

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REFERENCES

[1] Environmental Protection Agency of the Ministry of Environmental Protection of Serbia, "The Annual Report on the Air Quality in the Republic of Serbia", 2019, ISSN 2334-8763.

[2] J. S. Munir et al., "Structuring an integrated air quality monitoring network in large urban areas – Discussing the purpose, criteria and deployment strategy", Atmospheric Environment, p. 100027, 2019.

[3] T. Popović, "Report on air quality protection at the local self-government level in the Republic of Serbia", National Association of Local Authorities in Serbia, 2020.

[4] S. Dhingra et al., "Internet of Things Mobile - Air Pollution Monitoring System (IoT-Mobair)", IEEE Internet of Things Journal, vol. 6, no. 3, pp. 5577-5584, 2019.

[5] N. Setiwan and I. Kustawian, "IoT based Air Quality Monitoring", IOP Conf. Series: Materials Science and Engineering, vol. 384, p. 012008, 2017.

[6] N. Khera, P. Sharma, D. Shukala and I. G. Dar, "Development of Web-Based Gas Monitoring System Using LabVIEW", in Proc. of Recent Developments in Control, Automation & Power Engi-

neering (RDCAPE), 2017, pp. 439-441.

[7] R. K. Kodali and B. S. Sarjerao, "MQTT based Air Quality Monitoring", in Proc. of IEEE Region 10 Humanitarian Technology Conference (R10-HTC), 2017, pp. 742-745.

[8] Y. Munsadwala, P. Joshi, P. Patel and K. Rana, "Identification and Visualization of Hazardous Gases Using IoT", in Proc. of 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU), 2019, pp. 1-6.

[9] M. Đorđević, B. Jovičić, S. Marković, V. Paunović and D. Danković, "A smart data logger system based on sensor and Internet of Things technology as part of the smart faculty", Journal of Ambient Intelligence and Smart Environments, vol. 12, no. 1, pp. 1-15, 2020.

[10] D. Danković and M. Đorđević, "A Review of Real Time Smart Systems Developed at University of Niš", Facta Universitatis, Series: Electronics and Energetics, vol. 33, no. 4, pp. 669-686, 2020.

[11] Software tool: node.js. Available at: https://nodejs.org/en

[12] Heroku platform. Available at: https://www.heroku.com/

[13] I. Fette and A. Melnikov, The WebSocket Protocol, December 2011.

[14] H. Turkmanović, I. Popović, D. Drajić and Z. Čiča, "Green computing for IoT – software approach", Facta Universitatis, Series: Electronics and Energetics, vol. 35, no. 4, pp. 541-555, 2022.

[15] S. Benedict, P. Rumaize and J. Kaur, "IoT blockchain solution for air quality monitoring in smart cities", in Proc. of the IEEE Int. Conf. Adv. Netw. and Telecommunications Syst. (ANTS), 2019, pp. 1-6,

[16] Module Chart.js. Available at: https://www.chartjs.org/

[17] MiCS-5524 datasheet, Sensortech, 2018.

[18] J. A. Fatkhurrahman and I. R. J. Sari, "Affordable Metal Oxide Gas Sensor as Environmental Friendly Method for Ammonia Gas Measurement", IOP Conf. Ser.: Earth Environ. Sci. vol. 366, p. 012027, 2019.

[19] BME280 datasheet, Bosch, 2022.

[20] ESP12-E datasheet, Esspresif. 2015.

[21] Espruino tool. Available at: https://www.espruino.com/

[22] N. Mitrović et al. "Implementation of WebSockets in ESP32 based IoT systems", in Proc. of the 15th Int. Conf. Adv. Technol. Syst. Services in Telecommunications (TELSIKS), 2021, pp. 261-264.

Outcome Bbased Business Models Influenced with Internet of Things – in Agriculture

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Abstract—Industry 4.0 technologies and overall digitalization have accelerated the adoption of servitization models in the manufacturing industry such as outcome-based business model. While this model is gaining traction in the manufacturing space, there is little understanding of its applicability in other industries, in particular in agriculture. The aim and subject of this case study provides the main findings of the analysis of the feasibility of applying outcome-based business model in the agricultural sector, specifically winemaking. Result of the study confirm that the use of outcome-based business models in agriculture is still in the infant stage because of the many parameters in this industry that cannot be controlled. Therefore, the application of outcome-based business model in this sector can best take place following several modifications that are indicated in the paper.

Keywords - Outcome-based business model, Internet of Things, market maturity, technical readiness, agriculture.

I. INTRODUCTION

The focus of this research is the applicability of outcome-based business model (OBBM) in the agricultural sector. The agriculture sector is still in the early phases of its digital transformation [1]. Consequently, this is a sector that is yet to explore the full potential of the OBBMs. One of the key obstacles for more rapid digital transformation of agriculture are the up-front costs of the hardware and software required for establishmentment of the so-called smart farming practices [2,3]. To that end, OBBM might be a good choice for accelerating the introduction of data-based practices in the agriculture sector as service providers would offset the up-front costs in exchange for potentially higher earnings through revenue sharing with farmers. However, several issues have to be addressed before such business models are applied in the agriculture sector. These issues include the impact of climate variability on the yield, quality of the crops, the required energy resources such as water and energy used for irrigation, and the ability to continuously monitor all relevant operations in the field and act promptly on deviations.

Previous research has shown results on the use of OBBM in the manufacturing industry, however, there is a lack of research on the use of OBBM outside of the manufacturing industry, specifically the agricultural industry. The overall research goal of this study was to understand the applicability of outcome-based business contracts in agriculture. The main research objectives of this study is to indicate a set of recommendations related to the modification and customization of OBBSs from the manufacturing industry for the agricultural sector.

At the very beginning of the paper, the business model of OBBM and the basis of its foundation are presented. After that, within the same chapter, the readiness of the market to accept an innovative and new business process, as well as the application of technology and the development of digitization in the agricultural sector, was shown. In the fourth chapter, the subject, sample and objective of the case study are presented. In addition, research methods and models of the use of OBBM in the agricultural sector are presented. In the fifth chapter, the results of research on the use of OBBM in the specific case of digital transformation in the vineyard sector are presented. In the sixth chapter, the interpretation of the obtained results, as well as the limitations and shortcomings of this research, is presented. In the last part, the results of the case study, implications and a proposal for future research are presented in order to reduce the barriers to the adoption of technology by the agricultural sector.

II. THE OBBM AND DIGITALIZATION OF AGRICULTURE

A. The OBBM and its Values

Introduction of OBBM largely relies on using digital solutions in conjunction with the physical products which are the main offer of the vendor to ensure that these physical products are used in line with the agreements. Hence, the application of Industry 4.0 technologies such as IoT, Artificial Intelligence (AI), serverless computing, edge and cloud computing are crucial for implementation of outcome-based business models. Application of OBBM can occur in all business operations, production processes and services where data collection, data analysis, data optimization, and data-based decision-making can be used to control the conditions relevant for achievement of desired outcomes.

Values likely to be created due to the use of OBBM include growth, efficiency, and effectiveness [4]. The main goal of this business model is to identify mutually agreed value propositions that will define the value or business opportunities to create and ways of distributing the value between customers and providers. Providers will assume greater responsibility by providing guaranteed enhanced performance of the products and services.

There are three value drivers identified for value creation transformation in OBBMs [5]. These value drivers are information transformation, behavior transformation and material transformation. This study emphasizes that for a successful business contract based on an outcome, it is vital to have a value-driven alignment of people, information, and material. Additionally, there must be a perfect alignment of information and behavior among the customer and vendors for a contract to succeed. Otherwise, there will be no value creation nor distribution according to the established business plan.

OBBM is based on a digital servitization system that establishes a multi-dimensional collaboration between various types of business models that exist in a value system. These diverse business models are operated by raw material suppliers to final customers. Digitalization helps to create a collaboration among these business entities to produce an optimal outcome to end customers [6]. Overall digital servitization makes value creation and value capture more effective and efficient. Businesses can now achieve a more preventive and proactive approach toward their maintenance processes with the help of the digitization of business processes and activities [7].

B. Market Readiness for OBBM

The market acceptability of any innovative and new business model depends on its ease of implementation and adaptiveness. As OBBMs largely depend on the digitalization processes, the successful implementation of technological applications is a crucial factor to make the OBBM market-ready. Another element to making the OBBM more adaptive to the market acceptability is to understand the market needs and to perfectly align the model to customers' needs. However, it is difficult to determine the exact needs of customers [7,8]. Expected value creation for the customer may not be achieved or might be degraded for a lack of understanding of customer pain points and deficient processes by the service provider. Ganguly and Euchner (2018) argue that business firms have to evaluate new business model opportunities more carefully according to the needs of customers and then sign a deal with digital business solutions. Market acceptability and readiness to adopt OBBM largely depends on the effectiveness of solutions provided by the providers to its customers. Providers can consider a robust financial formula to ensure correct profit distribution. As miscalculations or no calculations can lead to a business failure and ultimately to market failure as well.

Financial clarity and understanding are also crucial for the digitalization of businesses to become market-ready. This is because revenue streams are not fully linked and proportional to the cost structures as in the traditional business model [9]. Further, it is common for new entrants to established markets to readily adopt OBBM than incumbent players who are afraid of losing control of the whole value creation process. Those incumbent companies prefer owning assets and investing in equipment rather than paying for outcomes that OBBM offer.

Market acceptability of OBBM models depends on the removal of the challenges of adoption before effective and seamless implementation into business activities. This means that businesses need to understand every change introduced by OBBM and its core digitalization processes for successful implementation of the service model and increase its acceptance by the market. Commonly, a huge digital change brings radical changes to the core business activities and core business values like value creation, value delivery, and value capture [6]. For instance, digitalization enables the manufacturing firms to use new kinds of capabilities like data analysis and software management to create value according to the customer's operational needs. These new capabilities are critical to the survival of new OBBMs and their ability to deliver the value created [10].

However, many companies do not have clear processes and have to face inertia or resistance from within the organization when they try to develop digital solutions for business processes beyond mechanical equipment [11]. Hence, it is foremost and vital to eliminate this inner organizational resistance to the adoption of digitalized business processes and therefore ultimate adoption of OBBM. From a technical perspective, companies need to develop smart products that are capable of being remotely monitored and controlled and for this task previous machine producers need to become software development companies as well or have very tight relationships with some of the IT companies that could help them in this journey. As noted by [6] data scientists are becoming a very important asset to any company that is looking into changing its business models toward more digital ones such as OBBM.

C. Digitalization of agriculture

In the agriculture sector, management of irrigation, fertilizer utilization and overall nutritional status management are crucial. Agriculture needs variable rate application of inputs according to variable changes in climate, soil, and moisture for different agricultural products at different geographical locations. IoT technologies based on sensors have high usage in collecting data from agricultural fields [12]. The proper use of collected data from the farms is necessary to arrive at the right decision at the right time. IoT technologies are useful in highlighting the usage of soil and topography monitoring with proximal sensors to map useful data regarding soil moisture level, soil temperature, bulk density, and soil matrix [12,13]. Climate monitoring is majorly done by weather stations or rain gauges in new world vineyards.

The study conducted by Balafoutis et al. (2017) finds that the site-specific applications of technologies can help with achieving these objectives and emphasize that excessive nutrient and water supply can damage the health of the soil, and agriculture products as well as loss to the farmers with excessive cost and low-quality output. An example of digitalization of agriculture is the use of Precision Viticulture (PV) techniques. These are techniques that facilitate data collection and analysis promoting data-based decision-making [14]. PV covers the overall agricultural management activities from the operation of machinery to optimum use of inputs like fuel, fertilizer, water, and pesticides, as well as an assessment of the quality of output [12]. These techniques help in producing maximum yield with high-quality produce and low cost for inputs. This study shows the marked difference in quality and quantity parameters due to PV adoption in two different vineyards from the traditional agricultural methods.

In further reviewing the role of digitalization in agriculture, sensors can give detailed information about the soil features in variable fields [13]. By testing soil parameters at several points and with the use of advanced techniques for interpolating we can come to quite precise information for any spot that is of interest in the huge agricultural fields. This paper suggests the application of differential management techniques to reduce the variability in different fields.

Further, the Internet of Food (IOF) 2020, H2020 DEMETER and Atlas provide insight into the digitalization of agriculture [15]. These projects explored and validate various IoT and data analysis components and solutions to demonstrate the key role of digital technologies in transformation of European agriculture [15]. Through a number of usage scenarios and pilots (potato production processing, pig health tracking; poultry chain management, intelligent fruit logistics, irrigation and fertilization management, grazing cow monitoring, etc.) the projects have demonstrated digitalization of agriculture is both possible and required. At the same time, it was shown that there are still a number of challenges that have to be overcome, of which the costs of introducing digital solutions ranks very high. This was shown by the DEMETER's farmers survey which indicated the barriers to smart farming technology adoption. Besides cost, other points of concern for adopting digital technology for farming include the lack of resources and data privacy [15].

An additional technology that can be helpful for the outcome-based agriculture produce is robotic technology which is most useful in agricultural farms where the level of mechanization is very high. Robotic pruning and canopy management can save huge labor costs and efforts and hence results in more profit for the producers [16]. Analysis of field variables can be used by the technology developers to focus on particular field tasks and develop and apply the appropriate technology accordingly [16]. Unfortunately, the H2020 project such as AgRobofood is coming to an end.

III. METHODOLOGY

A. Research Question

The research question addressed in this study is the following:

- RQ1: What are the applications of OBBM in the agricultural sector?

B. Research Method

This was a qualitative research study. This is a research method that facilitates the study of a phenomena and is especially useful in addressing questions regarding the why of something [17]. The study entailed exploring the phenomena of OBBM application in the agricultural industry following its success in the manufacturing industry. Thus, this encompassed conducting some comprehensive assessments of the use of this model. By using the qualitative research method this study provided insight into the experience of applying OBBM in the manufacturing industry and then agriculture.

C. Research Process

The research process of this study involved the following key steps: pre-study, literature review, and case studies. The pre-study was an initial step of this paper conducted to identify the research gap [18]. This research gap refers to the lack of research on the use of OBBM beyond the manufacturing industry. The second step of the research process involved conducting a review of the literature. This was done to identify the findings of previous studies on OBBM application. The final step in the research process involved the description of the case studies. The case studies illustrated a newer application area in the agricultural sector.

D. The sample used in Case Studie

The following case study weas used to achieve the research objective:

- A group of vineyards located in Montenegro running digital transformation pilots.

The vineyards case study leverages IoT and Machine Learning (ML) technologies to improve farming operations. Thus, this case provides a very good example of the digital infrastructure that can be expected in vineyards and of the monitored parameters as the important factors in setting up OBBM based collaboration.

IV. RESULTS

A. Results of Case Study: Smart vineyards case-Agricultural industry

The vineyard use case is analyzed based on a deployment of a vineyard management digital solution in Montenegro (see Figure 1).

The deployment includes devices with a set of sensors for monitoring environmental parameters:

- air temperature,
- relative air humidity,
- rainfall,
- leaf wetness,
- radiation,
- wind speed,
- soil moisture, soil temperature and soil electro-conductivity (EC), and
- the number of insects caught in pheromone traps

The expectation was that the use of this digital technology will result in better prediction of grape diseases, reduced use of pesticides, reduced workload for people working in the vineyard, and eventually improved grape quality and increased yield.

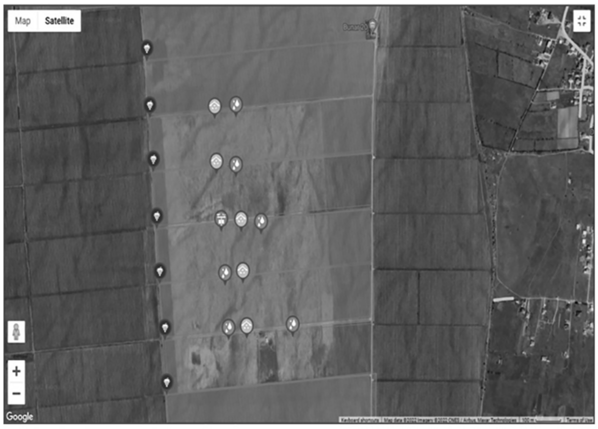

Figure 1. Map showing the vineyard

The monitored area covers 25 ha.

- Represents weather station, 1 in the whole monitored area.
- Represents smart pheromone trap, 5 per the whole monitored area.
- Represent devices equipped with sensors for monitoring soil conditions, 6 per the whole monitored area.

Data from all devices is collected via two LoRa gateways and sent to the cloud, where it's processed, and visualized. Data about the grapes such as the grape type and planting date are also stored in the cloud. Based on the measurements from the vineyard, taking into account the industry best practices, and vegetation status timely recommendations are generated by the solution. This system demonstrates the role of technology in fostering the application of OBBM in agriculture. This is because the technology in the system helps users to establish conditions for the best outcomes in planting grapes. In the smart vineyard there is also a weather station. The weather station is used to collect environmental parameters such as air temperature, relative air humidity, rainfall, leaf wetness, radiation, wind speed, wind direction, and active radiation. Based on these data items and appropriate algorithms/receipts, calculations and recommendations for grape spraying against different kinds of diseases and insects are done. Further, notifications on activities to be done are created and sent to the vineyard keeper, and once he executes them, the result of the spraying operation is made accessible in the cloud. Thus, this further illustrates the application of OBBM through technology that enables grape which helps in preventing disease in the vineyard a significant outcome. This means that the vineyard keeper can utilize the data attained from the algorithm and notifications to take up activities that will prevent disease such as spraying the crops as earlier mentioned.

The smart vineyard can also include the use of a smart pheromone trap. The trap can be used for monitoring grape moth activity calculating their number daily. Based on this information the order for their spraying can be executed. It is quite easy to install this device, but maintenance is required depending on the number of grape moths collected on the plate. Consequently, it will be necessary to change the plate with glue every few days up to a few weeks. Additionally, the pheromone sensor requires replacement every 4-6 weeks. This further fosters OBBM use in the vineyard because it enhances the chances of an outcome of crops that are disease free because of the automatic monitoring of grape moth.

There are sensors for monitoring soil moisture (ECH20, Teros 10) deployed at two depths (25 and 50 cm) covering the main part of the root zone in a smart vineyard. Sentek sensor measures soil moisture, soil temperature and EC at 6 depth, each 10 cm. By combining measured moisture with soil characteristics, grape requirements for water through the vegetation and forecasted temperature and precipitation instructions for activities to be undertaken are created (when to spray, what type of fungicide to use). This is essential in fostering an outcome of adequate moisture of the crops further demonstrating the significant role of OBBM in agriculture.

Because of the use of digital technology discussed above, the expectation is there are several parameters expected to improve. For instance, vineyards should experience improvement in yield following the implementation of digital technologies. This increased yield is because of the reduction of loss due to disease prevention.

Further, there should be some improvement in energy costs. Another expectation is the improvement in water costs. Additionally, the implemented technology will also reduce pesticide usage. Thus, all these outcomes illustrate the key benefits of the integration of OBBM in agriculture. The OBBM integration illustrate that there are ways of monitoring various parameters of interest in agriculture and viticulture. Therefore, this can serve as the basis for the introduction of OBBM that can very beneficial to winemakers. This is because OBBM can help winemakers to introduce technology more easily. For instance, OBBM in the vineyard reduces the cost of introducing and maintaining sensors and weather station. Additionally, there are some parameters that are difficult to control in agriculture such as temperature and precipitation. This explains the reason it was easier to introduce OBBM in the manufacturing industry compared to agriculture. In agriculture the introduction of OBBM can take place successfully following certain modifications.

Further, the implementation of OBBM enabled via digital technology enhances the agricultural activities in the vineyards through additional benefits. These benefits include considerable savings in the use of pesticides. OBBM also fosters the reduction of the damage caused by diseases through a process of early recognition of symptoms. All these serve to increase yield by reducing damage to the grapes because of disease.

V. DISCUSSION

A. OBBM in Agriculture

The case study on the vineyards demonstrates that there is the possibility of using OBBMs in agriculture through the collection of data, but there remain challenges. This is via the introduction of digital technology that can to a small extent contribute to better outcomes for the vineyards despite the uncontrollable parameters. Implementation of OBBM will require adding various elements of technology to the current farm management system. This includes the application of precision technologies together with big data analytics. This will be essential in fostering efficiency in agriculture which will be an outcome of increased profitability. The vineyard case study identified some examples of precision technology including sensors. At the same time, the way that farmers will be utilizing Big Data will significantly contribute to further improving farming outcomes and the use of OBBM. Therefore, the implementation of OBBM in agriculture will make the farming process futuristic by making the focus be on the outcome. Through OBBM it will be possible to make agriculture as per the vineyard case take place in a disease-free environment. That is, in instances in which there will be more yields of crops. The case study on the vineyard has shown that following the use of the right technology then outcome-based farming can become a norm in agriculture. While the use of OBBM in agriculture still feels a long way from emerging as the norm as demonstrated in manufacturing it is not impossible to attain.

B. Obstacles and Solutions to OBBM Implementation

However, the implementation of OBBM in the agricultural industry unlike the manufacturing industry is not an easy process because of challenges related to the application of this model. This is because the agricultural industry entails parameters that are beyond control unlike in manufacturing. Some of these parameters are climate, the amount of annual rain, and possible diseases to crops. For this reason, it becomes difficult to determine the outcomes that emanated from the use of the intelligent solutions applied based on the OBBMs. This is significant because the use of OBBMs in agriculture cannot with certainty illustrates the gains.

At the same time, major obstacles also become apparent for the digital technology implementation, and transformation from traditional product-based business models to OBBM. These challenges are ranging from proper utilization of digitalization technologies, organizational changes, changed relationships, and financial measures to understanding accurate needs and requirements of customers as well as business opportunities and future risks related to proper adoption and implementation of advanced technologies.

The success of OBBMs depends on the effective implementation of advanced technologies and a perfect alignment of relationships between people, systems and technologies. Companies must ensure digital business models address true customer needs, align with internal strategies, and maintain a judicious balance between risk and reward. Companies can decide upon the value proportion, creation and delivery mechanism in advance before any agreement is reached between business providers and customers. Otherwise, it often creates friction and disagreement among customers and service providers later.

Compensation is a huge factor to work upon. Innovative value distribution methods can be explored for payment. Outcome-based businesses can be compensated with two methods: payments for availability or payment for economic performance. In the first method of payment which is paid for availability, customers pay the suppliers for the product utilization irrespective of its economic output. The second payment method depends on the economic results gained by the customers as a result of enhanced product performance by the suppliers. Payment by economic value encouraged suppliers to perform effectively in more operations and make them more responsible for the customers' needs. The advancement of technologies has huge potential to deepen the usability of outcome-based business models in businesses.

VI. CONCLUSION

A. Conclusion

This study aimed to understand the scope of the possibility of using OBBM in the agriculture sector following its successful application in the manufacturing industry. As a result, the agriculture sector was explored as how it is responding to the industry 4.0 technologies like IoT, data analytics, cloud computing and other advanced technologies as a base to achieve outcome-based business contracts. However, the use of OBBM in agriculture is still in the infant stage because of the many parameters in this industry that cannot be controlled. Therefore, the application of OBBM in agriculture can best take place following several modifications to overcome the challenges posed by the uncontrollable parameters.

B. Implication

The findings of this study were instrumental in demonstrating the extent of the market maturity and technical readiness for the adoption of IoT-OBBM based in agriculture. Based on the analysis of the state of the art and the agriculture industry case studies, this study shows that it is possible to use OBBM in agriculture. However, in applying IoT-based OBBM it is essential to carefully review the scenario. This means that users must carefully review the conditions under which OBBM can be utilized and validated to ensure protection for users and businesses.

Collaboration, integration and perfect alignment are required not only between the service providers but among the systems, processes, information, management, technologies, people, and overall internal and external business environment. In using digital technology that fosters better outcomes in agriculture such as the reduced use of pesticides there should be more collaboration and integration between service providers and farmers. This includes creating an agreement for the value proposition, value creation and value delivery after farmers utilize the technology. Thus, this will demonstrate to farmers the benefits of using OBBM.

Technological deployment is the main factor and prerequisite that can help in the achievement of these above-mentioned alignments. Hence, the main hurdles for technology implementation and adoption can be removed for smooth and flawless data and information collection, analysis and usage. Addressing these obstacles includes constantly monitoring and providing compensation.

C. Future Studies

Implementing OBBMs beyond manufacturing is difficult as shown by the case of agriculture. This study has demonstrated that a successful application of OBBMs in agriculture is challenging as it depends on several factors which cannot be easily controlled. However, it remains important to continue research into the potential of using OBBM in agriculture as a way of lowering barriers for technology adoption by farmers. This will serve to expand the literature and reveal additional cases where the use of OBBM is successful. For instance, there can be additional research conducted regarding the application of OBBM in the agriculture sector. This is a sector in which the use of OBBM remains at an infant stage.

REFERENCES

[1] Shepherd, Mark, James A. Turner, Bruce Small, and David Wheeler. 2018. "Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture revolution." Journal of the Science of Food and Agriculture, 100(14): 5083-5092. https://doi.org/10.1002/jsfa.9346.

[2] Rijswijk, Kelly, Laurens Klerkx, Manlio Bacco, and Fabio Bartolini. 2021. "Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation." Journal of Rural Studies, 85: 79-90. https://doi.org/10.1016/j.jrurstud.2021.05.003.

[3] Thomson, Linus. 2022. "Leveraging the value from digitalization: a business model exploration of new technology-based firms in vertical farming." Journal of Manufacturing Technology Management, 33(9): 88-107.

[4] Visnjic, Ivanka, Marin Jovanovic, Andy Neely, and Mats Engwall. 2017. "What brings the value to outcome-based contract providers? Value drivers in outcome business models." International Journal of Production Economics, 192: 169–181. https://doi.org/10.1016/j.ijpe.2016.12.008

[5] Ng, Irene, David Xin Ding, and Nick Yip. 2013. "Outcome-based contracts as a new business model: The role of partnership and value-driven relational assets." Industrial Marketing Management, 42(5): 730–743. https:// doi.org/10.1016/j.indmarman.2013.05.009.

[6] Sjödin, David, Vinti Parida, Maximilian Palmié, Joakim Wincent. 2021. "How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops." Journal of Business Research, 134: 574–587. https:// doi.org/10.1016/j.jbusres.2021.05.009.

[7] Kohtamäki, Marko, Vinit Parida, Pejvak Oghazi, Heiko Gebauer, and Tim Baines. 2019. "Digital servitization business models in ecosystems: A theory of the firm." Journal of Business Research, 104: 380–392. https://doi.org/10.1016/j.jbusres.2019.06.027

[8] Lerch, Christian and Matthias Gotsch. 2015. "Digitalized product-service systems in manufacturing firms: A case study analysis." Research-Technology Management, 58(5): 45–52. https://doi.org/10.5437/08956308x5805357

[9] Sjödin, David, Vinti Parida, Maximilian Palmié, Joakim Wincent. 2021. "How AI capabilities enable business model innovation: Scaling AI through co-evolutionary processes and feedback loops." Journal of Business Research, 134: 574–587. https:// doi.org/10.1016/j.jbusres.2021.05.009.

[10] Parida, Vinit, David Sjödin, and Wiebke Reim. 2019. "Leveraging digitalization for advanced service business models: Reflections from a systematic literature review and special issue.

[11] Kamalaldin, Anmar, Lina Linde, David Sjödin, and Vinit Parida. 2020. "Transforming provider-customer relationships in digital servitization: A relational view on digitalization." Industrial Marketing Management, 89: 306–325. https:// doi.org/10.1016/j.indmarman.2020.02.004.

[12] Kumar, Lalit, Prashant Ahlawat, Pradeep Rajput, and Rahul

Navsare. 2021. “Internet of things (IoT) for smart precision farming and agricultural systems productivity: a review.” International Journal of Engineering Applied Sciences and Technology, 5(9): 141-146. https://doi.org/10.33564/IJEAST.2021.v05i09.022.

[13] Saifuzzaman, Md, Viacheslav Adamchuk, Asim Biswas, and Nicole Rabe. 2021. “High-density proximal soil sensing data and topographic derivatives to characterise field variability.” Biosystems Engineering, 211: 19-34. https://doi.org/10.1016/j.biosystemseng.2021.08.018.

[14] Ammoniaci, Marco, Simon-Paolo Kartsiotis, Rita Perria, and Paolo Storchi. 2021. “State of the art of monitoring technologies and data processing for precision viticulture.” Agriculture, 11(3): 1-20. https://doi.org/10.3390/agriculture11030201.

[15] Cordis. 2020. Periodic Reporting for period 3 - IoF2020 (Internet of Food and Farm 2020). [Online] Available at: https://cordis.europa.eu/project/id/731884/reporting [Accessed 18 August 2022].

[16] McCorkle, Dean. A., Rebekka M. Dudensing, Dan D. Hanselka, and Ed W. Hellman. 2019. “The long-term viability of US wine grape vineyards: assessing vineyard labor costs for future technology development.” International Journal of Entrepreneurship and Small Business, 36(3): 308. https:// doi.org/10.1504/ijesb.2019.097734.

[17] Green, Judith, and Nicki Thorogood. 2018. Qualitative methods for health research. 4th ed. London: SAGE Publications Ltd.

[18] Hameed, Hassan. 2020. “Quantitative and qualitative research methods: Considerations and issues in qualitative research.” The Maldives National Journal of Research, 8(1): 8-17.

IoT System for Smart Bekeeping

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Abstract—This article tackles the problem of creating an IoT (Internet of Things) system for smart beekeeping. The goal is to propose an infrastructure that could provide necessary information to prove the organic origin of honey and other honey-based products. The infrastructure includes multiple sensors which are gathering data about the location of the hive, air quality, production process and other essential data. The system also includes streaming collected data to cloud database and blockchain network. This article analyses different solutions and proposes a model of the IoT system for smart beekeeping. The article also shows an implementation of the prototype for the described system.

Keywords - IoT, smart agriculture, data streaming, blockchain

I. INTRODUCTION

Usage of IoT devices is getting more applications in different areas of economy [1]. Smart environments enable easy access to the data, overlooking key process activities and wide range of information that can later be used to predict future behaviors [2].

IoT-based ecosystems in agriculture can be divided into three key types: system for monitoring, system for tracking product origin, and system for managing greenhouses [3]. The goal of this paper is to monitor honey production and gather essential data. This includes data about the location of the beehive, air quality, possible pollution of the land, etc. Interconnected and efficiently located IoT devices gather data from different sensors in real time. This helps to create a more efficient system, with minimum requirements for human interaction and barely any room for error [4].

Conventionally, IoT systems send all data to cloud server [5]. This enables a simple way of accessing information for all stakeholders and setting up an uncomplicated web application. But one of the problems with this approach is that all data is stored on a centralized server managed by a third party. The solution to this problem can be found in using blockchain network. As decentralized character and immutability of data are some of the key qualities of a blockchain network, we can use that to our advantage to solve shortcomings of a cloud database. Critical data gathered using IoT can be stored on the blockchain network to prove that data has not been manipulated at any moment. Additional data will still be stored using centralized cloud databases.

II. RELATED WORK

Different authors have explored similar areas related to smart environments and their usage in agriculture and beekeeping more specifically.

Authors from [6] implemented an automated IoT based system for beekeeping. The prototype is specifically designed to provide data about the conditions inside the beehive. Noises, temperature, and humidity data are monitored in real time. This data is accessible to farmers through a mobile application.

Other authors highlight un-controlled temperature, humidity and traditional beekeeping management as main issues in maintaining bee populations [7]. They propose creating a self-powered monitoring system that can use energy from ambient sources to run, rather than needing to be connected to the power grid.

Authors Fitzgerald et al. emphasize the weight of the colony as one of the key metrics for tracking a beehive. They state that weight data relates to health, conditions, and productivity of the beehive [8].

Developing IoT systems usually implies communication between heterogeneous wireless devices. A gateway is needed to convert different types of data through parsing and re-encapsulating [9].

One of the problems when implementing IoT systems outside urban areas is transferring data over long distances. Traditionally used cellular networks are high on power consumption and hence not applicable in these scenarios. The solution can be found in low-power, wide-area (LPWA) technologies. LoRa technology is considered one of the leading emerging technologies [10]. Key advantages of LoRa are ability to transfer data over long range and low interference with its signal [10].

III. MODEL PROPOSITION

Having in mind similar problems and solutions from other articles, in this paper a model of the IoT system for smart beekeeping is proposed.

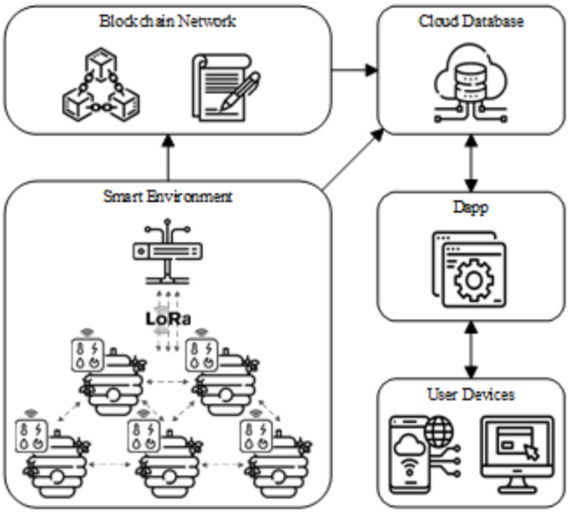

Fig. 1. Software architecture of the IoT system for smart beekeeping [11]

Figure 1 shows the software architecture of the IoT system for smart beekeeping. Every beehive is equipped with a device that gathers sensory data from the beehive and its surroundings. Sensors measure air quality including levels of carbon monoxide, carbon dioxide, oxygen, and chemical pollutants in example NO_2, H_2, NH_3. Sensors also collect data about temperature, humidity, and changes in location of the beehive. Since sensory devices can be spread over a wide area, a gateway is needed to collect and aggregate data and pass it further to the system. Communication and sending data over long distances is applicable use case for implementation of LoRa technology. Data is then collected using a gateway and passed further to the system.

All collected data is passed to a cloud database. Critical data that can be used to prove origin and organic qualities of honey is first passed through blockchain network to ensure truthfulness and immutability. Algorand blockchain platform is used to send data quickly and at a low price. Algorand relies on Pure Proof of Stake algorithm which enables security, scalability and decentralization at the same time [12], [13]. A web-based distributed application is used to provide real time access to information to the beekeeper, but also other stakeholders such as distributors, wholesalers, and end customers. Collected data can be used for future analysis and predictions.

The goal of the proposed system is to provide real-time data to beekeepers, but also make the IoT system for smart beekeeping efficient. Considering these two opposing conditions, frequency of getting data from sensors is an important factor. Providing data in shorter periods results in a more precise system and more data for future analysis. On the other hand, large amounts of data can be difficult to transfer and expensive to store. We need to bear in mind that when moving from a controlled environment to a real environment, power consumption can become an important factor. Putting sensors to sleep can make the system more power efficient. Considering that some sensors need at least 30 seconds to warm up and prepare before outputting reliable data, an interval of logging data should be no less than 60 seconds.

Many gas sensors react to different gases, a term known as cross sensitivity. For example, MQ-2 sensor can detect propane, hydrogen, methane, carbon monoxide, etc., but we cannot be entirely sure if the detection of the targeted gas is affected by other gases. Using multiple different types of sensors and combining their output to differentiate between targeted gas and others can improve quality as well as reliability of data [14].

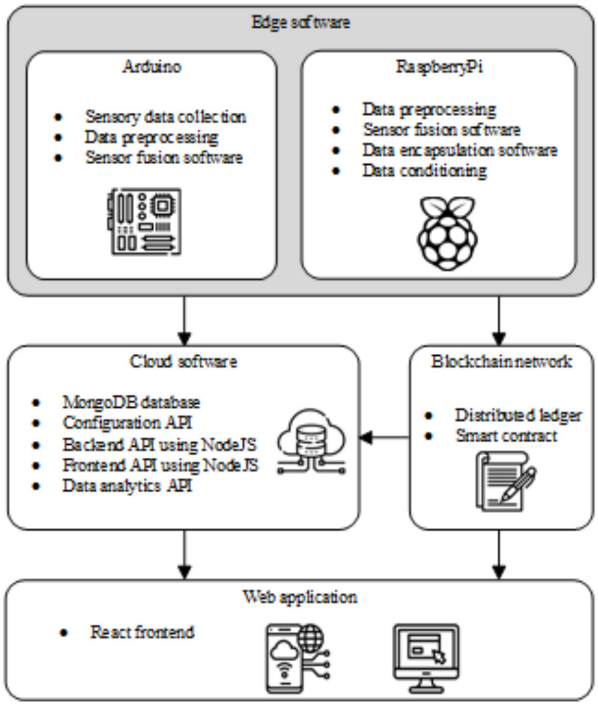

Fig. 2. Software components of the IoT system for smart beekeeping

Figure 2 shows proposed software components for the IoT system for smart beekeeping. Traditionally, IoT systems relied solely on the computation power from external sources, sending all data to cloud. In this case, cloud infrastructure is not very efficient, due to the long latency [15]. Implementation of edge computing reduces the amount of data that is being sent through the system, partly relying on computational power of IoT devices. This way, tasks are only partly transferred to the cloud network.

Arduino microcontroller contains software for gathering sensory data as input, but it is also used as a part of edge computing infrastructure. One Arduino gathers data from sensors attached to one beehive. Data is then preprocessed to an appropriate format. For example, if a sensor outputs temperature in degrees Fahrenheit, we can translate it to degrees Celsius right at the source. Multi-sensor data fusion software is used to combine large volumes of data into single output [16]. Sensory data fusion software is needed in the proposed IoT system for smart beekeeping to aggregate air quality data from multiple sensors into a more accurate and useful output. Another advantage of this approach is that it enables us to avoid usage of precise sensors with high power consumption and instead use multiple low power consumption sensors, which combined can give accurate information [17].

Similar processes are also executed on Raspberry Pi microcomputer. Here we use data fusion to combine data from multiple hives and transform them to the needed format that can be sent further through the system to the cloud database and blockchain network.

On the cloud, MongoDB database is used. Using a document-based database enables writing data in looser format than SQL databases, which is beneficial for writing sensory data. Multiple APIs are also deployed on the cloud for configuration, writing sensory data to database, implementation of operations used on the web application, etc. Configuration API is implemented for determining how the system operates and for making future changes. It enables us to change configuration settings without modifying the code. For example, we can change reading intervals on sensors used in the system and make the system more dynamic. Implementing configuration API can help to set up security and authorization restrictions. Backend API is tasked with gathering sensory data and writing them to the database. It is also used for performing data processing operations. Frontend also needs its own API. This API will mostly deal with reading data from database and sending them to the web application. It also involves implementation of data analytics that will help beekeepers notice trends in the beehive environment.

Essential data for proving the origin of honey is uploaded to a distributed ledger. On the blockchain network, a smart contract is deployed to check if all conditions that prove the origin of the honey are fulfilled. The smart contract will also form a part of the backend of our web application. Availability of smart contract data increases trust in the system.

All data is available to beekeepers through a web application implemented using React library. The proposed design of a web application used by beekeepers is shown in Figure 3.

Beekeeper receives scheduled daily notification about the state of the hives. In case there is an indication that parameters are out of desired scope, beekeeper will get an alert with an appropriate information. Using the application, beekeeper is also able to schedule maintanance of the beehives and important dates, such as checking the beehives, moving the beehives, collecting honey, etc. Data analytics is also available with a goal to help beekeeper understand trends in the environment where beehives are located.

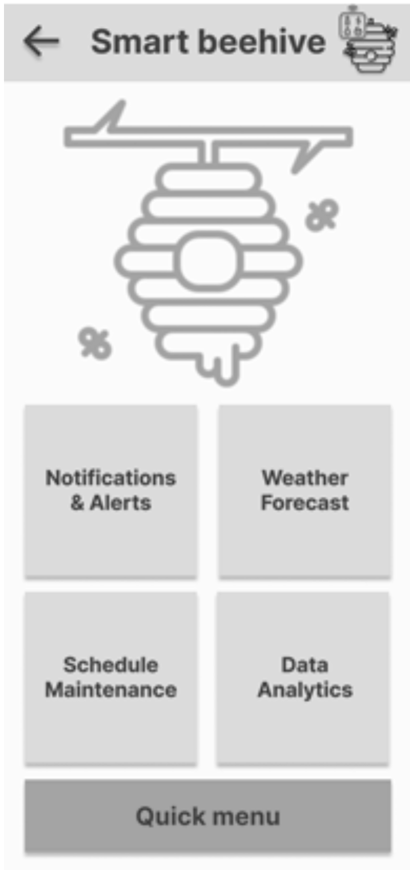

Fig. 3. Web application design

IV. IMPLEMENTATION

The implementation phase includes the development of a prototype for a smart beehive. For collecting data about air quality, we propose using MQ-135 and MQ-2 sensors to detect gases such as ammonia (NH3), carbon dioxide (CO2) and carbon monoxide (CO). For measuring levels of temperature and humidity, DHT11 sensor can be used. All sensors are connected to Raspberry Pi microcomputer which sends data further to the network.

Communication between devices is performed using LoRa wireless modulation, which enables easy and cheap transfer of data over long distances with low power consumption. On top of LoRa, LoRaWAN protocol is used to define way of transmitting and formatting of the messages [18].

Considering that large amounts of data are expected from IoT system with numerous writing operations, NoSQL databases are chosen for storing data on the cloud [19]. Bulk insert of data enables inserting multiple records in a single operation improving writing performance. For this scenario, best results are expected from MongoDB according to the experiment from [20].

The prototype of the smart beehive will be tested in a controlled environment to check for problems in implementation and potential improvements.

V. CONCLUSION

Implementation of the IoT technology in traditional industries, such as beekeeping, automates gathering of essential information and thus improves efficiency of processes [21]. Having real-time information enables fast response time in case problems arise. Sensory data helps beekeepers, but also provides additional information to other stakeholders. Information about origin, location, air quality etc. are significant to final consumers. Proving the high quality of the honey helps final consumers make fact-based decisions when buying final product. This is especially important considering the fact that according to newly organized EU action "From the Hives", 46% of honey tested on the EU market proved to be mixed with sugar sirup [22][23].

Considering the large amounts of data that can be gathered using IoT, future work in this field could include developing a cloud infrastructure for managing data streaming.

In the future, the IoT system can be expanded to collect data from other stakeholders such as distributors and wholesalers. This would allow tracking honey through the whole supply chain providing fast and open access to data.

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REFERENCES

[1] B. Radenković, M. Despotovic-Zrakic, Z. Bogdanović, D. Barać, A. Labus, and Ž. Bojović, Internet inteligentnih uređaja. Univerzitet u Beogradu, Fakultet organizacionih nauka, 2017.

[2] E. Ahmed, I. Yaqoob, A. Gani, M. Imran, and M. Guizani, "Internet-of-things-based smart environments: State of the art, taxonomy, and open research challenges," IEEE Wirel. Commun., vol. 23, no. 5, pp. 10–16, Oct. 2016, doi: 10.1109/MWC.2016.7721736.

[3] V. K. Quy et al., "IoT-Enabled Smart Agriculture: Architecture, Applications, and Challenges," Appl. Sci. 2022, Vol. 12, Page 3396, vol. 12, no. 7, p. 3396, Mar. 2022, doi: 10.3390/APP12073396.

[4] A. Kaur, G. Singh, V. Kukreja, S. Sharma, S. Singh, and B. Yoon, "Adaptation of IoT with Blockchain in Food Supply Chain Management: An Analysis-Based Review in Development, Benefits and Potential Applications," Sensors 2022, Vol. 22, Page 8174, vol. 22, no. 21, p. 8174, Oct. 2022, doi: 10.3390/S22218174.

[5] M. A. Uddin, A. Stranieri, I. Gondal, and V. Balasubramanian, "A survey on the adoption of blockchain in IoT: challenges and solutions," Blockchain Res. Appl., vol. 2, no. 2, p. 100006, Jun. 2021, doi: 10.1016/J.BCRA.2021.100006.

[6] M. S. Mahamud, M. A. Al Rakib, T. M. Faruqi, M. Haque, S. A. Rukaia, and S. Nazmi, "Mouchak-An IoT Basted Smart Beekeeping System Using MQTT," 2019 4th Int. Conf. Robot. Autom. Eng. ICRAE 2019, pp. 84–88, Nov. 2019, doi: 10.1109/ICRAE48301.2019.9043815.

[7] E. Ntawuzumunsi, S. Kumaran, and L. Sibomana, "Self-Powered Smart Beehive Monitoring and Control System (SBMaCS)," 2019, doi: 10.3390/s21103522.

[8] D. W. Fitzgerald, F. Edwards-Murphy, W. M. D. Wright, P. M. Whelan, and E. M. Popovici, "Design and development of a smart weighing scale for beehive monitoring," 2015 26th Irish Signals Syst. Conf. ISSC 2015, Jul. 2015, doi: 10.1109/ISSC.2015.7163763.

[9] Y. Chen, M. Li, P. Chen, and S. Xia, "Survey of cross-technology communication for IoT heterogeneous devices," IET Commun., vol. 13, no. 12, pp. 1709–1720, Jul. 2019, doi: 10.1049/IET-COM.2018.6069.

[10] R. S. Sinha, Y. Wei, and S. H. Hwang, "A survey on LPWA technology: LoRa and NB-IoT," ICT Express, vol. 3, no. 1, pp. 14–21, Mar. 2017, doi: 10.1016/J.ICTE.2017.03.004.

[11] P. Lukovac, A. Miletić, and B. Radenković, "Designing a blockchain-based e-business system for tracking honey production," in SUSTAINABLE BUSINESS MANAGEMENT AND DIGITAL TRANSFORMATION: CHALLENGES AND OPPORTUNITIES IN THE POST-COVID ERA, 2022, pp. 184–185.

[12] S. Micali, "ALGORAND'S CORE TECHNOLOGY (in a nutshell)," Medium, Apr. 04, 2019. https://medium.com/algorand/algorands-core-technology-in-a-nutshell-e2b824e03c77 (accessed Sep. 09, 2022).

[13] Y. Gilad, R. Hemo, S. Micali, G. Vlachos, and N. Zeldovich, "Algorand: Scaling Byzantine Agreements for Cryptocurrencies," 2017, doi: 10.1145/3132747.3132757.

[14] J. Y. Kim, C. H. Chu, and S. M. Shin, "ISSAQ: An integrated sensing systems for real-time indoor air quality monitoring," IEEE Sens. J., vol. 14, no. 12, pp. 4230–4244, Dec. 2014, doi: 10.1109/JSEN.2014.2359832.

[15] W. Rafique, L. Qi, I. Yaqoob, M. Imran, R. U. Rasool, and W. Dou, "Complementing IoT Services through Software Defined Networking and Edge Computing: A Comprehensive Survey," IEEE Commun. Surv. Tutorials, vol. 22, no. 3, pp. 1761–1804, Jul. 2020, doi: 10.1109/COMST.2020.2997475.

[16] F. Alam, R. Mehmood, I. Katib, N. N. Albogami, and A. Albeshri, "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey," IEEE Access, vol. 5, pp. 9533–9554, 2017, doi: 10.1109/ACCESS.2017.2697839.

[17] S. Vural and E. Ekici, "On multihop distances in wireless sensor networks with random node locations," IEEE Trans. Mob. Comput., vol. 9, no. 4, pp. 540–552, Apr. 2010, doi: 10.1109/TMC.2009.151.

[18] "What are LoRa and LoRaWAN? | The Things Network." https://www.thethingsnetwork.org/docs/lorawan/what-is-lorawan/ (accessed Apr. 25, 2023).

[19] B. G. Tudorica and C. Bucur, "A comparison between several NoSQL databases with comments and notes," in 2011 RoEduNet International Conference 10th Edition: Networking in Education and Research, 2011. doi: 10.1109/RoEduNet.2011.5993686.

[20] P. Thi Anh Mai, J. K. Nurminen, and M. Di Francesco, "Cloud Databases for Internet-of-Things Data," Proc. - 2014 IEEE Int. Conf. Internet Things, iThings 2014, 2014 IEEE Int. Conf. Green Comput. Commun. GreenCom 2014 2014 IEEE Int. Conf. Cyber-Physical-Social Comput. CPS 20, pp. 117–124, 2014.

[21] B. Radenković, M. Despotović-Zrakić, Z. Bogdanović, D. Barać, A. Labus, and T. Naumović, "A blockchain system for monitoring food supply chain," in International Scientific conference Sustainable development of rural areas, p. 2021.

[22] E. Anti-Fraud Office, "Press release: (No) sugar for my honey: OLAF investigates honey fraud," 2023, Accessed: Apr. 28, 2023. [Online]. Available: https://anti-fraud.ec.europa.eu

[23] E. Commission et al., EU coordinated action to deter certain fraudulent practices in the honey sector : analytical testing results of imported honey. Publications Office of the European Union, 2023. doi: doi/10.2760/184511.

Эффективное развитие складской отрасли логистики: преимущества систем автоматического взвешивания и контроля грузов

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Abstract—Современный глобальный мир повсеместно нацелен на поступательное развитие, расширение ассортимента товаров, что связано в основном с внедрением передовых технологий в деятельность всех структурных элементов экономики, в том числе развитием современных складских технологий. Технологические решения и цифровые технологии позволяют ускорять процессы на таможенных складах временного хранения, что в конечном итоге повышает их результативность и эффективность. В статье рассмотрены основные прогрессивные цифровые технологии складской отрасли, обозначены проблемы обеспечения цифровыми технологиями. Авторами предлагается алгоритм дальнейшего развития связанной системы учета и контроля поставок во взаимодействии государственных органов и их логистических частных партнеров.

Keywords - цифровизация, склады, технологии, логистика, управление, автоматизация, процессы, издержки, система, безопасность поставок.

I. ВВЕДЕНИЕ

Современная логистика требует постоянного совершенствования и оптимизации процессов, чтобы обеспечить максимальную эффективность и минимальные затраты. Одним из ключевых направлений развития является использование новых технологий, таких как системы автоматического взвешивания и контроля грузов. Эти инновационные решения позволяют значительно ускорить и упростить процессы складирования и транспортировки товаров, а также повысить точность и надежность контроля за грузами [2].

Склады временного хранения (далее – СВХ) играют важную роль в цепи поставок и логистических операциях, обеспечивая хранение и перемещение товаров между производством и конечными потребителями. Оптимизация и автоматизация складской деятельности являются ключевыми факторами для повышения эффективности [11], снижения издержек и улучшения общей производительности. Несомненно, что одним из методов снижения расходов и повышения уровня логистического сервиса, является сотрудничество со специализированными российскими логистическими операторами [9], в том числе являющимися складами временного хранения по совмещению функций.

Основными функциями деятельности СВХ являются: хранение товаров под таможенным контролем до завершения временного хранения или их выпуска в соответствии с заявленной таможенной процедурой; получение дополнительного времени для преодоления ограничений тарифного и нетарифного характера; размещение крупных партий товаров с правом изъятия товаров отдельными партиями под таможенную процедуру выпуска для внутреннего потребления, что позволяет снизить объем оборотных средств, необходимых для уплаты таможенных пошлин [8].

В настоящее время не существует универсального программного продукта, способного полностью покрыть потребности в автоматизации управления [5] складами временного хранения, но даже какой-либо одной их области.

В данной статье предлагается рассмотреть преимущества внедрения таких систем и возможности их использования для оптимизации затрат логистических предприятий, в том числе актуальность исследования связана и с рассмотрением в настоящий момент проекта изменений в Федеральный закон от 03.08.2018 № 289-ФЗ «О таможенном регулировании в Российской Федерации», вынесенного на рассмотрение депутатом В.М. Резником – членом Комитета Государственной Думы по бюджету и налогам (далее – Комитет Госдумы), на данный момент проект изменений №296887-8 находится на рассмотрении в втором чтении.

Вопросам внедрения прогрессивных цифровых технологий складской отрасли посвящены работы Ильиной Т.А., Кириной Д.Н. [1], Николаевой Т. И [2], Гимельштейн, Е. А. [6], Федоренко, В. Ю. [7] и др.

II. МАТЕРИАЛЫ ИССЛЕДОВАНИЯ

Системы автоматического взвешивания и контроля грузов являются важными инструментами для оптимизации процессов складирования и транспортировки товаров. Они позволяют значительно ускорить процессы приемки и отгрузки товаров, а также повысить точность и надежность контроля за грузами.

Системы автоматического взвешивания позволяют быстро и точно определить вес груза, что особенно важно при работе с большими объемами товаров и безопасностью поставок. Это позволяет избежать ошибок при расчете стоимости доставки и уменьшить риски связанные с перегрузкой грузовых машин.

Контроль транзитных грузов позволяет отслеживать перемещение товаров по всему пути следования, начиная от момента отправления до момента доставки. Это обеспечивает полную прозрачность процесса и позволяет быстро реагировать на любые возможные задержки или проблемы.

Автоматизация складирования является развивающейся сферой, которая охватывает многие бизнес-процессы [6]. Внедрение систем автоматизации позволяет значительно сократить затраты на транспортировку и складирование товаров [1]. Более точный контроль за грузами позволяет избежать потерь и повреждений товаров. Это позволяет сэкономить на затратах связанных с обработкой возвратов и рекламаций, а также повысить уровень удовлетворенности клиентов логистической услуги.

Обозначенный выше проект изменений №296887-8, в том числе устанавливает новые требования к обустройству территорий, прилегающих к складам временного хранения (далее – СВХ) и самих СВХ в отношении, в том числе:

- оснащения системой видеонаблюдения, обеспечивающей возможность визуального контроля всей территории склада, дистанционного вращения
- в вертикальной и горизонтальной плоскостях, фокусирования, приближения и удаления участков и объектов видеонаблюдения;
- оснащения стационарной системой радиационного контроля с детекторами гамма- и нейтронного излучения, оснащенной комплектом видеонаблюдения с выводом информации на автоматизированное рабочее место;
- наличие автоматизированной системы учета товаров, совместимой с программными продуктами государственных органов;
- обеспечение информационного взаимодействия между владельцем склада временного хранения и таможенным органом через личный кабинет, в том числе обеспечение передачи таможенному органу в электронном виде через личный кабинет сведений, содержащихся в отчетности о товарах, находящихся на складе временного хранения, и получения в электронном виде от таможенного органа сведений о выпуске товаров, находящихся на складе временного хранения;
- оснащения системой считывания регистрационного номера автомобиля в местах въезда (выезда) на (с) территорию склада временного хранения с предоставлением доступа к указанной системе таможенному органу и возможностью передачи информации в информационную систему таможенных органов;
- оснащения инспекционно-досмотровым комплексом [3].

Введение требований по наличию современных систем контроля и отслеживания за перемещением товаров, транспортных средств, лиц по территории СВХ, в том числе систем таможенного контроля, позволит повысить уровень автоматизации отдельных операций, приведет к возможности опосредованного участия должностных лиц в контроле за размещением товаров на территории склада временного хранения.

Первый шаг в исследовании возможностей применения модели автоматизации складской деятельности на складах временного хранения - это анализ методики автоматического взвешивания. Методика основана на использовании специализированного оборудования и алгоритмов для автоматического взвешивания товаров при их поступлении на склад, перемещении и отгрузке. Основными преимуществами этой методики можно выделить такие аспекты как повышение точности и скорости взвешивания, устранение возможности человеческой ошибки и сокращение времени обработки груза.

Вторым шагом модели автоматизации складской деятельности на складах временного хранения является визуальный автоматизированный контроль. Этот подход включает использование систем компьютерного зрения и алгоритмов обработки изображений для автоматического контроля качества товаров, идентификации и сортировки по параметрам, позволяющее выявить преимущества данной методики, такие как повышение точности и надежности контроля, ускорение процесса погрузочно-разгрузочных работ и улучшение общей эффективности операций на складе временного хранения.

Третий шаг - это анализ возможностей внедрения модели автоматизации складской деятельности на складах временного хранения. При внедрении модели автоматизации необходимо учитывать специфические особенности складов временного хранения, такие как большой и не всегда прогнозируемый объем товаров, быстрая сменяемость товарной номенклатуры и частая ротация

Процесс автоматизацию склада можно разделить на две основные задачи:

1. выбор программного обеспечения и системы учета;
2. выбор и приобретение необходимого оборудования [7].

Примерами систем автоматического взвешивания российской разработки можно привести системы производства компании "МЕТРА" [4]; автоматизированную систему управления АСУ «Весовой поток» - это модули системы интеллектуального управления логистикой Ярд 2.0 – современного программно-аппаратного комплекса, разработанные компаниями «Цифровые контрольные технологии»; системы динамического взвешивания WIM VanJee производства компании Sensotec и другие - данные системы на датчиках, которые устанавливаются на дороге (дорожном покрытии) и позволяют автоматически взвешивать грузовые автомобили, распознавать государственные номера с обеспечением фотофиксации и видеофиксации взвешивания, управления шлагбаумами и светофорами.

Примерами системы электронных пропусков можно привести VideoNet-AUTO PSIM, EME.WMS 5.5 и другие, позволяющие создавать электронные пропуска на основе QR-кодов или биометрических данных.

В общем понимании программно-аппаратные комплексы для автоматизации взвешивания и распознавания данных предназначены для уменьшения влияния человеческого фактора, упорядочивания и ускорения процесса взвешивания автомобилей, контроля за работой сотрудников, предотвращения мошенничества при взвешивании, проведения автоматического взвешивания без участия оператора.

В базовую систему входят следующие модули:

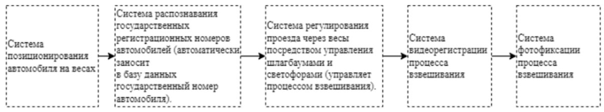

Рис. 1. Модули системы программно-аппаратного комплекса для автоматизации взвешивания и распознавания данных (составлено авторами)

Алгоритм взвешивания в автоматическом режиме (без участия оператора/ человеческого фактора) представлен на рисунке 2 [4].

Рис. 2. Алгоритм взвешивания в автоматическом режиме

Также схематично представим возможный алгоритм прохождения цепочки поставки до момента поступления на СВХ с применением автоматизированных методик.

Рис.3. Алгоритм прохождения цепочки поставки до момента поступления на СВХ с применением автоматизированных методик (составлено авторами)

Для расчета экономии при внедрении на складе системы автоматического взвешивания автомобилей и формирования электронных пропусков можно использовать следующую формулу, в которой учитывается среднее время на взвешивание до и после внедрения системы, стоимость часа работы сотрудника, количество взвешиваний в день и количество рабочих дней в году:

Э=Твз ср- Твз ср*С*А*АY, где (1)

Э – Экономия,

Т вз ср - среднее время на взвешивание до внедрения,

С - стоимость часа работы сотрудника,

А - количество взвешиваний в день,

АУ - количество рабочих дней в году

Модель построения сигмоиды для прогнозирования затрат на основе данных о затратах на транспортировку грузов, складирование товаров, упаковку и маркировку товаров, количестве перевозок в месяц, объеме перевозимых грузов в месяц, дистанции между складом и пунктом назначения, средней стоимости топлива в регионе и налогах и сборах на транспортировку грузов, позволяет оптимизировать затраты на логистические процессы. Это позволяет предсказывать будущие затраты и принимать решения, направленные на оптимизацию логистических процессов.

III. ВОЗМОЖНОСТИ ПРИМЕНЕНИЯ ПРЕДЛАГАЕМОЙ МОДЕЛИ

Для того чтобы произвести необходимые расчеты и определить возможности применения модели необходимо выделить ключевые параметры на складах временного хранения, влияющие на формирование издержек, определить какие расходы повлечет за собой необходимость внедрения автоматизированных законодательных инициатив, в течение какого срока данные расходы будут компенсированы и за счет каких производимых изменений производственной цепочки.

В качестве входных данных на складах предлагается принимать следующие параметры: номер СВХ по реестру; наименование, ИНН и местонахождение владельца СВХ; площадь СВХ (открытой и закрытой площадки); тип склада; региональный таможенный орган, контролирующий деятельность склада; текущие издержки на содержание всех контрольно-пропускных пунктов, диспетчерской, производственных помещений; количество и фонд оплаты труда сотрудников на каждом элементе склада; стоимость заезда товарной партии на СВХ; стоимость закупки и внедрения выбранной АСУ; стоимость интегрированного ПО выбранной АСУ; стоимость ежемесячного обслуживания выбранной АСУ.

Путем анализа указанных характеристик каждого объекта и использования методов экономико-математического моделирования возможно произвести расчет основных параметров и рассчитать точный срок окупаемости внедрения автоматизированных методик взвешивания и контроля грузов.

В общем понимании, применение автоматического взвешивания и контроля позволяет улучшить точность и скорость процессов взвешивания товаров, а также сократить время обработки груза, что способствует оптимизации операций на складе. Визуальный автоматизированный контроль позволяет повысить качество контроля товаров и эффективность сортировки, а также улучшить общую надежность и точность процессов.

Модель автоматизации складской деятельности, основанная на методике автоматического взвешивания и визуального автоматизированного контроля, представляет значительные возможности для складов временного хранения. Применение данной модели может привести к повышению эффективности, снижению ошибок и издержек, улучшению качества контроля и общей производительности склада. Однако необходимо учитывать специфические особенности складов временного хранения при внедрении данной модели.

Основываясь на проведенном анализе и исследовании, можно сформулировать несколько рекомендаций для успешного внедрения модели автоматизации складской деятельности на складах временного хранения:

1. Анализ текущих процессов.

Перед внедрением модели автоматизации необходимо провести тщательный анализ текущих процессов складской деятельности на складах временного хранения:

- идентификация узких мест, проблем и возможных областей для улучшения. Это поможет определить, какие именно аспекты автоматизации будут наиболее полезны и эффективны для вашей организации.
- адаптация модели к специфике конкретного склада временного хранения –необходимо учесть специфические особенности складов временного хранения, большой объем товаров, быструю сменяемость номенклатуры и необходимость обеспечения оперативности обработки грузов.,
- разработка стратегии, которая учитывает особенности и оптимизирует процессы складской деятельности.

2. Обеспечение необходимой инфраструктуры и оборудования: внедрение модели автоматизации потребует соответствующей инфраструктуры и специализированного оборудования, в том числе консультации с производителями и поставщиками оборудования для получения рекомендаций, обучение персонала и обеспечение поддержки.

3. Оценка результатов и постоянный мониторинг эффективности – необходимо произвести сравнение показателей работы до и после внедрения модели, такие как точность взвешивания, скорость обработки грузов, качество контроля и общая производительность склада. На основе этой оценки уже определяется необходимость внесения корректировок или доработок модели автоматизации, чтобы добиться наилучших результатов.

IV. ЗАКЛЮЧЕНИЕ

Сфера складской логистики сталкивается с постоянно возрастающими требованиями эффективности и точности. Модель автоматизации складской деятельности, основанная на методике автоматического взвешивания и визуального автоматизированного контроля, представляет значительные возможности для оптимизации и улучшения процессов на складах временного хранения. Применение этой модели может привести к повышению эффективности, снижению ошибок и издержек, улучшению качества контроля и общей производительности. Однако успешное внедрение модели требует анализа текущих процессов, адаптации к специфике складов временного хранения, обеспечения необходимой инфраструктуры и оборудования, обучения персонала и оценки результатов. Систематический подход к внедрению и постоянное улучшение модели позволят организациям достичь оптимальной автоматизации складской деятельности и повысить свою конкурентоспособность на рынке.

Очевидно, что прогрессивные цифровые технологии складской логистики позволяют реализовать поставленные задачи: точный учет поставок товаров; таможенный контроль; отслеживание поставок; цифровизация услуг для клиентов и их высокое качество; расширение диапазона услуг предпродажной подготовки товаров к реализации до их выпуска. Применение искусственного интеллекта (AI) в качестве инструмента аналитики и первичного исследования обосновано возможностью делегировать «умной» системе рутинные складские процедуры, которые, с одной стороны, не требуют интеллектуальных усилий человека, с другой – необходимы в рамках определенных технологических и хозяйственных процессов [10].

В связи с вышеизложенным авторы полагают, что системы автоматического взвешивания и контроля грузов позволяют значительно ускорить и упростить процессы складирования и транспортировки товаров, а также повысить точность и надежность контроля за грузами. Внедрение таких систем способствует автоматизации процессов взвешивания и контроля товаров на складе, устранению ошибок, снижению потерь и повышению общей эффективности, сокращению затрат на транспортировку и складирование товаров, а также повышение уровня безопасности данных и удовлетворенности клиентов.

БИБЛИОГРАФИЯ

[1] Ильина Т.А., Кирина Д.Н. Цифровизация логистических процессов российских предприятий на основе внедрения технологии RFID // Научно-технические ведомости СПбГПУ. Экономические науки. - № 4. - 2020 // URL: https://economy.spbstu.ru/userfiles/files/articles/2020/4/03_Ilina%2C-Kirina.pdf (дата обращения: 14.04.2023).

[2] Николаева Т.И. Прогрессивные технологии складской логистики и перспективы их развития. // Евразийский Союз Ученых (ЕСУ). - № 30. - 2016 // URL: https://elibrary.ru/item.asp?id=27439895 (дата обращения: 14.04.2023).

[3] Законопроект № 296887-8 «О внесении изменений в Федеральный закон "О таможенном регулировании в Российской Федерации и о внесении изменений в отдельные законодательные акты Российской Федерации"» (о совершенствовании законодательства Российской Федерации о таможенном регулировании с учетом правоприменительной практики) // URL: https://sozd.duma.gov.ru/bill/296887-8 (дата обращения: 14.04.2023).

[4] Программно-аппаратный комплекс для автоматизация взвешивания // URL: http://www.metra.ru/catalogue/catalogue-auto/programno-aparatnyi-kompleks-dlja-avtomatizacija-vzveshivanija.html (дата обращения: 14.04.2023).

[5] I. Eremina, V. Degtereva, Kh. Kobulov, N. Yuldasheva. Automation of Investment and Project Management Based on the Introduction of an Enterprise Resource Planning System in the Power Grid Company. // Sustainable Development and Engineering Economics. - № 1(7). – 2023.// URL: https://www.elibrary.ru/item.asp?id=50749455. (дата обращения: 14.05.2023).

[6] Гимельштейн Е. А. Логистика склада. Процессы внедрения автоматизации в современные склады. // Бизнес-образование в экономике знаний. – № 1(18). – 2021..// URL: https://www.elibrary.ru/item.asp?id=44755431. (дата обращения: 14.05.2023).

[7] Федоренко В. Ю. Автоматизация процессов производства радиоэлектроники на примере внедрения цифровой системы управления складской логистикой на предприятии.// Мировая наука. – № 8(53). – 2021. .// URL: https://www.elibrary.ru/item.asp?id=46537940. (дата обращения: 14.05.2023).

[8] Ефремов Я. В., Е. Н. Ефремова Особенности использования складов временного хранения и таможенных складов в сфере таможенного дела. // Транспорт в интеграционных процессах мировой экономики: Материалы Международной научно-практической онлайн-конференции, Гомель, 24 апреля 2020 года/ Под редакцией профессора В.Г. Гизатуллиной. – Гомель: Учреждение образования "Белорусский государственный университет транспорта". 2020. // URL: https://www.elibrary.ru/item.asp?id=48677045. (дата обращения: 14.05.2023).

[9] Кривонос А. Д. Оптимизация логистических издержек путем привлечения специализированных операторов// Ученые записки Международного банковского института. – 2022. – № 4(42). // URL: https://www.elibrary.ru/item.asp?id=50244404. (дата обращения: 14.05.2023).

[10] Микуленков А. С. Искусственный интеллект: драйвер цифровой трансформации и источник экономических угроз// Ученые записки Международного банковского института. – 2022. – № 1(39). // URL: https://www.elibrary.ru/item.asp?id=48392462. (дата обращения: 14.05.2023).

[11] Назаров П. В. Экономическая безопасность и устойчивость социально-экономической системы в периоды кризисов / П. В. Назаров, А. В. Плотников // Ученые записки Международного банковского института. – 2022. – № 4(42). // URL: https://www.elibrary.ru/item.asp?id=50244409. (дата обращения: 14.05.2023).

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VR, AR AND COMPUTER SIMULATION

Simulation and Analysis of Blockchain Operations Model with RSA Algorithm in CrypTool2

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Abstract—In this paper the simulation model of blockchain operations is created and tested through a few transactions among the participants. The participants are able to send and receive coins or to mine blocks to earn coins, while all transactions are stored in the blocks' data, including the address of sender and the address of the receiver. The address is a hash value of a public key for asymmetric cryptography. The RSA (Rivest-Shamir-Adleman) asymmetric algorithm is used, including public key and private key. The model is created in CrypTool2 software, including three blocks and smaller numbers for generating the RSA public and private key pairs than in real blockchain transactions, in order to minimize the simulation time. Some attacks are also simulated, and those transactions are not accepted because of invalid signature, since the attacker does not have someone's private key.

Keywords - blockchain technology, CrypTool2, valid and invalid transactions, RSA algorithm

I. INTRODUCTION

Blockchain is a contemporary technology composed of various elements that work together to create a network that ensures trust between users. It is a decentralized and distributed database that allows for the verification of transactions and cannot be altered or deleted [1]. The network is made up of blocks, chains, and nodes, and is based on distributed general ledger technology. The use of cryptographic techniques ensures data encryption and record integrity, making it a secure approach to data storage [2].

Authors utilize CrypTool2, a software tool specifically designed for cryptographic and security-related simulations and analysis [3]. CrypTool2 offers a user-friendly interface that enables the creation and testing of various cryptographic algorithms, including the RSA (Rivest-Shamir-Adleman) asymmetric algorithm employed in our simulation model. The software provides functionality for generating RSA public and private key pairs, as well as simulating blockchain-based transactions and attacks. By utilizing CrypTool2, we can effectively model and evaluate the behavior of our blockchain-based simulation in a controlled environment [4].

Each block in the network is a list of transactions that are recorded chronologically and stored on various computers connected through a peer-to-peer protocol. Nodes in the network continuously verify the authenticity of records, and the function of mining is used to validate these transactions. Once a transaction has been validated, it cannot be altered or deleted [5].

The process of selecting a valid block of transactions is known as proof-of-work, which protects the network from misuse. Once a block has been validated, it is propagated to other nodes in the network and connected with other transactions in the new block, forming a chain of blocks or a blockchain. The hash, which is a fingerprint of data, connects each block together and cannot be decrypted, making it a secure approach to data storage [6]. The blockchain is comprised of three layers, namely the protocol layer, the network layer, and the application or business layer. Each layer contributes distinct elements to the blockchain with the purpose of advancing its development [7]. The utilization of blockchain technology across various domains offers several advantages due to its key features such as decentralization, immutability, transparency, and security [8].

A. Decentralization

The flexibility of blockchain is attributed to its decentralized nature where there is no central entity controlling the process. Multiple and distributed nodes ensure the network cannot be easily attacked or destroyed. However, some doubt has been raised regarding decentralization, especially in large-scale mining activities as highlighted in research studies [9].

B. Immutability/Resistance to abuse

Blockchain is characterized by its resistance to change or deletion of transaction records, making it difficult to modify records unnoticed. The use of public-private keys or cryptographic signatures ensures integrity and authentication, thus reducing the possibility of fraud [10].

C. Transparency

The use of a book available to all users or a predefined set of users provides transparency. In public or open blockchains, all participants have equal rights to access and update the book according to existing consensus mechanisms, making transactions transparent and visible. However, transparent data in public systems can become an issue when confidential information is accidentally made publicly available or needs to be modified due to errors or inaccuracies [11].

D. Security

Blockchain provides a high level of security due to the anonymity of transactions. Any transaction or digital event taking place in a blockchain network must be agreed upon by the consensus of the majority of users participating in the process, ensuring verification and security [9].

II. BLOCKCHAIN SIMULATION MODEL

A blockchain simulation model is a computer-based model that simulates the behavior of a blockchain network. It allows users to understand and test the functionality of a blockchain network without the need for actual implementation [12], [13]. A simulation model consists of different elements of a blockchain network, including nodes, transactions, and consensus algorithms. By adjusting these elements, users can simulate various scenarios and observe the network's behavior in response to different inputs [14].

There are different types of simulation models, such as agent-based models and discrete event simulation models. These models can be used to simulate different types of blockchain networks, such as public and private blockchains [15]. Simulation models can be used for various purposes, such as testing the performance and scalability of a blockchain network, evaluating the effectiveness of consensus algorithms, and analyzing the impact of different network parameters on the overall network behavior [4].

Blockchain simulation models provide a valuable tool for understanding and optimizing blockchain networks, helping to reduce the costs and risks associated with implementing new blockchain solutions [11].

The simulation model with three blocks (block ID 0, block ID 1 and block ID 2) and two participants, Ana and Goran, is presented in Fig. 1.

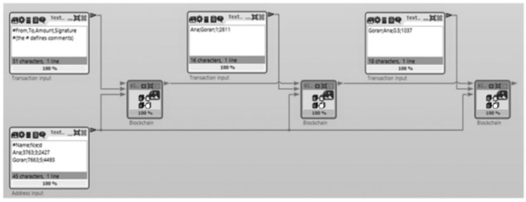

Fig. 1. The simulation model of blockchain operations with 3 blocks and 2 participants

A blockchain simulation model is a computer-based model that enables users to simulate the behavior of a blockchain network without actual implementation [16]. It serves as a valuable tool for understanding and optimizing blockchain networks, allowing users to test different scenarios and observe network behavior [9]. The simulation model presented in this study consists of three blocks (Block ID 0, Block ID 1, and Block ID 2) and involves three participants, Ana, Hana and Goran. The participants engage in transactions and maintain balances within each block. The transactions and balances within these blocks are illustrated in Figs 2-7. Figs 2-7 provide a detailed representation of the transactions and balances in each block. Fig. 2 displays the transactions that occurred within Block ID 0, including sender and receiver addresses and the amount of coins transferred. Fig. 3 showcases the balance of coins held by Ana and Goran within Block ID 0. Fig. 4 illustrates the transactions within Block ID 1. Fig. 5 presents the balance of Ana and Goran after the transactions within Block ID 1. Fig. 6 represents the transactions within Block ID 2. Fig. 7 shows the final balance of Ana and Goran after the transactions within Block ID 2. These figures provide a visual and informative overview of the simulation model, giving insights into the specific transactions made by participants and the corresponding changes in their balances as the blockchain progresses. The simulation model, along with the detailed depiction of transactions and balances, facilitates the evaluation of blockchain network performance, consensus algorithms, and the impact of various parameters on network behavior. It serves to reduce costs and risks associated with the implementation of new blockchain solutions.

The transactions and balance in each block are given in Figs 2-7.

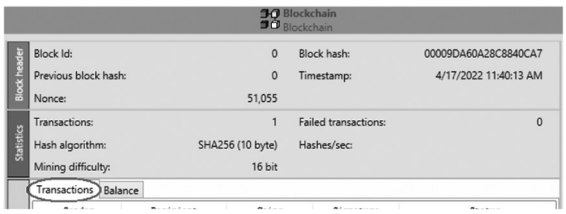

Fig. 2. Block ID 0 transactions

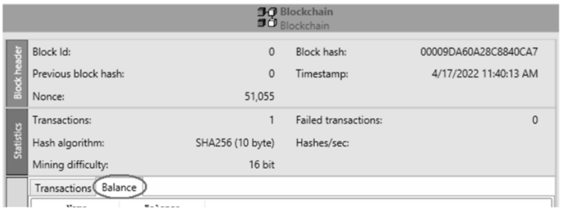

Fig. 3. Block ID 0 balance

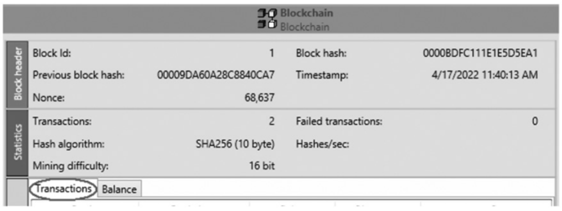

Fig. 4. Block ID 1 transactions

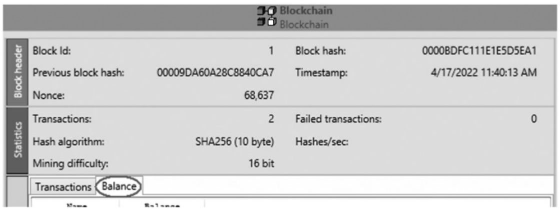

Fig. 5. Block ID 1 balance

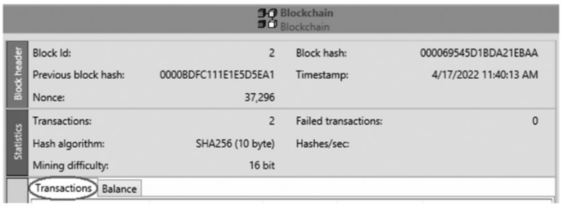

Fig. 6. Block ID 2 transactions

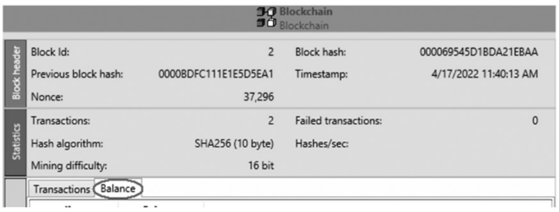

Fig. 7. Block ID 2 balance

After adding the text output block after block ID 2, in order to analyze all transactions in JSON (JavaScript Object Notation) file, the model given in Fig. 8. is created, while the JSON format data is presented in Fig. 9.

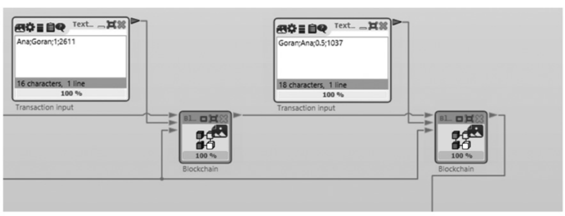

Fig. 8. Adding the Text Output block in order to analyze transactions in JSON format

Fig. 9. Transaction data in JSON format

III. ADDING A NEW PARTICIPANT

The new participant's (Hana) address is generated, using the RSA key generator, as it is presented in Fig.10.

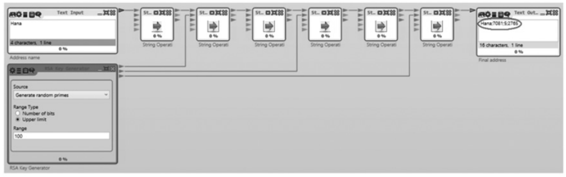

Fig. 10. Creating the new participant's address

The model with new participant added is presented in Fig.11.

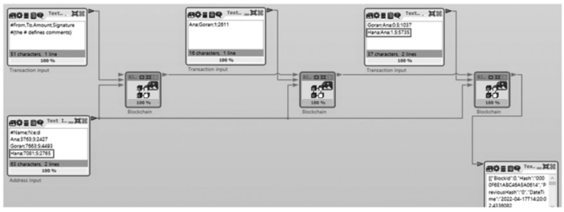

Fig. 11. The simulation model with new participant (Hana) and her transactions

The transactions after adding the new participant are presented in Fig.12-Fig.14.

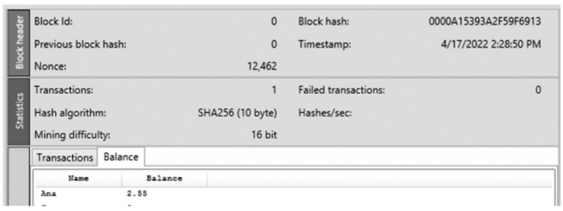

Fig. 12. Block ID 0 balance after adding the new participant

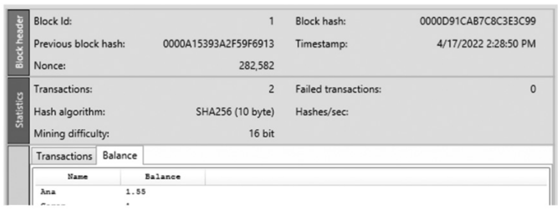

Fig. 13. Block ID 1 balance after adding the new participant

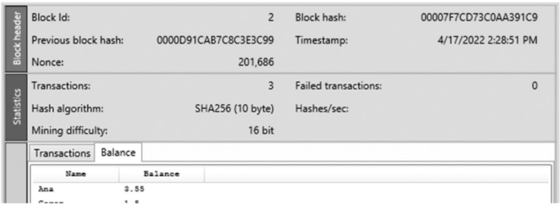

Fig. 14. Block ID 2 balance after adding the new participant

IV. SIMULATION MODEL OF BLOCKCHAIN ATTACK

When Hana attempts to attack Ana in order to earn extra coins, some errors and warnings are generated, indicating that the transaction is not valid. This is because Hana does not possess Ana's signature, as depicted in Fig.15 and Fig.16. By using the general names of the participants (Hana and Ana) consistently throughout the sentence, it maintains coherence and clarity in describing the situation where one participant (Hana) tries to attack another participant (Ana) in the simulation.

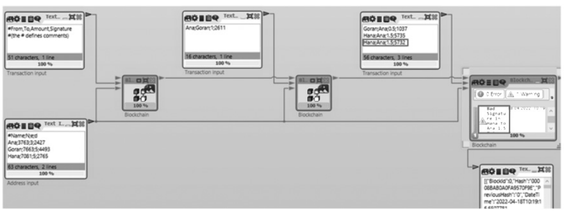

Fig. 15. The simulation model of blockchain attack (Hana wants to get some coins from Ana)

The transaction is not valid, since Hana does not have Ana's private key and cannot sign the transaction (the "Bad signature" and "Failed transactions" messages are generated), as it is presented in Fig.16. Also, the balance is not changed, and Hana does not earn any coins from Ana. It is shown that the balance is not changed.

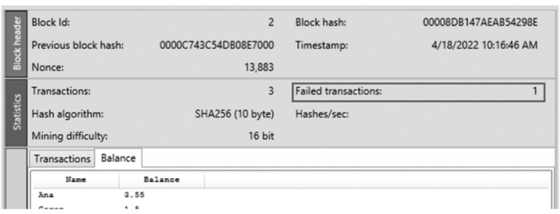

Fig. 16. The illustration of failed transaction

V. CONCLUSION

In this paper, the authors have presented a simulation model of blockchain operations that can be used to test various transactions between users. This model has been implemented using CrypTool2 software, and it includes three blocks with smaller numbers for generating RSA public and private key pairs than in real blockchain transactions, in order to minimize the simulation time.

The simulation model enables the participants to send and receive coins or mine blocks to earn coins, with all transactions being stored in the blocks' data, including the address of the sender and receiver. The address is a hash value of a public key for asymmetric cryptography, and the RSA (Rivest-Shamir-Adleman) asymmetric algorithm is used, including public key and private key.

The authors have also simulated some attacks on the blockchain, where these transactions were not accepted due to invalid signatures. In this way, the model can identify and prevent potential threats to the blockchain.

Overall, the simulation model presented in this paper provides a useful tool for testing and analyzing blockchain transactions. The simulation demonstrates both successful and unsuccessful financial transactions and illustrates the potential for using blockchain technology in various applications [10], [17].

The simulation model presented in the paper could be used as a basis for further development of blockchain-based systems and applications. It could be utilized in the testing and validation of new blockchain models, as well as in the education and training of professionals in the field of blockchain technology. Furthermore, the simulation model could be used in the development and testing of decentralized applications, such as cryptocurrencies, smart contracts, and supply chain management systems. Overall, the simulation model presented in the paper has the potential to contribute to the advancement and practical application of blockchain technology in various domains.

REFERENCES

[1] G. Bjelobaba, M. Paunovic, A. Savic, H. Stefanovic, J. Doganjic, and Z. M. Bogavac, "Blockchain Technologies and Digitalization in Function of Student Work Evaluation," Sustain., vol. 14, no. 9, pp. 1–22, 2022, doi: 10.3390/su14095333.

[2] E. Androulaki et al., "Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains," Proc. 13th EuroSys Conf. EuroSys 2018, vol. 2018-Janua, 2018, doi: 10.1145/3190508.3190538.

[3] H. Stefanovic, A. Savic, R. Veselinovic, and G. Bjelobaba, "An application of visual cryptography scheme with digital watermarking in sharing secret information from car number plate digital images," 2021. [Online]. Available: www.ijeijournal.com.

[4] J. Menez, P. van Oorschot, and S. . Vanstone, Handbook of Applied Cryptography, 5th ed. CRC press Series on Discrete Mathematics and Its Applications, 2001.

[5] H. Hyvärinen, M. Risius, and G. Friis, "A Blockchain-Based Approach Towards Overcoming Financial Fraud in Public Sector Services," Bus. Inf. Syst. Eng., vol. 59, no. 6, pp. 441–456, 2017, doi: 10.1007/s12599-017-0502-4.

[6] Andreas M, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies," 2014, [Online]. Available: https://sci-hub.do/https://books.google.com/books?hl=zh-CN&lr=&id=IXmrBQAAQBAJ&oi=fnd&pg=PR4&dq=Antonopoulos,+Andreas+M.+2014&ots=9C9UrwGrNX&sig=3l49cnJsCUpJcR51eJK10_OaH-E.

[7] C. Farchi, B. Touzi, F. Farchi, and A. Mousrij, "Sustainable per-

formance assessment: A systematic literature review," J. Sustain. Dev. Transp. Logist., vol. 6, no. 2, pp. 124–142, 2021, doi: 10.14254/jsdtl.2021.6-2.8.

[8] G. Danezis and S. Meiklejohn, "Centrally Banked Cryptocurrencies," May 2017, doi: 10.14722/ndss.2016.23187.

[9] P. Velmurugadass, S. Dhanasekaran, S. Shasi Anand, and V. Vasudevan, "Enhancing Blockchain security in cloud computing with IoT environment using ECIES and cryptography hash algorithm," in Materials Today: Proceedings, 2020, vol. 37, no. Part 2, pp. 2653–2659, doi: 10.1016/j.matpr.2020.08.519.

[10] H. Yi, "Securing e-voting based on blockchain in P2P network," Eurasip J. Wirel. Commun. Netw., vol. 2019, no. 1, Dec. 2019, doi: 10.1186/s13638-019-1473-6.

[11] M. Finck, "Blockchains and Data Protection in the European Union," Eur. Data Prot. Law Rev., vol. 4, no. 1, pp. 17–35, Mar. 2018, doi: 10.21552/edpl/2018/1/6.

[12] A. W. Dent and C. J. Mitchell, User's guide to cryptography and standards. Boston: Artech House, 2005.

[13] H. Stefanovic, A. Savic, R. Veselinovic, and G. Bjelobaba, "An application of visual cryptography scheme with digital watermarking in sharing secret information from car number plate digital images," in International Journal of Engineering Inventions–IJEI, 2021, vol. 10, no. 2, pp. 1–11, [Online]. Available: www.ijeijournal.com.

[14] M. Rauchs et al., "Distributed Ledger Technology Systems: A Conceptual Framework," SSRN Electron. J., no. August, 2018, doi: 10.2139/ssrn.3230013.

[15] A. E. Gencer, S. Basu, I. Eyal, R. van Renesse, and E. G. Sirer, "Decentralization in Bitcoin and Ethereum Networks," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 10957 LNCS, pp. 439–457, 2018, doi: 10.1007/978-3-662-58387-6_24.

[16] D. Lizcano, J. A. Lara, B. White, and S. Aljawarneh, "Blockchain-based approach to create a model of trust in open and ubiquitous higher education," J. Comput. High. Educ., vol. 32, no. 1, pp. 109–134, Apr. 2020, doi: 10.1007/s12528-019-09209-y.

[17] D. Shah, D. Patel, J. Adesara, P. Hingu, and M. Shah, "Integrating machine learning and blockchain to develop a system to veto the forgeries and provide efficient results in education sector," Vis. Comput. Ind. Biomed. Art, vol. 4, no. 1, Dec. 2021, doi: 10.1186/s42492-021-00084-y.

Application of 3D Modeling in the Fashion Industry

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Abstract—This paper presents an application of 3D modeling in the fashion industry, with an emphasis on augmented reality. The benefits of 3D modeling and augmented reality in the fashion industry are discussed in detail. The purpose is to show this way of product presentation as the future of the fashion industry. This paper aims to present 3D modeling garment design using the CLO3D software tool. Using software environments for 3D clothing modeling combined with augmented reality creates a new world of digital fashion, where it is possible to wear digital fashion items in the Metaverse, but also to create and sell them as NFTs in markets.

Keywords - fashion industry, digital fashion, 3D modeling, augmented reality, NFT

I. INTRODUCTION

Traditional principles of fashion product development result in a large amount of fabric waste, the production of an unnecessary number of samples, shipping and transportation costs. If we take into account that the fashion industry produces 20% of global wastewater and 8-10% of global carbon emissions [1], it is concluded that the introduction of changes in the entire industry, in order to be more in line with the global goals of sustainable development, is inevitable. Including technology and different software in product development in the fashion industry has a high potential to at least reduce if not fully solve those problems.

Digital fashion is a visual representation of clothing using computer technologies and 3D software. The industry is currently on the rise due to ethical awareness and the use of digital fashion technologies, such as artificial intelligence to create products with complex social and technical software. [2]. Using software environments for 3D clothing modeling improves productivity. A fashion item gets from the fashion designer to the end user faster. All this reduces production, storage and sampling costs.

The term digital fashion was first introduced to the fashion industry in the early 21st century with the rise of e-commerce. Marketers used the term to describe e-commerce platforms that sold fashion products. Digital fashion products were often referred to as wearables, which are referred to as a type of portable computing hardware [3]. With the development of 3D and virtual technologies, the definition has expanded to include all fashion concepts that are integrated with experimental technologies in clothing and fashion accessories, including 3D printing, body scanning and virtual design [4].

The application of 3D technologies is becoming more and more present in various industries. Thus, in the fashion industry, 3D modeling is experiencing a blast, because it brings a significant increase in efficiency and effectiveness.

The goal of this document is to showcase the future of the fashion industry through the practical example of 3D modeling. This paper covers both the theoretical and practical aspects of using 3D modeling and augmented reality in fashion. It aims to provide a comprehensive understanding of the garment design process using the CLO3D software tool. The document covers the entire process of creating a new garment, demonstrating how the combination of 3D modeling and augmented reality can create a new world of digital fashion. Ultimately, the goal of this document is to emphasize the potential of 3D modeling and augmented reality to transform the fashion industry.

II. DIGITAL TECHNOLOGIES IN THE FASHION INDUSTRY

The fashion industry, like most other industries, tries to keep up with developing technology and apply the most modern concepts. Some of the technologies used in the fashion industry today are [5]: Artificial intelligence (AI), the Internet of Things (IoT), Blockchain, 3D printing, Online vector editors, Sustainability, Virtual reality (VR) and Augmented reality (AR).

A. Artificial intelligence

The application of Artificial intelligence in the fashion industry most often refers to the application of Chatbots on the websites of fashion brands and smart mirrors based on the application of augmented reality. Chatbots are a very common feature of many fashion brand websites. They serve as a personal assistant, they are there to answer questions related to delivery, but also to help the user choose the perfect fashion combination for an important occasion. In addition, artificial intelligence is used to predict future trends. Another interesting application can be seen in neural networks, which are trained to understand the style, colors and materials that a particular user likes and based on this, they can conclude whether the user would like a new product.

Some other practical examples can be found in Burberry‘s usage of AI to boost sales and customer satisfaction. In 2015, the company announced that their investment in personalized customer management programs had resulted in a 50% increase in repeat custom. If Burberry knows that a customer has recently bought a particular coat, for example, then assistants may be encouraged by the app to show them a handbag that is popular with other buyers of the coat [6].

The authors in the research described companies like ‘Edited’ and ‘Stylumia’ which offer solutions that support the strategic decisions of fashion brands and fashion retailers by analyzing big data using artificial intelligence. The convergence of big data and artificial intelligence scales personalized services on the web as examples of ‘Coded Couture’, ‘StitchFix’ and ‘Thread’. The insights gained from artificial intelligence and big data help create new fashion retailing platforms such as ‘Botshop’ and ‘Lyst’. Also, artificial intelligence and big data assist with design. ‘Ivyrevel’ designs digital fashion, assisted by a macroscopic perspective on fashion trends, markets and consumers through the analysis of big data [7].

B. Internet of things

The Internet of Things means connecting different types of devices to the Internet, most often sensors and actuators [8]. Using these devices, it is possible to create smart environments that can automate the execution of everyday tasks. IoT enables data sharing, inventory management, security and increased efficiency and productivity [8]. Many companies allow customers to literally use the Internet to share data with them daily. This includes clothing with digital capabilities/properties, such as smart clothing, multi-functional designs, sports clothing that responds to environmental influences and more. An example is smartwatches, which are dominated by brands such as "FitBit" and "Apple", from which we can conclude that wearable technology dominates the market of fashion accessories.

There are many examples related to health monitoring, for example, there is a T-shirt, a product of the company of the same name "Hexoskin", which serves as an EKG - monitors heart rate and body temperature. Also, some socks count steps and calories.

Some instance of firms employing IoT within the fashion industry is Coded Couture by IVYREVEL, which is a Swedish-based brand that partnered with Google to design a Coded Couture app. This app is responsible for tracking your activities in order to design a dress. In accordance with where you go, be it any popular nightclub or an acclaimed restaurant, the app will suggest adding elements like diamonds or a traditional style or a particular color, etc. [9].

C. Blockchain and NFTs

Blockchain is a complex mathematical algorithm whose goal is to enable maximum security of financial transactions using cryptographic methods. It provides a distributed, immutable, transparent and secure financial ledger where all money transactions are reliably recorded. Each transaction represents one block, where the blocks are connected by a chain [8]. Blockchain offers a cryptographic seal, i.e. a serial number representing a physical identifier, which is associated with the "digital twin" of an individual product. Records can be kept at each stage of production. Every time a product moves through the supply chain, it is recorded on the blockchain. This can prevent counterfeiting and the diversion of goods.

In the fashion industry, we can see the application of blockchain in tracking and keeping records of clothing and supply chains. This is where technology is used to track and manage inventory. According to the fashion industry, a major blockchain application is to track materials and products throughout different manufacturing stages, ranging from initial raw materials management to finished product management. As an instance of the fashion product with the use of environmentally friendly materials, the promise of blockchain is it does not require the involvement of any additional inspections or certifications. Instead, once the information is recorded in the blockchain system, it is immutable and publicly visible [10]. This simplifies the information disclosure processes and ensures reliable environmental effort claims [11].

In 2021, a blockchain consortium called Aura was launched, signing up leading labels such as Prada, Louis Vuitton and Cartier. The Aura Blockchain Consortium allows consumers to access product history and proof of authenticity of luxury goods from sourcing to sales, all the way to second-hand markets [12].

When it comes to the fashion industry, transactions on an e-commerce platform are made secure, easier and faster with blockchain, but blockchain also allows us to control and monitor all articles, directly from the stage of production to their purchase by the end consumer [13]. So all the business segments of a fashion brand that has an online store can be supported by blockchain. Blockchain can enable us to scan a QR code on your new shirt and just see all the information about its origin, from materials, confirmation of authenticity and sustainability, to the country of origin as well as all the transaction details. In the fashion industry, stakeholders involved in all the required processes are suppliers of raw materials, designers or fashion companies, manufacturers, distributors, sellers and customers. Each stakeholder in the supply chain presents their requirements and conditions in the smart contracts [14]. Customers have insight into the product's origin and value [8].

NFTs (non-fungible tokens) are unique cryptographic tokens that exist on a blockchain and cannot be replicated. They can represent digital or real-world items like artwork and real estate [15]. When it comes to the fashion industry, utilizing NFTs as a marketing tactic in the fashion industry can contribute to brand equity in various scenarios [16]. Fashion brands are getting involved with NFTs increasingly, including well-known luxury brands such as Gucci and Burberry, but also brands like Nike [17].

D. 3D printing

3D printing can be applied in the fashion industry.

Even though it takes many hours to create, the benefits are less waste and much less labor intensive than other types of production. 3D printing takes fashion to a new level of conceptual art. [8]

It is also interesting that we can meet digital knitting, which has made great progress in the world of 3D printing and offers countless customization options. Dutch designer Iris van Herpen was one of the first to use 3D printing in the fashion industry. She already managed to impress everyone at the 2022 Met Gala with her extraordinary 3D-printed creations which were worn by Teyana Taylor, Winnie Harlow and Fredrik Robertsson [18].

Dutch designer Iris van Herpen made 3D-printed garments more accessible, as she introduced 3D printing as a “staple piece” to the haute couture fashion scene almost one decade ago. Today 3D-printed fashion items are increasingly popular and have trickled down from being solely used within haute couture fashion to being used for jewellery, bikinis and shoes and thus have become available for a wider audience. Traditional garment manufacturing processes produce offcuts (unwanted surplus material) as patterns are transferred onto fabrics, leaving enough space to cut the shapes out of the material. Contrarily, for the 3D-printing manufacturing process, only the necessary amount of raw material is used, resulting in zero waste [19].

E. Online vector editors

Many online vector editors are used today as a replacement for Adobe Illustrator. They allow downloading, embedding, or sharing links of designs with the public in SVG format. Some of them are Vectr, Boki SVG Editor and Repsketch. They use pre-made templates created by graphic or fashion designers. They also include design details such as different types of collars, sleeves, or pockets. They make the process of designing clothes easier and faster because they eliminate the need to sketch everything from scratch [20].

F. Sustainability

We witness that 92 million tons of clothes end up in waste every year. The fashion industry is responsible for up to 10% of global CO2 emissions, 20% of world industrial wastewater, 24% of insecticides and 11% of pesticides used. As a result, more and more brands are opting for sustainable production and more consumers are choosing environmentally conscious brands over "fast" fashion brands [21].

One solution for reducing waste from garment manufacturing is 3D designing. Programs like CLO3D, Marvelous Designer, Adobe Illustrator, Browzwear, Tuka3D and Romans CAD facilitate the design process and reduce waste. With 100% accurate digital samples, every idea can be explored most sustainably. Also, these programs are used to create digital clothing.

For example, Levi Strauss & Co.’s website proclaimed, “Sustainability is sewn into the fabric of everything we do from how our clothing is made to the work we do to help protect our planet.” The site relates the term “sustainability” to the company’s “long history of caring” for women (by introducing the first blue jeans for women), apparel workers (via the company’s code of conduct related to labor contracting) and the environment (via water quality standards and a restricted substances list applied to contracted manufacturing facilities). The range of possible meanings, associations and practices that are said to fall under the category of “sustainable fashion” is expansive [22].

G. Virtual and Augmented reality

Combining the physical and online worlds of retail is one of the most interesting applications of Virtual Reality in the fashion industry. Using VR [23], customers can virtually try on clothes. Thanks to the customized measurement functionality, this application provides high precision and augmented reality technology is also used [24]. Augmented reality (AR) is an interactive experience of a real-world environment, where real-world objects are enhanced with computer-generated perceptual information [25]. That perceptual information activates all the senses, so the experience is more realistic.

Many companies are increasingly implementing VR and AR. OBSESS is a platform that enables brands to create 360-degree 3D shopping experiences on their websites, mobile apps and social channels through the 3D Commerce Cloud. CLO is a tool that allows brands to instantly edit designs and instantly review changes. This can help to improve the quality of the design by checking the silhouette and making changes before the construction process. In this way, waste is minimized and errors in the samples are reduced. Selling digital clothing is also becoming more popular.

For example, Louis Vuitton designed "skins" for characters from the game League of Legends. Ralph Lauren has partnered with the Bitmoji app, where customers can create their own Bitmoji look with Polo Ralph Lauren brand outfits. The fashion retailer Tommy Hilfiger was among the first to provide VR headsets in stores, enabling their consumers to enjoy their 2015 autumn/winter fashion show as a 360-degree experience. In 2017, Coach installed VR headsets in their stores to provide full access to their latest fashion show and Oasis also used VR headsets to promote their collaboration with the Zoological Society in London, whereby consumers could experience a virtual safari sitting in a jeep [26].

Augmented reality in the fashion industry allows companies to build their brand by providing an immersive experience (this involves generating a three-dimensional image that gives the impression of surrounding the user). The most common examples of applications are in the form of smart mirrors and applications. AR mirrors can be seen today in various fashion stores around the world. Many modern houses like H&M, Zara, Ralph & Lauren and Burberry have already installed smart mirrors in their stores. The mirror uses radio frequency identification with augmented reality technology. When the user brings a piece of clothing in front of the mirror, it scans and saves an image of it. The mirror then scans the user to create a virtual model wearing that scanned piece of clothing. Also, the virtual model shown in the mirror moves in real-time to show a 360 view. The first fashion brand to use smart mirrors was Uniqlo in San Francisco in 2012. UNIQLO “created a seamless retail experience that allowed consumers to try on the full range of colors for a variety of UNIQLO Fall/Winter jackets”. Additionally, Neiman Marcus installed what they called the “memory mirror”, which showed customers’ outfits in 360 degrees and what they would look like in different colors, also allowing customers to share images and videos through email, social media, or with sales staff for further recommendations [19]. This type of shopping experience keeps customers longer because they like to see the product on themselves before buying and also use interesting technology.

Applications based on AR technologies used by fashion companies work by scanning the body or a part of the body with the help of the device's (mobile phone or tablet) camera. The software then overlays the selected garment over the scanned part of the body, so that the user can get an impression of how the garment would fit in the real world. An example of such an application is Converse’s “The Sampler”.

AR technologies, such as magic mirrors, create a connection with these younger generations that are often time pressured and live a busy lifestyle, as it allows them to make decisions faster, without having to queue and wait for changing rooms to become available and/or see how different colors of the same garment suit them. Consumers thus have the opportunity to select garments according to their needs and preferences and gain a real-life experience of what the product may look like on themselves [26].

III. 3D MODELING IN THE FASHION INDUSTRY

3D modeling is the process of creating a mathematical representation of a three-dimensional object. The result of this process is a 3D model [27]. It can be said that 3D modeling is a process that precedes the process of 3D printing. 3D modeling is part of a new phase in the development of the fashion industry, which will allow a clear and precise overview of the final product. Instead of using physical samples to create e-commerce photos, photorealistic designs could completely replace the current trend for photos of real, tangible products on websites. 3D design can help reduce waste by producing better, more thoroughly researched garments [28].

Artists, fashion designers and designers would draw a sketch of the future product, including the color and only then proceed to implement it. This approach had several drawbacks. It was impossible to predict how the material would work on a particular garment and in general, a two-dimensional drawing can never give a completely clear idea of the future garment. 3D modeling allows all manipulations to be performed in a special software environment, taking into account all characteristics, both material and shape, environment, interior, etc. It is much easier to realize products that have a photorealistic display. In addition, the client can make changes according to their taste and this will not incur any costs [29].

A. 3D Tools

There are many 3D modeling tools available today. Blender is one of the most famous 3D software. It was previously used to create video games, but today it is used in the creation of animated films, visual effects, 3D printed models, motion graphics, interactive 3D applications, virtual reality, etc. Blender features include 3D modeling, UV mapping, texturing, digital drawing, rendering, motion graphics, video editing and compositing. It is also widely used in the fashion industry.

Autodesk Maya is one of the best software for animation creators. It is used to create interactive 3D applications, video games, animated films, TV series and visual effects. It is used in the simulation of fluids, fabrics, fur, etc.

ZBrush is a digital design tool that combines 3D modeling, texturing and painting. It had an impact on the film and VFX industry. Iti is used for: 3D painting, illustration, polygon painting and rendering.

Rhino (Rhinoceros or Rhino3D) is a commercial 3D computer graphics and computer-aided design (CAD) software. It is used for computer-aided design (CAD), computer-aided manufacturing (CAM), rapid prototyping, 3D printing and engineering in industries including architecture, industrial design, product design and multimedia and graphic design [30].

As far as the fashion industry is concerned, the most common tools for 3D modeling are CLO3D, Marvelous Designer, Blender, Adobe Illustrator + Optitex 3D, Browzwear, Tuka3D, Romans CAD and The Fabricant Studio.

CLO3D is a 3D fashion design software program that creates virtual, realistic visualization of clothing with the latest simulation technologies for the fashion industry. It allows quick visualization of the design. By utilizing virtual sampling techniques, the time it takes to bring a product to the market can be reduced significantly. It is used by designers, small businesses and fashion industry titans to achieve a seamless digital workflow. With 100% accurate digital samples, every idea can be explored most sustainably.

Marvelous Designer is a fabric simulation program that creates dynamic 3D clothing for games, movies, 3D art and 3D animation. In the real world, clothing patterns are what seamstresses use to create clothing. Marvelous Designer adapted the traditional fabric manufacturing method into 3D fabric modeling. It provides the most accurate and fastest fabric simulation.

Browzwear is a leading provider of 3D fashion design, development and merchandising solutions. It represents a complete solution for 3D fashion. With the help of Browzwear, fashion brands are transitioning to realistic digital samples that remove barriers to productivity, accelerate time to market and improve sustainability. Leading fashion brands and manufacturers around the world use Browzwear products to accelerate product development and business growth.

Tuka3D is a 3D fashion design software founded by the company "Tukatech". It comes with a fabric and trim library that is frequently updated to reflect the development of new trends, as well as a color library. It can also be used in conjunction with graphic design applications such as Adobe Photoshop or Illustrator to create designs that will aid in 3D virtual prototyping. The main focus is on the fit of the clothes, i.e. the assessment of looseness or tightness of clothing in a virtual 3D environment.

The Fabricant Studio is a platform where anyone, anywhere can become a digital fashion creator and participate in the digital fashion economy. It enables designing digital clothing in the Metaverse, wearing digital clothing with the help of augmented reality and selling it as NFT [31]. The Fabricant Studio is a Web3 fashion house dedicated to building a modern industry that is inclusive, fair and accessible to all, providing a collaborative ecosystem where creators own and profit from their work and unlimited self-expression using imagination.

Romans CAD is one of the best CAD software used in the footwear and leather goods industry. This CAD software includes functions such as cost reduction and accelerated performance, is adaptable to user needs and uses modern design tools. The virtual prototype contributes to a huge cost reduction and allows collections to be approved two to three times faster.

B. 3D fashion design

The following components are required to create a 3D clothing pattern:

- A model of a person called an avatar – the designer can explicitly set all parameters of the figure;
- Pattern sewing – ready-made patterns can be imported into software programs or created from scratch directly in the program;
- Fabric parameters, accessories, prints.

Based on the components, the designer creates the product and models the behavior of the avatar (movements) to evaluate how the clothes will behave in real life.

In the future, 3D modeling could mean that instead of distributing a finished product to consumers, designers could sell data files with 3D design models online. One disadvantage is that this may encourage some consumers to modify existing product designs to their liking, produce them for their use, or distribute them.

Any 3D designer will confirm that the most difficult part of the job is to make the product as realistic as possible and then use the templates for tailoring on an industrial scale. Despite all the obvious advantages of using 3D technology, when creating the first samples of the collection, a small part of the fabrics and resources are saved.

3D technology reduces the risk of buying things that do not suit the customer. In the traditional approach, brand catalogs use photographs of garments on models. Technically, there is no way to consider the specific characteristics of each person's figure, so we mostly see photos of models in standard clothing sizes. In comparison, in 3D modeling, it is possible to show clothes without a person, which allows the shopper to imagine the clothes more accurately. All this reduces the risk of buying clothes from online stores and then returning or throwing them in the trash. All these factors reduce the amount of clothing that is thrown away and not properly disposed of for various reasons [28].

IV. APPLICATION OF 3D MODELING IN THE FASHION INDUSTRY USING CLO3D

In this chapter, the process of creating a garment in the "CLO3D" software program will be detailed and explained. CLO is a 3D fashion design software program that creates virtual, realistic visualization of clothing with cutting-edge simulation technologies for the fashion industry. CLO is the most advanced, intuitive and cohesive software of its kind.

CLO is a very easy-to-use interface that allows visualizing designs quickly and without any problems. Virtual sampling significantly shortens the time it takes to bring a product to the market. It is used by designers, small businesses and fashion industry titans to achieve a seamless digital workflow. With 100% accurate digital samples, every idea can be explored most sustainably - at no cost. It visualizes the fabric, cut and silhouette of the design with dignity and precision. CLO is a good 3D software to increase creativity and productivity in the clothing industry and can save not only time in the design process but also the cost of prototyping. CLO also makes an environmental contribution to the world of fashion, as designing with virtual garments reduces sample production, shipping and material waste. The main advantage of using CLO is that it saves a lot of time in the design process and reduces production costs. For example, when designing a collection, everything can be visualized, which helps improve communication between designers and potential customers.

A. Steps in making a garment

1) Choice of avatar

The first step is choosing an avatar. Avatar can be selected in the Library tab and the desired model. In this case, the selected model is Mara, but any other model from the offered ones can be downloaded and chosen.

By right-clicking on the model and holding it, the model can be rotated in a circle of 360 degrees from all perspectives. By pressing and holding the scroll button on the mouse, we can manually move within the window. It is also possible to customize the model. In the displayed folders, there are features of the model that can be changed: hairstyle, movements, pose, shoes, size and texture (underwear of the model). There is also the possibility of changing the hairstyle. In this case, the blue bun "FV2_Bun_C_SP_V1_BLD.zacs" is selected. In case we want to change the model's shoes, we can do so by going to the Shoes folder, downloading the desired pair and selecting it. In this case, the pair "FV2_Open_Toe_Pump_BK.zacs" is selected. In addition, the model's pose was changed to "FV2_02_Aforsize.pos".

2) Tailoring of the garment

The next step is cutting. In the 2D window, we select the Polygon and zoom in on the shadow of the model by scrolling the mouse down.

Then, by clicking the mouse, we just connect the dots until we get back to the starting point. So we make the base part of our cut. We can also add other cut elements. In this case, we add sleeves and staff. If we are dissatisfied with the cut, we can delete it completely and start again, by marking the cut that does not suit us on the 3D window and pressing the Delete button. Another option is to click on the Edit Pattern tab in the 2D window. It allows the flexibility of the seams and movement as we see fit. In Figure 1, select the Transform Pattern tab and go to the Symmetric Pattern option.

Figure 1. Making a cut and symmetrical addition

To add internal cuts, use the Internal Polygon/Line tab. After symmetrically adding all parts, we get a complete front cut, shown in Figure 2.

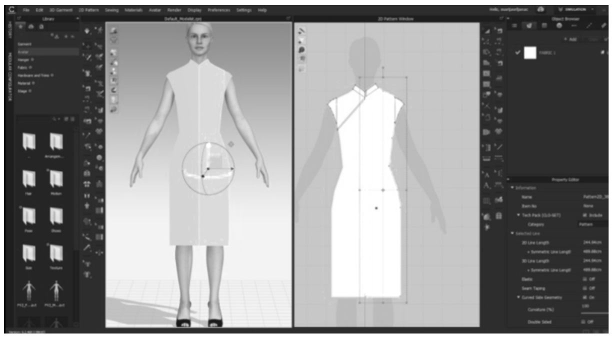

Figure 2. The final cut of the front of the dress

Now we need to do the same for the back cut. First, we need to move the finished part of the model. We do this with the help of the Transform Pattern, by marking all the parts and just dragging to the side. Following the same procedure as before, we also get the back part of the dress.

3) Trying on the garment

Next, the procedure of transferring the back of the dress back is applied. First, in the 3D window, go to the Avatar Display tab, then to Show Arrangement Points. We are shown blue dots around the model. In the 2D window, we mark the whole back of the dress, with the Transform Pattern (we can drag with the mouse and mark the whole back or by clicking manually on the parts with Shift, so that they are all marked) finally we click on one blue dot, as shown.

Now we have received a prototype, which we can change and correct errors in the form of the length and width of the parts of the dress. Using the Edit Pattern we can adjust the length of certain parts. By clicking on the line, then right-clicking on it and selecting the Change Length option, a window opens in which we can enter the desired length of the part. If we hold the left click on the Edit Pattern, we can select various other options, such as Edit Curve Point, Edit Curvature and Smooth Curve, based on which we can round straight lines or straighten curves. In Figure 3, again using Avatar Display -> Show Arrangement Points, we adjust the fit to the model's body shape.

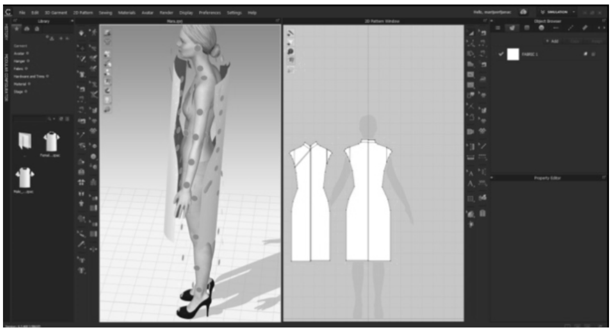

Figure 3. Adapting the cut to the model's body shape

4) Sewing a garment

Next, from the toolbar of the 2D window, we select the Segment Sewing option and connect the parts that we plan to sew. The seams mustn't cross, i.e. the lines joining the parts are straight and not going in an X, because in that case, the seam will not turn out well. And the last step is the GPU (assembly of parts). At the end of this part and after fine adjustments, the dress should look like in Figure 4.

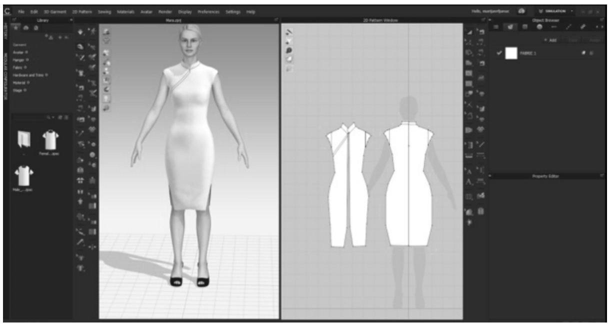

Figure 4. Assembled dress

5) Dyeing the garment

In Figure 5, we select the material by selecting the Fabric option from the Library menu. Then we scroll until we get to the "Silk_Duchess_Satin. fab" material. Double-click to select it. Next, we apply the material to the dress. We do this by physically holding the left click of the mouse and dragging the material onto the parts of the dress that we want to be made of that material. We can repeat the procedure if we use several types of materials.

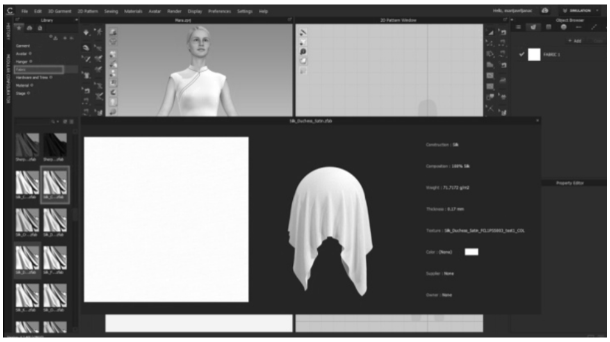

Figure 5. Choice of materials

After that, we can add the patterns we want. In the 3D window, select the option Graphics (3D Pattern). Next, we add any image, preferably a PNG image with a transparent background. In this case, it is a pattern with roses. The pattern can be easily adjusted to our liking. In the end, it should all look like in Figure 6, where the pattern itself is spread out and carefully glued in 4 parts.

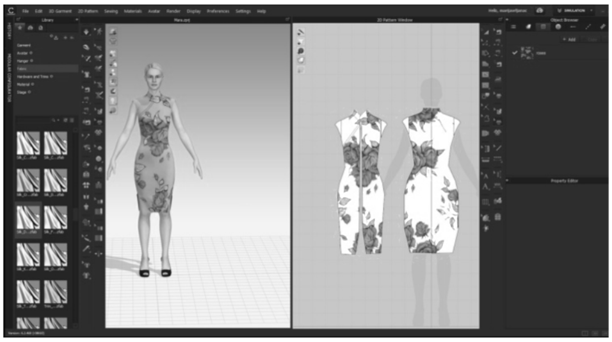

Figure 6. Finished adding the pattern

6) Adding details

Now we can add some more details, like buttons, zippers, etc. The button is selected by clicking on the "Button" tab in the 3D toolbar. We can also customize the button, which is shown - in this case, its color has been changed. This was done by first clicking on the button in the Object Browser, then in Property Editor -> Basic Parameters -> Color in the color palette, we selected the one we want.

Also, as part of the finesse, we can iron our dresses. We do this by selecting the Steam option in the 2D toolbar. It is possible to expand or narrow parts of the material. In the "Brush" pop-up window, in the "Shrinkage" section, if you want to expand the dress, drag it to the right (u +) and if, as in this case, you want to shrink it, drag the mouse to the left (u -).

7) Final layout

At the very end, after the final changes (finely adjusting the cut, changing the pose to "FV2_02_Attention.pos") and changing the color of the material to black, our dress looks as shown below. Figure 7 is a GIF animation, where the model rotates 360 degrees, so the dress can be seen from all angles.

Figure 7. The final result

V. CONCLUSION

Considering the rapid development of technology, it can be seen that in the future, 3D modeling tools will prevail over traditional ones, at least when it comes to the fashion industry. The rise in popularity of social media and the demand for constant content has put an end to seasonal fashion. Saving time, materials and waste during sampling represent the productive and sustainable advantages these technologies provide. 3D design is not only a technological revolution, but it is also a human revolution. Investing in the training of digital tailors and designers is inevitable.

Fashion designers have an increasingly realistic representation of the behavior of the fabric itself, which can indicate potential errors, which can be quickly and simply corrected before the actual production process. All this promotes creativity and innovation, providing a path to a new world of fashion, where the expression of style knows no boundaries. People who value their uniqueness and taste will find it much easier and safer for the environment to order a unique digital item than to order a real garment that consumes a lot of energy to make and has a high chance of becoming trash.

The development of 3D technologies for the creation of clothes enables the reduction of fabric consumption and the use of fossil energy sources when sewing clothes in the following stages: creating the first samples (minimal impact), reducing the risk of buying inappropriate clothes (medium impact), moving clothes from a real object that can be felt into digital (maximum impact). Observing minimalism in clothes, humanity gets the opportunity to show its individuality and style by creating digital masterpieces of clothes and trying them on in virtual salons and posting pictures on social networks [28].

The combination of 3D modeling and augmented reality creates a new world of fashion - the world of digital fashion. In that world, there is not much room for sampling errors, waste materials, storage and inventory costs. The process of design, production and shipping is significantly accelerated and fashion items arrive from the designer to the end users much faster. The existence of possibility for people to develop digital fashion items themselves encourages creativity and investment in education and raises culture to a higher level.

The next steps could be a combination of AR and 3D modeling. So, for example, as one of the possible solutions in the future, one can imagine that directly on the website of the fashion brand there is an option for the user to make their own clothes and try them on.

The idea is that there is a section of the site that has software for the 3D modeling of fashion items. The software would essentially consist of the basic and simplified features of the 3D modeling tools for fashion items, listed in Chapter III A. 3D tools. There would be six basic components from which the user could further choose the sub-components that suit them. Those components would be:

- Model – the user first chooses from the list a male or female model who will wear the item of clothing;
- Garment – the type of garment the user wants to make;
- Cut – the cut of the garment, with the possibility of adjusting the dimensions;
- Material – the material which the garment will be made of;
- Prints – patterns and designs that can be applied to a garment;
- Hardware and Trims – metal parts like zippers and decorations like buttons.

The entire software, of course, although simplified, works on the same principle as existing 3D tools for modeling fashion items, such as CLO3D or Marvelous Designer.

Another detail that would be included in the solution is the "Try it on!" button, which appears after the design is finished. Clicking on the button turns on the user's webcam if they are using a website, or the camera on their phone if they are using a mobile application. With the help of augmented reality (AR) technologies, the user is allowed to try on a garment that they have previously created.

REFERENCES

[1] Ro, C. “Can fashion ever be sustainable?,” bbc.com, (2020). [Online]. Available: https://www.bbc.com/future/article/20200310-sustainable-fashion-how-to-buy-clothes-good-for-the-climate.

[2] T. P. Caudell and D. W. Mizell, "Augmented reality: an application of heads-up display technology to manual manufacturing processes," Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, 1992, pp. 659-669 vol.2, doi: 10.1109/HICSS.1992.183317.

[3] Park, S. H., & Lee, J. H. (2001). Exploratory research for design of digital fashion product based on the concept of "wearable computer" I. Journal of Fashion Business, 5(3), 111-128.

[4] Baek, E., Haines, S., Fares, O., Huang, Z., Hong, Y., Lee, S. (2022). Defining digital fashion: Reshaping the field via a systematic review. Computers in Human Behavior. 137. 107407. 10.1016/j.chb.2022.107407.

[5] Kochar, S. (2022). Top 9 Technology Trends Reshaping The Fashion Industry In 2022. Преузето са Techpacker: https://techpacker.com/blog/design/top-9-fashion-technology-trends/

[6] Marr, B. (2017). “The Amazing Ways Burberry Is Using Artificial Intelligence And Big Data To Drive Success,” Forbes. [Online]. Available: https://www.analyticssteps.com/blogs/what-role-iot-fashion-industry.

[7] Kim, C., E., Jin, H. L., (2018). Trends of Big Data and Artificial Intelligence in the Fashion Industry, https://koreascience.kr/article/JAKO201810237886067.pdf

[8] Radenković B., Despotović-Zrakić, M., Bogdanović, Z., Barać, D., & Labus, A. (2015). Elektronsko poslovanje. TRENDOVI U TEHNOLOGIJAMA ELEKTRONSKOG POSLOVANjA:Internet inteligentnih uređaja. 20(1) (str. 275-277). Fakultet organizacionih nauka. ISBN:978-86-7680-304-0

[9] Rangaiah, M. “What is the Role of IoT in the Fashion Industry?,” https://www.analyticssteps.com/, (2020). [Online]. Available: https://www.analyticssteps.com/blogs/what-role-iot-fashion-industry.

[10] Noris, A., Harley Nobile T., Kalbaska N., & Cantoni, L. (2020). Digital Fashion: A systematic literature review. A perspective on marketing and communication, Journal of Global Fashion Marketing, DOI: 10.1080/20932685.2020.1835522

[11] Guo, S., Sun, X., & Lam, H. K. S. (2020). Applications of Blockchain Technology in Sustainable Fashion Supply Chains: Operational Transparency and Environmental Efforts. IEEE Transactions on Engineering Management, 1–17. doi:10.1109/tem.2020.3034216

[12] Rauturier, S. (2022). “Can Blockchain Technology Make Fashion More Transparent?,” goodonyou.eco, [Online]. Available: https://goodonyou.eco/blockchain-technology-fashion-transparency/.

[13] Elmessiry, M., & Elmessiry, A. (2018). Blockchain Framework for Textile Supply Chain Management. .10.1007/978-3-319-94478-4_15

[14] Röscheisen, M., Baldonado, M., Chang, K., Gravano, L., Ketchpel, S., Paepcke, A. (1998). "The Stanford InfoBus and its service layers: Augmenting the internet with higher-level information management protocols". Digital Libraries in Computer Science: The MeDoc Approach. Lecture Notes in Computer Science. Springer. 1392: 213–230. doi:10.1007/bfb0052526. ISBN 978-3-540-64493-4.

[15] Sharma, R. (2023). Non-Fungible Token (NFT): What It Means and How It Works. Investopedia, https://www.investopedia.com/non-fungible-tokens-nft-5115211

[16] Vogel, L. (2023). The use of non-fungible tokens (NFTs) in the fashion industry. 040198 – 3859

[17] Robinson, S. (2022). Fashion Retailers And Luxury Amp Up NFT Activations After Adopting The Technology Last Year. Available at: https://www.forbes.com/sites/roxannerobinson/2022/04/30/fashion-retailers-and-luxury-amp-up-nft-activations-after-adopting-thetechnology-last-year/?sh=73e83fd07a16 (Accessed 29.05.2022)

[18] P. Alexandrea, “3D Printed Fashion: The Top Designs,” 3dnatives.com, 2022. [Online]. Available: https://www.3dnatives.com/en/3d-printing-fashion-designs150620174/

[19] McCormick, H., Zhang, R. Boardman, R., Jones, C., & Henninger, C.E., (2019). ‘3D Printing in the Fashion Industry: A Fad or the Future?’, in Vignali, G., Reid, L., Ryding, D., & Henninger, C.E. (eds), Technology-Drive Sustainability: Innovation in the Fashion Supply Chain, London, Palgrave Macmillan, pp.137-154.

[20] Betts, A. (2022). The 8 Best Free Browser-Based Adobe Illustrator Alternatives, Make Use Of, https://www.makeuseof.com/tag/free-browser-adobe-illustrator-alternatives/

[21] Kell, G. (2018). Can Fashion Be Sustainable?, Forbes Magazine, https://www.forbes.com/sites/georgkell/2018/06/04/can-fashion-be-sustainable/?sh=6338d5eb412b

[22] Thomas, K. (2019). Cultures of Sustainability in the Fashion Industry. Fashion Theory, 1–28. doi:10.1080/1362704x.2018.1532

[23] Goode, L. (2019). "Get Ready to Hear a Lot More About 'XR'". Wired. ISSN 1059-1028 , https://www.wired.com/story/what-is-xr/

[24] Uddin, M. (2022). Augmented reality (AR) and virtual reality (VR) in fashion industry, https://www.linkedin.com/pulse/augmented-reality-ar-virtual-vr-fashion-industry-pgd-tm/?trk=articles_directory

[25] Gillis, A. (2022). Augmented reality (AR), https://www.techtarget.com/whatis/definition/augmented-reality-AR

[26] Boardman, R., E. Henninger, C. E., and Zhu, A. (2020). Augmented Reality and Virtual Reality:

New Drivers for Fashion Retail?

[27] Petty, J. (2018). What is 3D Modeling & What's It Used For?, Concept Art Empire, https://conceptartempire.com/what-is-3d-modeling/

[28] Ursachi, E. (2021). 3D modeling in fashion industry. Universitatea Tehnică a Moldovei, Facultatea Textile și Poligrafie, Departamentul Design și Tehnologii în Textile și Poligrafie, grupa DVI-201, Chișinău, Republica Moldova

[29] Watson, T. (2022). 3d Modeling For Fashion Industry: Use Cases And Benefits, Skywell Software, https://skywell.software/blog/3d-modeling-for-fashion-industry-use-cases-benefits/

[30] Rhino 3D 6 for Windows and Mac. (2020). NOVEDGE. https://novedge.com/products/buy-rhino-3d-cad-7-for-windows-and-mac

[31] Crook, L. (2021). The Fabricant Studio "allows anyone to become a digital fashion designer", Deezen, https://www.dezeen.com/2021/11/03/the-fabricant-studio-digital-fashion-dezeen-15/

A Methodological Framework: Studying The Effect Of An Augmented Reality Mobile App On Online Customer Experience and Purchase Intention

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Abstract—This study presents a methodological framework for investigating the impact of an augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry. The framework aims to address the lack of interactivity and engagement in traditional online shopping, which may result in lower purchase intention and customer satisfaction. The study will explore the effectiveness of an augmented reality mobile app in enhancing the customer experience and increasing purchase intention. The research will contribute to the existing literature by providing empirical evidence on the effectiveness of an augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry. This research aims to demonstrate the potential of augmented reality technology to transform the online shopping experience in the fashion industry.

Keywords - Augmented Reality, Mobile App, Customer experience, Purchase intention, Fashion, E-commerce

I. INTRODUCTION

With the continuous advancements in technology, the fashion industry is increasingly incorporating innovative tools to enhance the customer shopping experience. The use of augmented reality (AR) in fashion retail is a relatively new concept that allows customers to interact with products in a virtual space. The ability to create a personalized avatar [1] to try on clothing pieces from their favourite brands is a unique feature that enhances the shopping experience.

Previous research has shown that the use of AR technology has a positive impact on customer satisfaction and purchase intention [2] [3]. The use of mobile applications in e-commerce has also been shown to increase customer engagement and retention [4]. Additionally, the ability to share virtual try-on experiences on social media platforms can increase brand awareness and influence purchase decisions [5].

The purpose of this study is to investigate the impact of an augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry. The study aims to contribute to the existing body of literature by examining the effectiveness of a mobile application that combines AR technology, personalization, and social media sharing in enhancing the customer shopping experience. Specifically, the study will investigate the impact of avatar creation on customer experience and purchase intention in the context of online fashion retail.

The rest of the paper is structured as follows: In Section 2, we present a comprehensive literature review that examines the relationship between customer experience, purchase intention, and AR technology. In Section 2.1, we synthesize previous studies that investigate the impact of customer experience on purchase intention. In Section 2.2, we review the literature on AR technology and its effects on purchase intention.

We discuss the key features of AR technology and how they influence consumers' perceptions of products. Section 3 describes the research methodology used in this study, including the research design, sample, and data collection methods. Section 4 describes the AR mobile app that was implemented, with 3D product models, customization features, and social media sharing to test the effects of AR on purchase intention.

II.LITERATURE REVIEW

A. Customer experience (CX) and purchase intention (PI)

Customer experience (CX) and purchase intention (PI) are two critical concepts in the online retail industry. CX refers to the overall perception that customers have of a brand, based on their interactions with the brand across different touch points. PI, on the other hand, refers to the likelihood of a customer making a purchase from a particular brand or store. Recent research has shown that CX and PI are strongly related. For instance, a study by Marzo-Navarro and Pedraja-Iglesias [6] found that perceived value and trust mediate the relationship between CX and PI. Similarly, Chen and Wang [7] demonstrated that augmented reality technology can enhance CX and drive PI in the online fashion retail industry.

Several factors have been identified as influential in shaping CX and PI in the fashion industry. For example, Zhou and Xie [8] found that brand image significantly affects CX and PI. Price is also a critical factor, with studies showing that customers are more likely to make a purchase when they perceive a product to offer good value for money [9,10]. Additionally, product quality and customer service have been shown to significantly impact CX and PI in the fashion industry [6,7].

Augmented reality (AR) technology is rapidly changing the landscape of the retail industry, particularly with regards to customer experience (CX). AR can enhance CX by providing a more immersive, personalized, and interactive shopping experience for customers. Recent studies have shown that AR technology positively affects CX. For example, Jang and Kim [11] found that AR significantly enhances CX in the retail industry by providing a more engaging and memorable shopping experience. Similarly, Gupta and Bhatnagar [12] found that AR can improve CX by increasing customer satisfaction and loyalty.

AR technology can also enhance customer engagement by providing personalized shopping experiences. Studies have shown that customers prefer personalized experiences, and AR can facilitate this by providing tailored product recommendations based on customer preferences and history [8]. Additionally, AR can allow customers to virtually try on products, which can increase engagement and lead to higher purchase intention [7].

The effectiveness of AR in enhancing CX is contingent on several factors, including the quality of AR technology, ease of use, and customer attitudes towards technology. For example, a study by Kim and Kim [9] found that customers who have positive attitudes towards technology are more likely to use AR technology in their shopping experiences.

B. AR and Purchase Intention

Augmented reality (AR) technology has the potential to significantly impact purchase intention in the retail industry. AR technology can provide customers with a better understanding of product features and benefits, leading to increased purchase intention.

Recent studies have shown that AR technology can increase purchase intention. For example, a study by Lee, Kim, and Lee [13] found that AR technology positively influences purchase intention by providing customers with a more realistic view of products. Similarly, Park, Kim, and Song [14] found that AR technology significantly increases purchase intention by providing customers with a more immersive and interactive shopping experience.

AR technology can also improve purchase intention by providing customers with more information about products. Studies have shown that providing customers with more information about products can increase purchase intention [15]. Khan and Ahmad [15] found that AR technology can facilitate this by providing customers with a better understanding of product features and benefits through 3D visualizations and interactive product demonstrations.

However, the effectiveness of AR in increasing purchase intention is contingent on several factors, including the quality of AR technology, customer attitudes towards technology, and the type of product being sold. For example, a study by Kim and Lee [16] found that the effectiveness of AR in increasing purchase intention varied depending on the type of product being sold.

Overall, the literature suggests that AR technology can be an effective tool for enhancing customer engagement and improving purchase intention in the fashion industry. However, there is still a need for further research to explore the mechanisms underlying the impact of AR on customer behaviour and to identify the most effective ways of implementing AR technology in online fashion retail.

C. Technology Acceptance Model

The Technology Acceptance Model (TAM) has been widely used to examine the factors that influence the adoption and usage of modern technology [17,18]. In the context of AR technology in the fashion industry, the TAM suggests that perceived usefulness and perceived ease of use are key factors that influence customer adoption and usage [18]. For example, Lee and Park [18] found that perceived usefulness and perceived ease of use were significant predictors of customer intention to use an AR-based virtual fitting room app.

The Stimulus-Organism-Response (S-O-R) framework has also been used to examine the impact of external stimuli on internal psychological processes and behaviour [19,20]. In the context of AR technology in the fashion industry, the S-O-R framework suggests that the use of AR technology in a mobile app can influence customer emotions and cognitive processing, which in turn can lead to a behavioural response, such as increased purchase intention [20]. For example, Cheung et al. [20] found that the use of AR technology in a virtual try-on app led to increased emotional response and purchase intention among customers.

Avatar creation has been identified as an important aspect of the customer shopping experience when using AR technology in the fashion industry [21,22]. Personalized avatars allow customers to see how clothing items would look on them before making a purchase, which can enhance the perceived usefulness of the app and increase purchase intention [21]. This concept is supported by the Social Influence Theory, which suggests that individuals are more likely to conform to social norms and expectations, including those related to fashion and appearance [22]. For example, Li and Li [21] found that the use of personalized avatars in an AR-based fashion retail app led to increased purchase intention among customers.

In summary, the literature supports the use of the Technology Acceptance Model, Stimulus-Organism-Response framework, and the Social Influence Theory to examine the impact of an augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry, with a particular focus on the importance of avatar creation.

III. RESEARCH METHODOLOGY

The purpose of this study is to investigate the impact of an augmented reality (AR) mobile app on customer experience and purchase intention in the fashion online retail industry. The study proposes a mixed methodology consisting of two phases: a qualitative phase and a quantitative phase.

Research Questions:

1. How does the use of augmented reality technology in a mobile app impact the perceived usefulness and perceived ease of use of the shopping experience in the fashion online retail industry?
2. What is the effect of the use of personalized avatars in the augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry?
3. How do emotions and cognitive processing of customers change when using the augmented reality mobile app in the fashion online retail industry, and how do these changes impact their purchase intention and satisfaction with the shopping experience?
4. What are the potential limitations or barriers to the adoption and usage of augmented reality mobile apps in the fashion online retail industry, and how can these be addressed to improve customer experience and purchase intention?

In the first phase of this study, a qualitative approach will be adopted to explore the factors that influence customer engagement and purchase intention in the fashion industry. Semi-structured interviews with fashion industry experts and customers who have used AR-enabled mobile apps for fashion shopping will be conducted to gather data. The interviews will be transcribed and analysed using thematic analysis, drawing on the theoretical frameworks of the Technology Acceptance Model and the Stimulus-Organism-Response model.

In the second phase, a quantitative study will be conducted to measure the impact of the AR-enabled mobile app on customer experience and purchase intention. Participants will be recruited from online fashion retailers and will be asked to experiment with the AR-enabled mobile app developed by the researcher. The online survey will include questions on perceived usefulness, perceived ease of use, perceived enjoyment, customer satisfaction, and purchase intention, and will be analysed using descriptive and inferential statistics, drawing on the theoretical frameworks of the Technology Acceptance Model and the Stimulus-Organism-Response model. Additionally, the study will consider the impact of avatar creation on the customer shopping experience.

IV. IMPLEMENTATION

The researcher developed an augmented reality mobile app designed for fashion shopping.

The Augmented reality development: The AR functionality of the app is built using Unity, which is a popular AR development platform.

3D modelling: The models used in the app are created using Blender, which is a 3D modelling software.

Backend and database: The apps backend and database is hosted on Amazon Web Services (AWS), which is a cloud-based hosting platform.

E-commerce Integration: The apps e-commerce functionality is integrated using Magento, which is an open-source e-commerce platform. The payment gateway used for transactions in the app is Paypal.

The app allows users to virtually try on clothing items, see how they look, and purchase them online. Users can customize their avatars and adjust clothing sizes and colours to fit their preferences. The app also includes a social media feature that allows users to share their outfits on social media platforms. The mobile app is downloadable on both IOS and android platforms. Presented below are pictures from the mobile application that we have implemented Figure 1 and Figure 2.

These pictures illustrate the ability for the online shopper to browse the ecommerce store and then create an avatar.

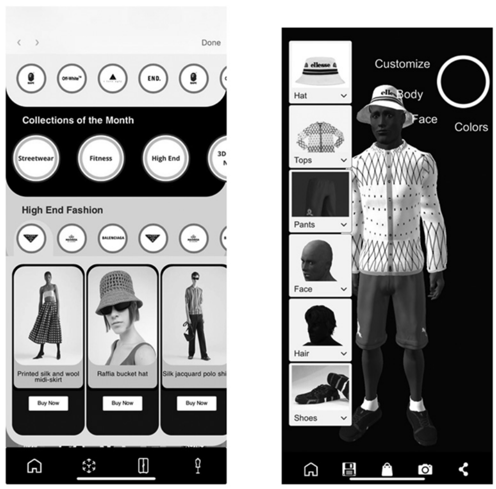

Fig. 1. Ecomerce and avatar creation

These pictures illustrate the ability for the online shopper to share their choice of clothes and avatars on social media. The online shopper can also place their avatar in reality.

The online shopper can choose different avatar looks. Here in Figure 3, the avatar has changed skin tone, hair and shape.

The online shopper in the next figures has decided on the white hoodie from the brand and is ready to check out.

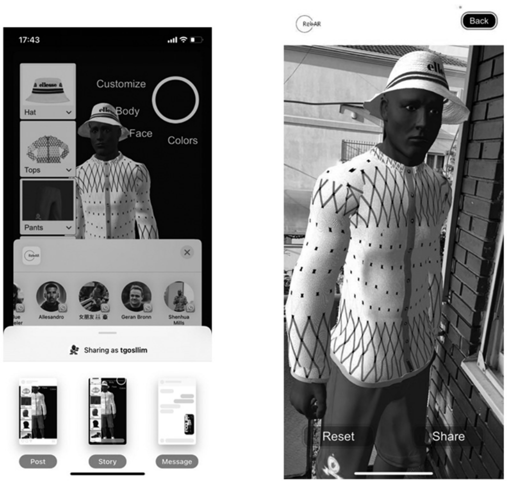

Fig. 2. Social media sharing and placing avatar into reality

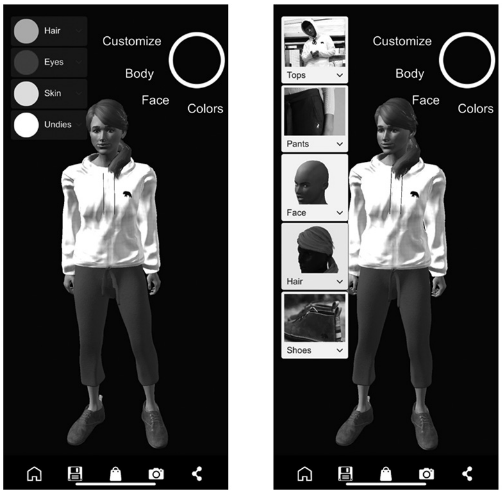

Fig. 3. Avatar skin tone and hair colour variation

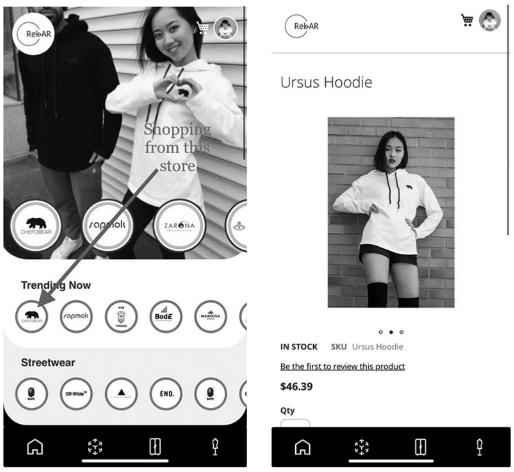

Fig. 4. Online shopper has decided to buy this based on avatar experience

The check out process of the clothing item shown below in figure 5. The online shopper can pay for the item using Paypal or visa card.

The mobile application currently has 20 active users on IOS, with a 4.8 rating. The android platform has 22 users with a rating of 4.8.

Although the mobile application has some positive reviews there are obstacles that the researcher must overcome to see the success of the mobile application. Shown in figure 6 are customer reviews on IOS and android mobile devices.

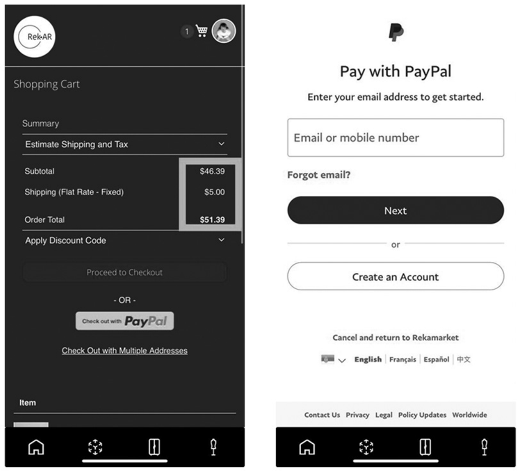

Fig. 5. Customer checkout – Using Paypal or Visa card

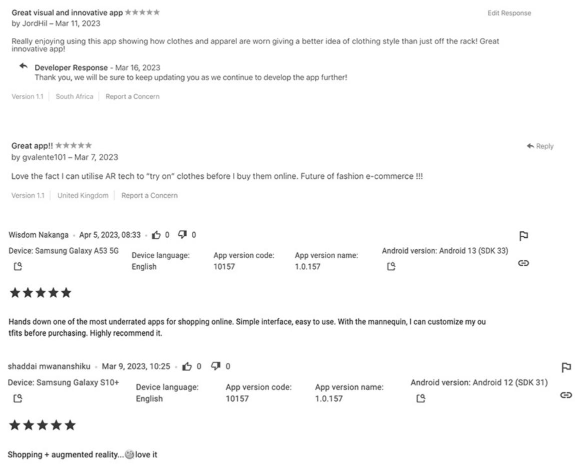

Fig. 6. Customer Reviews – IOS and Android mobile devices

The challenges that the researcher must overcome are 3D modelling challenges, automation of 3D modelling and the high cost to fully build out the mobile application.

V. CONCLUSION

In conclusion, this study presents a methodological framework for investigating the impact of an augmented reality mobile app on customer experience and purchase intention in the fashion online retail industry. The framework addresses the lack of interactivity and engagement in traditional online shopping, which can result in lower purchase intention and customer satisfaction. The study findings suggest that an augmented reality mobile app can significantly enhance the customer shopping experience and purchase intention. This is based on the researcher's interpretation of the existing literature and theoretical framework, as questionnaire results were not available for this study. However, it is acknowledged that the absence of questionnaire results is a limitation of this research. Future studies should consider incorporating qualitative and quantitative methods, including questionnaires, to gather empirical data and validate the effects of AR on customer satisfaction and purchase intention.

By incorporating features such as avatar creation, personalization, and social media sharing, fashion retailers can create a unique and engaging shopping experience for their customers. This research highlights the potential of AR technology to transform the e-commerce industry and improve customer satisfaction and purchase intention.

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REFERENCES

[1] R. Oh and B. Pinsonneault, "On the Assessment of the Construct of Avatar Creation: Scale Development and Validation," Journal of the Association for Information Systems, vol. 19, no. 1, pp. 1-24, Jan. 2018.

[2] W. Huang, Y. Zhou, and W. Lu, "Enhancing the Online Shopping Experience with Augmented Reality Applications," Journal of Retailing and Consumer Services, vol. 40, pp. 139-149, Jul. 2017.

[3] K. Y. Chan, H. Luo, and G. Birtwistle, "The Impact of Augmented Reality Technology on Customer Responses: A Conceptual Framework," Journal of Marketing Management, vol. 32, no. 9-10, pp. 973-996, Jun. 2016.

[4] D. K. Kim, H. Y. Shin, and J. Kim, "The Effects of Mobile Application Use on Customer Engagement and Satisfaction: Evidence from Online Retail," International Journal of Information Management, vol. 36, no. 6, pp. 1155-1169, Dec. 2016.

[5] X. Wang and Y. Zhang, "Social Media Marketing of Luxury Fashion Brands: A Content Analysis of Official Weibo Accounts," Journal of Business Research, vol. 69, no. 11, pp. 5162-5169, Nov. 2016.

[6] Marzo-Navarro, M., & Pedraja-Iglesias, M. (2016). The role of perceived value and trust in online purchase intention: the case of Spanish shoppers. Journal of Business Research, 69(11), 5312-5317.

[7] Chen, X., & Wang, D. (2019). Exploring the influence of augmented reality technology on fashion retailing. Sustainability, 11(14), 3859.

[8] Zhou, L., & Xie, J. (2019). Research on the impact of brand image on purchase intention based on the customer experience of online shopping. Journal of Physics: Conference Series, 1257, 032039.

[9] Kim, Y. K., & Kim, S. M. (2019). The influence of price and quality on purchase intention in online fashion markets: Moderating role of perceived values. Sustainability, 11(3), 747.

[10] Wang, S., & Kim, S. H. (2017). The effects of perceived value on purchase intention in social commerce context. International Journal of Information Management, 37(3), 221-229.

[11] Jang, S., & Kim, D. J. (2019). Enhancing customer experience with augmented reality technology in the retail industry. Journal of Travel & Tourism Marketing, 36(4), 430-442.

[12] Gupta, A., & Bhatnagar, A. (2021). Assessing the role of augmented reality technology in shaping customer

[13] S. Lee, H. Kim, and C. Lee, "Impact of augmented reality on consumers' impulse purchase intention in the fashion industry," Journal of Global Fashion Marketing, vol. 11, no. 3, pp. 232-243, Sep. 2020.

[14] C. Park, Y. Kim, and J. Song, "The effects of augmented reality on consumer purchase intention in the fashion industry," Journal of Retailing and Consumer Services, vol. 61, Oct. 2021, 102572.

[15] M. A. U. Khan and S. A. Ahmad, "The impact of augmented reality on consumers' purchase intention: A study on apparel retail," Journal of Fashion Marketing and Management, vol. 24, no. 4, pp. 543-562, Aug. 2020.

[16] K. Kim and E. Lee, "The effects of augmented reality on consumers' purchase intention in the fashion industry: Focused on high and low involvement," Journal of Fashion Marketing and Management, vol. 22, no. 4, pp. 580-595, Oct. 2018.

[17] Venkatesh, V., Davis, F. D. (2000). A theoretical extension of the Technology Acceptance Model: four longitudinal field studies. Management Science, 46(2), 186-204.

[18] Lee, H., Park, J. (2017). Fashion retail marketing strategy using mobile augmented reality. Sustainability, 9(9), 1-18.

[19] Mehrabian, A., Russell, J. A. (1974). An approach to environmental psychology. Cambridge, MA: MIT Press.

[20] Cheung, R., Lee, Z. W. Y., Rabjohn, N. (2018). The impact of augmented reality technology on customer emotions and behavioral intentions. Journal of Retailing and Consumer Services, 43, 8-18.

[21] Li, J., Li, H. (2020). Avatar creation and purchase intention in fashion mobile augmented reality retailing. Journal of Interactive Marketing, 51, 48-62.

[22] Cialdini, R. B., Kallgren, C. A., Reno, R. R. (1991). A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. Journal of Personality and Social Psychology, 58(6), 1015-1026.

Digital Twin Road Network as a Part of ITS Rig Move Model: Case Study Oil Industry of Oman

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Abstract—This paper presents a digital twin approach to address a component of the Rig Scheduling Problem (RSP) - rig transport or rig move. The main idea is to apply Intelligent Transport Systems (ITS) technology to solve problems during rig transportation, avoid potential risks, and minimize costs. The ITS concept for the rig moves process is based on a Model of an Intelligent Transport System from a Russian research group, modified to be applied in the current Petrol Development Oman system. The conclusion is that the implemented scenario has been assessed using an open-source tool - SUMO software. This study demonstrates the feasibility of constructing realistic microsimulation scenarios for extensive road networks [1].

Keywords - rig schedule problem, digital twin, intelligent transport systems; oversized cargo, traffic management

I. INTRODUCTION

To extract oil from the surface of the well, it is necessary to use various techniques and equipment. If equipment fails, interventions are needed to restore productivity and fix oil flow losses. These interventions, known as workovers, can involve re-completion, restoration, cleaning, stimulation and other operations that require the use of oil rigs. One such process is moving the rig to another drilling location. Oil rigs are costly and any delay during transportation can result in expenses ranging from US$ 50,000 to US$ 700,000 per day, depending on their type, market and operational characteristics [2].

Intelligent transport systems (ITS) are advanced systems that use innovative techniques to model transportation networks and regulate traffic flow. These systems provide users with more information and safety and improve the level of interaction between road users compared to traditional transportation systems. A key component of ITS is the use of digital twin (DT), which employs mathematical modelling to analyse transportation networks and develop solutions to transportation optimization ensuring smooth data transfer between physical and virtual worlds [3], [4].

In this paper, we aim to utilize Digital Twin models of Intelligent Transport Systems to optimize the transportation of rigs within a specific location as part of the Rig Scheduling Problem (RSP) [5]. Our goal is to minimize unnecessary expenses that may depend on various factors such as motor vehicle incidents involving rig convoys, collisions with stationary objects, traffic congestion on specific road sections, adverse weather conditions, and other accident scenarios [6].

The rest of the paper is organized as follows. Section 2 describes the main theoretical concepts of Rig schedule problem, oversize cargo transport and the digital twins concept. Section 3 describes a suggested modification to the Intelligent Transportation model for use as a Rig Move model ITS. Section 4 presents the concept of a Digital Twin Road network using Simulation of Urban Mobility (SUMO) with a TraCI interface. Section 5 presents concluding remarks and future work.

II. RELATED WORK

The research was initiated based on the identification of the Rig schedule problem, which revealed the existence of the problem and the utilization of operational research methods as potential solutions. The application of ITS can further enhance these solutions [7], [8].

The problem requests determining the optimal schedule for attending to wells using rigs, aiming to minimize rig fleet costs and reducing oil production loss from the well [2].

The research also explored the transportation aspect of the problem, considering the availability of solutions for similar problems. The transportation of oversized, non-standard, or over-metric cargo is classified as over-standard. Specialized transport methods and handling machinery capable of carrying such loads are necessary for transporting this type of cargo [9].

Fig. 1. Problematic elements and structural solutions during the transport of an oversized cargo [2].

In 2020, the group of authors tried to make Czech Republic Backbone routes for transport of oversized and excesive cargoes [3].

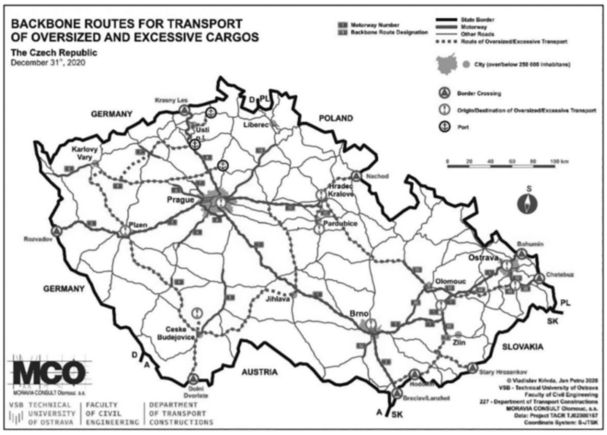

Fig. 2. Backbone routes for transport of oversized and excesive cargoes.

Machine learning and AI can reduce maintenance costs in the oil and gas industry by predicting equipment failures before they occur, optimizing maintenance schedules, and improving the efficiency of maintenance operations. Machine learning algorithms can identify patterns and anomalies that indicate potential equipment failures by analyzing data from sensors and other sources. Additionally, AI can optimize maintenance schedules by considering factors such as equipment usage, environmental conditions, and historical maintenance data. This can help reduce unnecessary maintenance and extend the lifespan of equipment [12].

Road condition monitoring using various AI methodologies, with a focus on deep learning for classification, segmentation, and object detection. Data acquisition systems, which consist of non-intrusive sensors and their platforms, are crucial to the RCM system and can collect 1D data, 2D visual data, or 3D depth data. Different platforms have their own advantages and limitations that complement each other's usability. For simple distress classification tasks, RGB sensors are suitable, while LiDAR, laser, and thermal sensors are better for detailed studies involving various distress characteristics [13].

In the end, research focused on using DT for transportation purposes. Digital Twin technology combines various traditional tools like simulation modelling and sensors to enhance process performance, also DT technology has significant implications for safety management and its development can lead to a competitive and stable industry [14].

The digitization of transportation will require significant improvements in safety, efficiency, and user experience. This will involve incorporating the advantages of cutting-edge technologies and gaining a comprehensive understanding of people, vehicles, roads, environments, and information. To achieve this, we can break it down into several clusters: Cluster A (Blue) focuses on enhancing the efficiency of Intelligent Transportation System Element Management. Cluster B (Red) addresses the flows and goals of managing the entire life cycle. Cluster C (Green) is dedicated to the development and application of digital technologies. Finally, Cluster 4 (Purple) aims to optimize the associated algorithms and models. The growth of digital technologies in transportation is primarily driven by advancements in building information modelling (BIM) and digital twins (DTs) [15].

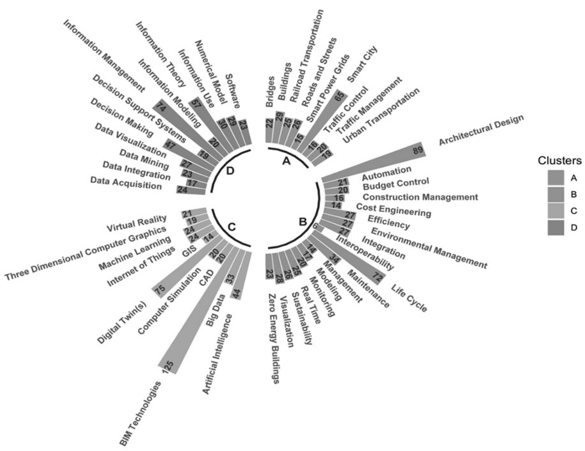

Fig. 3. Directions of digitization of transportation using digital tehnology

III. MODEL

According to conclusions in research that analyze the transportation issues in Oman towards the economic development sustainability of the country, adequate changes in technology are recognized as one of the main problems faced by the transportation system in Oman [16].

Otherwise, according to internal sources, there are several traffic accidents every year during rig transportation, most often collisions with stationary objects and motor vehicle accidents.

As a solution to these problems, we suggest a modified Model of an Intelligent Transport System, which Russian authors develop using the experience of implementation of

ITS in the city of Chelyabinsk, Russia and the case of the Main Roads Western Australia (MRWA), which is developing a digital twin to optimize planning and decision-making on the Australian road network. Also, they researched traffic management systems such as RITM3 (SIMETRA) (which can include modules such as PTV Vision Traffic Suite: PTV VISUM, PTV VISSIM, PTV VISWALK, PTV OPTIMA, LISA+ (Schlothauer & Wauer)), Trafficmap (AssetWise ALIM, Bentley), IRIS open source ATMS, Kimley-Horn Integrated Transport System, SWARCO AG (Traffic Management Software) [3].

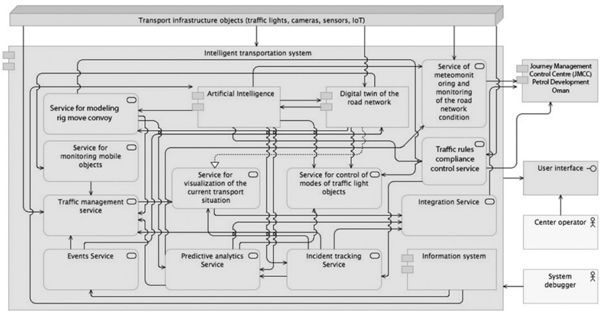

Fig. 4. Rig move Model of Intelligent Transport System.

The main changes of this model are:

- Service for modelling rig move convoys is aimed at the modelling of routes based on artificial intelligence algorithms that analyse current information and also from previous periods stored in the information system (including from sensors installed on the road transport network).
- Service for monitoring mobile objects. This service allows tracking the convoy with all specific dimensions and all parts of the convoy separately. Integrating this service with predictive analytics and a digital twin of the road network allows for displaying information about possible problems during transportation.
- Journey Management Control Centre (JMCC) of Petrol Development Oman is the unit which already exists to follow firstly traffic rules non-compliance and to fast react in case of motor vehicle incidents.

IV. DIGITAL TWIN ROAD NETWORK

Concept of a digital twin of the road network of Oman based on using Simulation of Urban Mobility (SUMO) with TraCI interface to create a map for routing oversized cargo like rig convoy for any dimension of width, length or height of all parts [17].

We will propose the utilization of a new model for the road network in Oman. This model will involve converting data from OpenStreetMap (OSM) format to SUMO XML format using SUMO's "netconvert" program. Additionally, we will manually edit the data using SUMO's "netedit" software. To supplement the data, we will incorporate satellite images and street-level graphical information from Google Maps as a background and conduct on-site inspections. To address connectivity issues, we will match GPS traces to the network, identifying errors in locations where network links are not properly connected. The road network data will consist of a directed graph comprising links and nodes. Each link will include one or more lanes, with important lane attributes such as maximum speed, width, and access rights. These attributes will be determined by analyzing the OSM attributes of the corresponding road segment. SUMO will assign a priority level to each link based on its attributes, ranging from 1 (footpath) to 13 (national motorway). Regarding lane connectivity at intersections, we will derive it from OSM or infer it using heuristics. We will manually verify the connectivity, along with road attributes and geometry. While OSM node attributes indicate traffic lights, we will generate signal information using heuristics. [1].

Fig. 5. Simulation zone from El Jadida city from Open Street Map and XML file edited by SUMO [4].

In combination with Predictive analytics service by selecting the best action among many based on certain objective criteria, we can optimize route performance. If problems are identified early enough, we have a range of control strategies available to mitigate or avoid them.

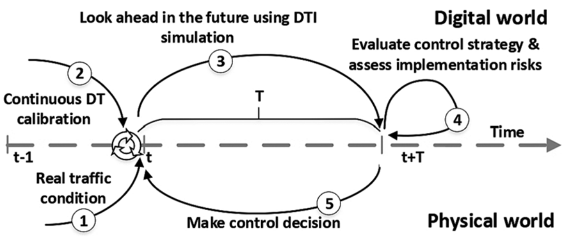

Fig. 6. Predictive analytics service [4].

The Predictive Analytics service of the Digital Twin Road Network will rely on two important options for routing in SUMO software. The first option, DUARouter, calculates the most efficient path between a vehicle's starting point and destination based on trip time or length, with various routing algorithms available. The second option, RandomTrips.py, generates a set of random trips on the road network, ensuring connected routes by automatically utilizing the duarouter tool to eliminate disconnected trips [19].

Furthermore, the utilization of In-Simulation Adaptive Rerouting (iSAR) in conjunction with SUMO empowers vehicles to dynamically update their routes during the simulation, thereby optimizing travel time based on real-time traffic conditions [20].

To assess the effectiveness of the Predictive Analytics service, simulations will be carried out to evaluate the occurrence of traffic congestion within specific segments of our digital road network, but for now, it's limited only by the length of rig movers.

V. FUTURE WORKS AND CONCLUSIONS

The usage of the Kalman filter or its variants for making short-term predictions of the system behavior based on the accumulated data on the previous states contained in the covariance matrix could improve Predictive analytics Service [21].

Moreover, SUMO provides the opportunity to develop Python-based tools that can establish correlations with other dimensions of a vehicle, such as width and height.

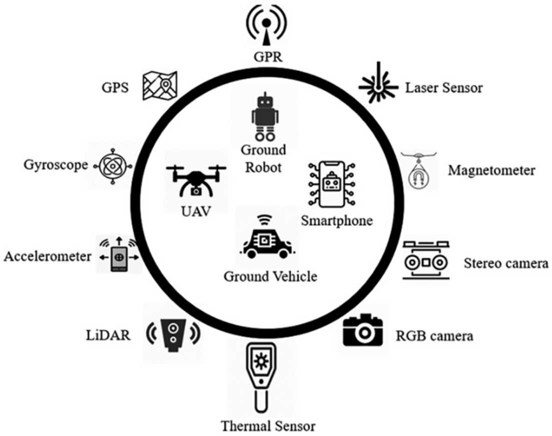

Fig. 7. A schematic representation of next-generation sensors and their platforms [5].

Smart sensing techniques offer highly detailed data on road surfaces, providing high-resolution information while overcoming spatial and environmental limitations. This enables the deployment of non-contact sensors on diverse mobile data acquisition platforms, facilitating convenient pavement inspection methods. Ultimately, this improves the service for monitoring mobile objects and road conditions [5].

The main conclusion of this paper is to propose the Rig Move Model of ITS - a modified model of ITS based on the implementation experiences from Russia. The paper suggests a problem solution utilizing Simulation of Urban Mobility (SUMO) with TraCI interface to create a digital twin of the road network in Oman, specifically designed for efficient routing of oversized cargo such as rig convoys. The Predictive Analytics service of the Digital Twin Road Network relies on dynamically updated routes based on real-time traffic conditions. Simulations will be conducted to evaluate traffic congestion in specific segments of the digital road network, taking into consideration the constraints imposed by the length of the rig mover's route.

The objective of the proposed digital twin for the road network, incorporating a service for modelling rig move convoys and a predictive analytics component, is to optimize the cost of rig moves and prevent motor vehicle incidents. By achieving these goals, significant savings in terms of both cost and time can be realized, which holds great importance in rig moves and overall (RSP).

REFERENCES

[1] J. Schweizer, C. Poliziani, F. Rupi, D. Morgano, and M. Magi, 'Building a large-scale micro-simulation transport scenario using big data', ISPRS Int J Geoinf, vol. 10, no. 3, Mar. 2021, doi: 10.3390/ijgi10030165.

[2] I. M. Santos, S. Hamacher, and F. Oliveira, 'A data-driven optimization model for the workover rig scheduling problem: Case study in an oil company', Comput Chem Eng, vol. 170, Feb. 2023, doi: 10.1016/j.compchemeng.2022.108088.

[3] A. Rudskoy, I. Ilin, and A. Prokhorov, 'Digital Twins in the Intelligent Transport Systems', in Transportation Research Procedia, Elsevier B.V., 2021, pp. 927–935. doi: 10.1016/j.trpro.2021.02.152.

[4] M. Despotović-Zrakić, Z. Bogdanović, A. Labus, D. Barać, and B. Radenković, E-BUSINESS TECHNOLOGIES 23-24 June 2022 Belgrade, Serbia Proceedings EDITORS.

[5] I. M. Santos, S. Hamacher, and F. Oliveira, 'A Systematic Literature review for the rig scheduling problem: Classification and state-of-the-art', Computers and Chemical Engineering, vol. 153. Elsevier Ltd, Oct. 01, 2021. doi: 10.1016/j.compchemeng.2021.107443.

[6] X. Li, Y. Zhang, C. Li, T. Wang, and C. Xi, 'Application of Digital Twin in Handling and Transportation of Hazardous Chemicals', Applied Sciences (Switzerland), vol. 12, no. 24, Dec. 2022, doi: 10.3390/app122412746.

[7] A. G. Ramírez and F. I. S. Anguiano, 'Simulation based optimization of drilling equipment logistics: a case of study', Procedia Comput Sci, vol. 217, pp. 866–875, 2023, doi: 10.1016/j.procs.2022.12.283.

[8] S. Chowdhury, Optimization and Business Improvement Studies in Upstream Oil and Gas Industry. 2016. doi: 10.1002/9781119246596.

[9] E. Macioszek, 'Oversize cargo transport in road transport Problems and issues', Scientific Journal of Silesian University of Technology. Series Transport, vol. 108, pp. 133–140, 2020, doi: 10.20858/sjsutst.2020.108.12.

[10] Abraj Energy Services SAOC rigs photo Accessible:, 'https://www.heavyliftnews.com/two-land-rigs-delivered-by-mammoet-from-uae-to-oman/'.

[11] J. Petru and V. Krivda, 'The transport of oversized cargoes from the perspective of sustainable transport infrastructure in cities', Sustainability (Switzerland), vol. 13, no. 10, May 2021, doi: 10.3390/su13105524.

[12] A. Sircar, K. Yadav, K. Rayavarapu, N. Bist, and H. Oza, 'Application of machine learning and artificial intelligence in oil and gas industry', Petroleum Research, vol. 6, no. 4, pp. 379–391, Dec. 2021, doi: 10.1016/J.PTLRS.2021.05.009.

[13] E. Ranyal, A. Sadhu, and K. Jain, 'Road Condition Monitoring Using Smart Sensing and Artificial Intelligence: A Review', Sensors, vol. 22, no. 8. MDPI, Apr. 01, 2022. doi: 10.3390/s22083044.

[14] G. P. Agnusdei, V. Elia, and M. G. Gnoni, 'Is digital twin technology supporting safety management? A bibliometric and systematic review', Applied Sciences (Switzerland), vol. 11, no. 6. MDPI AG, Mar. 02, 2021. doi: 10.3390/app11062767.

[15] C. Gao et al., 'Application of Digital Twins and Building Information Modeling in the Digitization of Transportation: A Bibliometric Review', Applied Sciences 2022, Vol. 12, Page 11203, vol. 12, no. 21, p. 11203, Nov. 2022, doi: 10.3390/APP122111203.

[16] O. A. Al Mukhini, A. P. Balasa, and S. I. Al Maqbalia, 'The Sultanate of Oman City Transportation in the Sharing Economy: Problems for Sustainable Development', European Journal of Business and Management Research, vol. 6, no. 5, pp. 26–38, Sep. 2021, doi: 10.24018/ejbmr.2021.6.5.1052.

[17] K. Kušić, R. Schumann, and E. Ivanjko, 'A digital twin in transportation: Real-time synergy of traffic data streams and simulation for virtualizing motorway dynamics', Advanced Engineering Informatics, vol. 55, Jan. 2023, doi: 10.1016/j.aei.2022.101858.

[18] S. Ajjaj, S. El Houssaini, M. Hain, and M. A. El Houssaini, 'Performance Assessment and Modeling of Routing Protocol in Vehicular Ad Hoc Networks Using Statistical Design of Experiments Methodology: A Comprehensive Study', Applied System Innovation, vol. 5, no. 1, Feb. 2022, doi: 10.3390/asi5010019.

[19] P. B. Bautista, L. Urquiza-Aguiar, and M. A. Igartua, 'Evaluation of Dynamic Route Planning Impact on Vehicular Communications with SUMO', MSWiM 2020 - Proceedings of the 23rd International ACM Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems, pp. 27–35, Nov. 2020, doi: 10.1145/3416010.3423233.

[20] J. A. Sánchez-Vaquerizo, 'Getting Real: The Challenge of Building and Validating a Large-Scale Digital Twin of Barcelona's Traffic with Empirical Data', ISPRS Int J Geoinf, vol. 11, no. 1, Jan. 2022, doi: 10.3390/ijgi11010024.

[21] B. Radenkovic et al., 'A distributed IoT system for modelling dynamics in smart environments', in Proceedings - 2020 International Conference Engineering Technologies and Computer Science, EnT 2020, Institute of Electrical and Electronics Engineers Inc., Jun. 2020, pp. 47–53. doi: 10.1109/EnT48576.2020.00015.

Simulation Models for Assessing the Probabilistic and Energy Characteristics of Information Interaction in the Internet of Things

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Abstract—The mutual influence of probabilistic-temporal and probabilistic-energy characteristics of a wireless sensor system (WSS) is investigated. A simulation model of information interaction in the Internet of things is considered. When developing a simulation model, a multiple access system with synchronous-time access to the on-air transmission medium was taken, which can be represented by a queuing system of the M/D/1 type.

The simulation model allows you to describe the objects of information interaction of the Internet of Things, and can be used for experimentation in order to design, analyze and evaluate the functioning of the WSS of the Internet of Things. The complex of simulation models of information interaction includes: a model in a single-channel transmission medium, a model in a multi-channel transmission medium, a model with heterogeneous sensor nodes using relative service priorities.

Keywords - probabilistic-energy characteristics, simulation modeling, internet of things, priority service

I. INTRODUCTION

The step-by-step implementation of the concept of the Internet of Things in many areas of human activity (in production, agriculture, transport infrastructure, housing and communal services, environmental projects, etc. [1]) is accompanied by the growing popularity of wireless sensor networks (WSN), which, along with other technologies: identification, sensors, are recognized as key drivers for the development of the Internet of things. WSNs play the role of an infrastructural basis that provides information interaction in the Internet of things.

On the basis of the WSN, the interaction of smart things of the Internet of Things is implemented [2, 3]. As a rule, smart things use independent autonomous power sources and have a limited energy resource [4]. The life time (or working time) of the BSS is determined by the period of life of each thing included in its composition. As a result, when studying the processes of functioning of the WSN, an assessment of the energy indicators of the information interaction of smart things is considered a necessary task.

As characteristics of the interaction of smart things with autonomous power in the WSN, the following are proposed: probabilistic-temporal characteristics (PTC) of the message transfer process and probabilistic-energy characteristics. The random process of message transmission is described by the average time and the probability of timely delivery of the message, and the process of energy consumption by a smart thing is described by the power of the radio signal generated on the transmitting antenna. The permissible power level of the radio signal depends on the level (power) of interference in the radio channel.

It can be assumed that increasing the power of the radio signal at the output of the transmitting antenna of a smart thing, on the one hand, will increase the reliability of signal transmission and improve the quality of service, but, on the other hand, leads to an increase in energy consumption by smart things, and, in accordance with this, to shorten their lifespan. For the productive operation of smart things and the WSN in general, as well as for increasing the lifetime of the network, it is important to find a balance between the quality of information interaction and energy consumption, i.e., choose such a radio signal power that will provide the required speed and quality of message delivery.

The study of the mutual influence of the probabilistic-temporal and probabilistic-energy characteristics of the WSN is an urgent task of designing networks of the Internet of things and was touched upon earlier in [5], where an analytical model was proposed for assessing the energy characteristics of multiple access in over-the-air networks.

In this paper, we consider a simulation model of information interaction in the Internet of things, developed on the basis of the analytical model [5].

II. MODEL

When developing a simulation model, a multiple access system with synchronous-time access to the on-air transmission medium was taken, which can be represented by a queuing system of the M/D/1 type.

The simulation model allows you to describe the objects of information interaction of the Internet of Things, and can be used for experimentation in order to design, analyze and evaluate the functioning of the WSN of the Internet of Things [6]. Unlike the analytical solution, as a result of which the formulas were obtained and the probabilistic-temporal and probabilistic-energy characteristics were calculated [6], the simulation model will allow you to determine which parameters and how they affect the simulated system, as well as how these parameters are related to each other.

The purpose of using simulation modeling in this case is to verify the numerical experiments carried out earlier on the basis of the analytical model on the calculation of the PTC [5], as well as to conduct additional experiments.

When modeling the information interaction of smart things in WSN:

– the physical parameters of interaction of wireless network nodes are taken into account: the number of smart things - N, the distance between them – D [m], B – the frequency of the radio channel [Hz], the power of the radio signal at the transmitting and receiving antennas – $P_{пер}$ and $P_{пр}$ [W], the noise power in the radio channel – $P_{шум}$ [W] etc. The following are determined: the format and length of the transmitted messages, and the modes of their transmission [7].

To assess the quality of information interaction - a random process of transmitting messages in the WSN of the Internet of things, we use the given mathematical model presented in [8].

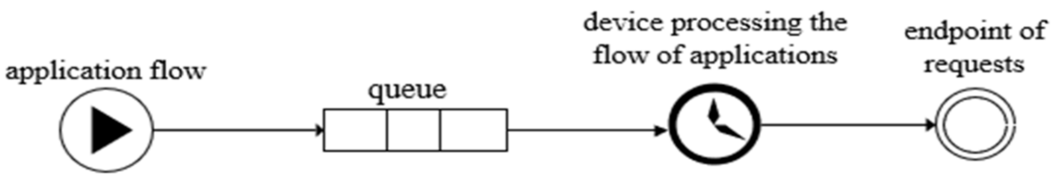

Fig.1. Message passing scheme

The WSN simulation model was implemented in the AnyLogic environment, and during its development, the features of multiple access with synchronous-time access to the air transmission medium used for transmitting messages by smart things were taken into account. The simulation model is shown in Figure 2 and includes several related modules: Applications – the flow of applications arriving in the system; Queue – a queue of applications waiting to receive applications in the system; Channel – a device that processes the flow of applications; End – the end point of applications.

To measure indicators in the model, timeMeasureStart was added – the beginning of the measurement period, timeMeasureEnd – the end of the measurement period. If the application is not waiting for acceptance, then the queue can discard it in Sink (end).

In the model, the arrival queues are Markovian, have a common distribution, and there is only 1 server for them. As a result of the work, the program provides probabilistic-temporal characteristics for analysis according to the M/D/1 model, such as: the number of applications in the queue, the average time the application was in the queue, the number of applications that left the system and the average time of applications in the system as a whole.

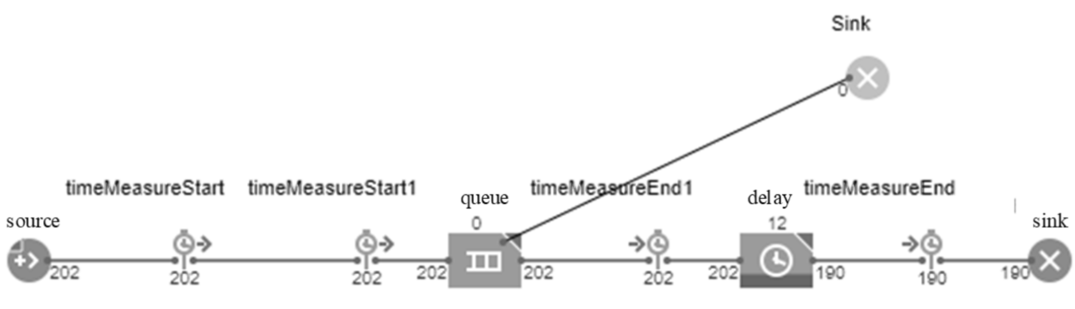

Fig.2. Simulation model of information interaction in the Internet of things

Further development of research based on the developed simulation model was carried out in the following areas:

1. Multichannel on-air transmission medium – M/D/N (Fig. 5, 6).

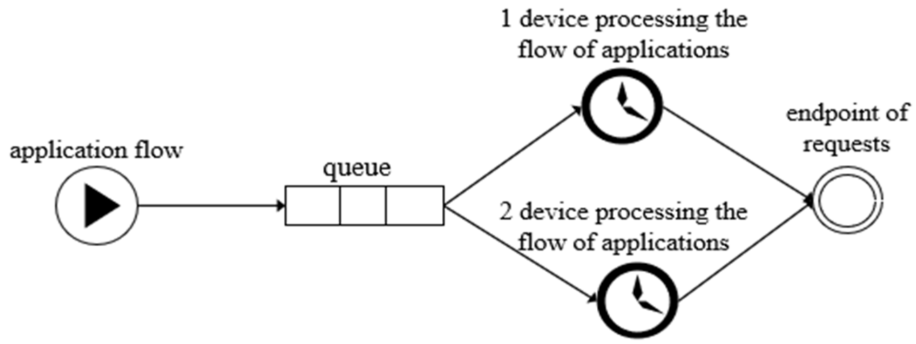

Fig.3. Message passing scheme with 2 processing devices

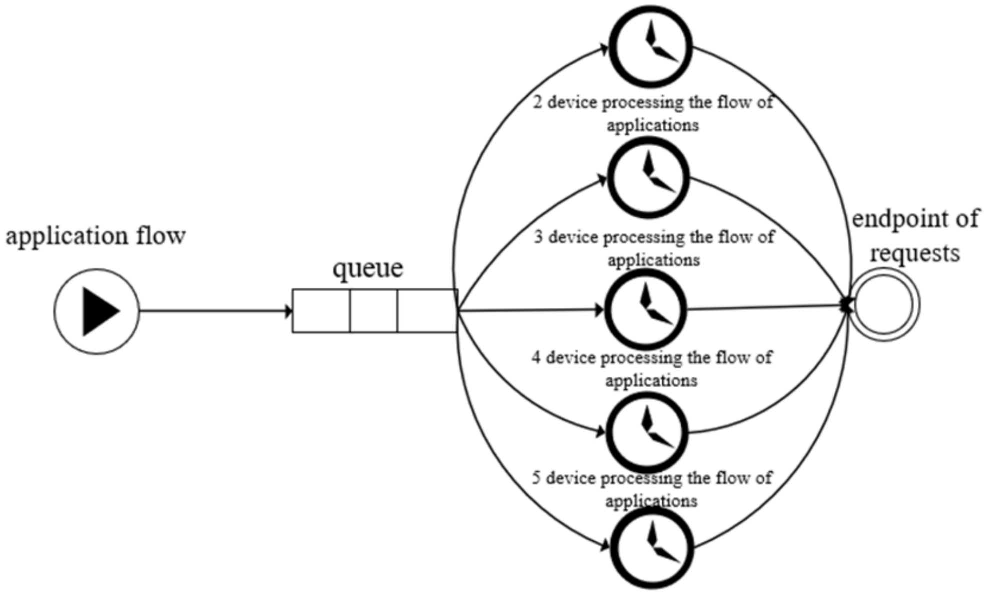

Fig.4. Message passing scheme with 5 processing

The results of the research are presented below:

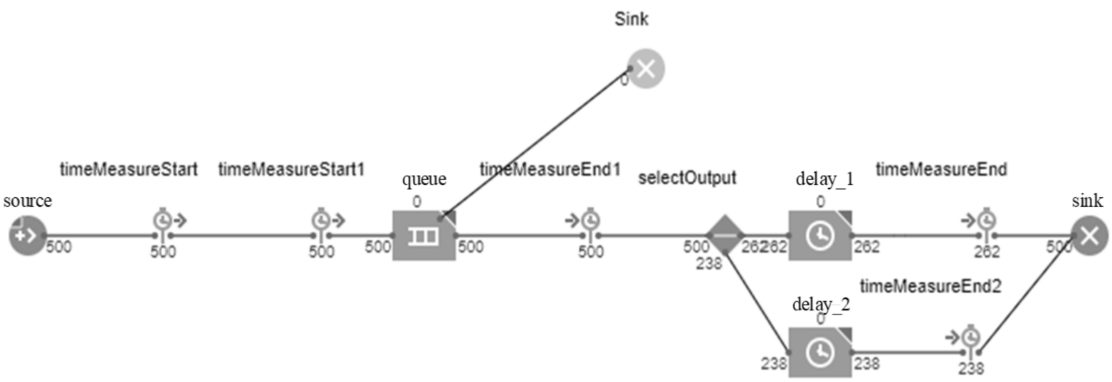

Fig.5. Simulation model. Multi-channel air data transmission medium (M/D/2)

Modeling for the case of a multichannel on-air transmission medium (M/D/N) was carried out with the following initial data λ=1 [message/s], $N \cdot T_{ок}$=0,362 [s], N=15000, Tλ0,00024 [s].

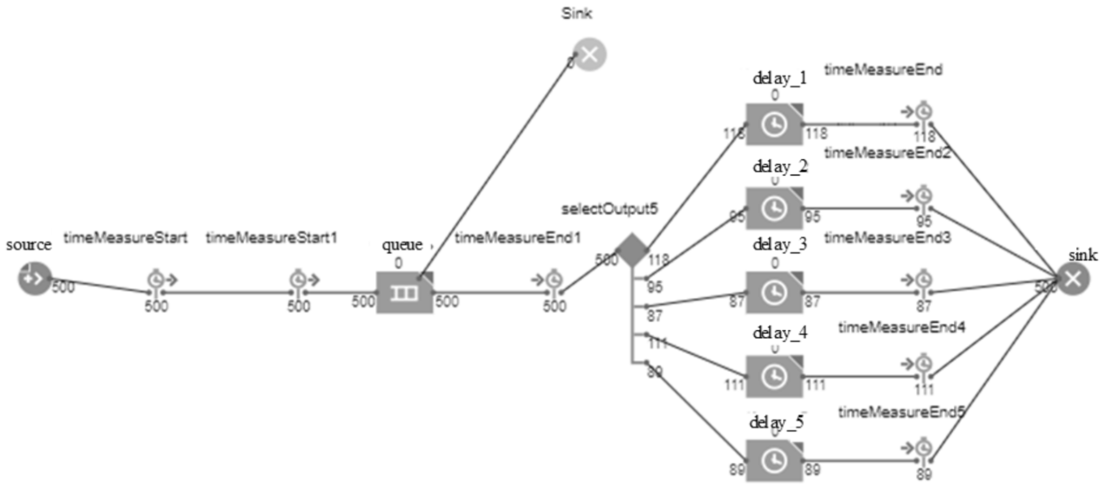

Fig.6. Simulation model. Multi-channel air data transmission medium (M/D/5)

2. Modeling the access system with priority service (Fig. 8).

Simulation modeling methods make it possible to study the impact of introducing a priority access procedure on the efficiency of the sensor network.

A single-channel wireless sensor network that supports messaging from *k*-type sensor nodes, where *k* is the number of priorities: *k* = 1, 2, 3... (*k* = 1 corresponds to service without priorities). All nodes in the network are respectively divided into *k* groups. The nodes of each group have their own admissible time of message transmission in the network – t_i(s) (i = 1…k). If the message is not transmitted within the time ti, then it is discarded. Let us assume, when modeling, that messages of the same fixed length (n) are transmitted and the flow of messages coming from a group of nodes of the *i*-th priority is the simplest with intensity λ_i. (i = 1…k) Priority service in a wireless network is carried out as follows: all nodes are polled and messages with the highest *k*-th priority are transmitted first, if there are none, then messages with the *k*-1st priority are transmitted, and so on.

The developed simulation model makes it possible to determine the influence of the number of priorities on the performance of the wireless network, which is proposed to be evaluated by the real-time information rate of the R_{PB} network (bps). The real-time information rate shows how much information (bits) is transmitted in real time per unit of time (s) over the sensor network. To determine R_{PB}, you can use the relation $R_{PB} = R_{1PB} + R_{2PB} + \ldots + R_{iPB} + \ldots + R_{kPB}$, ($i$ = 1…k), $R_{iPB} = n\,\lambda_i\,P_i$, ($i$ = 1…k), where P_i is the probability of timely delivery of messages from nodes of the *i*-th priority is determined by simulation, n is the length of the transmitted block.

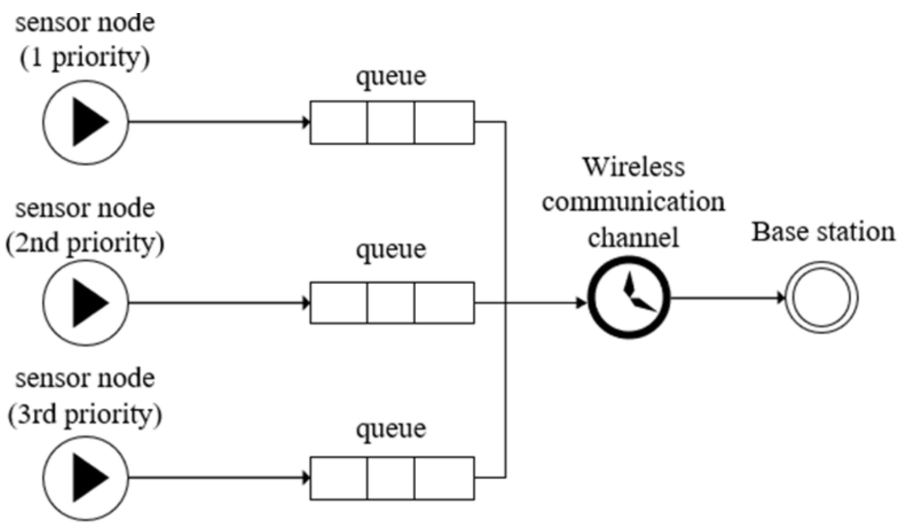

Fig.7. Message passing scheme with priorities

The created simulation model uses 3 priorities.

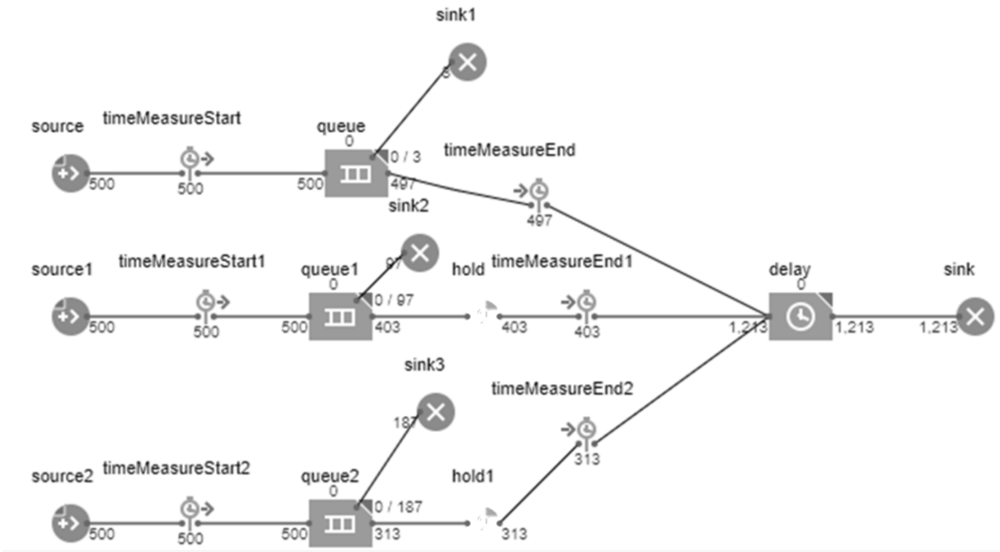

Fig.8. Simulation model of the access system with priority service

In this model, source is a high priority sensor node, source1 is a medium priority sensor node, and source2 is a low priority sensor node. The queue, queue1, queue2 blocks are the queue waiting for the next block to receive a message. The sink1, sink2 sink3 blocks are responsible for accounting for undelivered messages. The hold, hold1 blocks are responsible for blocking the sending of a message with a lower priority. delay – delays the message for a given period of time. The final sink block is responsible for accounting for correctly delivered messages. P_i is the probability of timely delivery of messages.

III. CONCLUSION

A complex of simulation models of information interaction in the Internet of things has been developed. Simulation models make it possible to describe the objects of information interaction of the Internet of things and can be used to conduct various experiments in order to design, analyze and evaluate the operation of the sensor network of the Internet of things. The complex of information interaction models includes: a model in a single-channel transmission medium, a model in a multi-channel transmission medium, a model with heterogeneous sensor nodes using relative service priorities.

The simulation model allows you to describe the objects of information interaction of the Internet of Things and can be used to conduct various experiments in order to design, analyze and evaluate the operation of the WSN of the Internet of Things. Unlike an analytical solution, a simulation model will allow you to clearly define which parameters affect the simulated system and how these parameters are related to each other.

REFERENCES

[1] Yadrovskaya, M. V. Prospects for the technology of the Internet of things / M. V. Yadrovskaya, M. V. Porksheyan, A. A. Sinelnikov // Advanced Engineering Research. 2021. №2. URL: https://cyberleninka.ru/article/n/perspektivy-tehnologii-interneta-veschey (Date of access: 04/06/2022).

[2] Astakhova, T. N. Smart agricultural field based on the Internet of things / T. N. Astakhova, M. O. Kolbanev, A. A. Romanova // Regional informatics and information security. Sat. works. Issue 5 / SPOISU. St. Petersburg, 2018. S. 201–202.

[3] Internet of things // Recommendation Y.2060. Overview of the Internet of Things. ITU-T, Geneva. June 2012.

[4] A. E. Kucheryavy, Self-Organizing Networks. / A. E. Kucheryavy, A. V. Prokopiev, E. A. Kucheryavy // St. Petersburg: Lubavitch. 2011. 312 p.

[5] Verzun, N. A., Kolbanev, M. O., Romanova, A. A., and Tsekhanovsky, V. V. Evaluation of the energy characteristics of multiple access in over-the-air networks, Izvestiya SPbGETU LETI. 2019. No. 10. S. 34-38.

[6] Emelyanov, A. A. Modeling information technologies on GPSS / A.A. Emelyanov // Applied Informatics. 2007. No. 2(8). pp. 83-109.

[7] Astakhova, T. N. Mutual influence of probabilistic-temporal and probabilistic-energy characteristics of wireless sensor networks / T. N. Astakhova, M. O. Kolbanev, A. A. Romanova // Perspective directions of development of domestic information technologies: materials of the V interregional scientific and practical conference, Sevastopol, September 24–28, 2019 / Sevastopol State University; St. Petersburg Institute of Informatics and Automation of the Russian Academy of Sciences. - Sevastopol: Federal State Autonomous Educational Institution of Higher Education "Sevastopol State University", 2019. - P. 241-242.

[8] Astakhova, T. N. Probabilistic and energy characteristics of the interaction of smart things / T. N. Astakhova, N. A. Verzun, M. O. Kolbanev, N. A. Polyanskaya, A. A. Shamin // Vestnik NGIEI. 2019. No. 4 (95). pp. 66-77.

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BLOCKCHAIN

Blockchain-based Healthcare Ecosystem

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Abstract—The subject of research is the development of a blockchain-based healthcare ecosystem. The paper will analyze the concepts of blockchain technology with a focus on application in healthcare. The paper will present the business model of blockchain application in healthcare. A blockchain ecosystem for healthcare will be presented. The practical part of the work will cover the design and development of a smart contract for participants in the proposed healthcare ecosystem. The PyTeal programming language will be used for the development of smart contracts. The Algorand platform will be used to record transactions between participants in the healthcare ecosystem. An application will be developed that will allow patients to monitor medical reports.

Keywords - healthcare, blockchain, smart contract, PyTeal, Algorand

I. INTRODUCTION

The healthcare industry today faces a number of challenges, including data privacy, interoperability, and trust issues. In general, emerged, modern technologies have significantly improved services in healthcare, and in recent years, blockchain is frequently viewed as a method of solving a number of issues in the healthcare area [1].

Blockchain technology is a distributed ledger and simultaneously decentralized database that can be used to securely store and share patient health data, enabling patients to have greater control over their own health data while ensuring its privacy and security [2] [3].

In a healthcare field, enables secure transfer of patient data, eliminating the need for a central data administration [4], strengthens vulnerable data defenses, manages pharmaceutical supply chains [5] and make an advancement in genetic research and clinical research [6]. Blockchain is frequently viewed as the most necessary and optimal healthcare technology and its most popular application is to keep medical data safe and secure. This is achievable by decentralized nature of itself technology.

The health applications could use blockchain technology to create a tamper-proof, decentralized record of patient health data, with patients and healthcare providers holding their own private keys to access and update the data. These applications could also use smart contracts to automate and streamline the process of managing patient health data, such as sharing it with other healthcare providers or researchers. Furthermore, the applications could use blockchain technology to incentivize healthy behaviors through the use of cryptocurrency-based reward systems. Patients could earn cryptocurrency for meeting certain health goals or participating in clinical trials, which could be used to pay for healthcare services or to purchase health-related products [7] [8].

In this paper, we propose a blockchain-based healthcare ecosystem. The new business model for healthcare based on blockchain is shown. As part of the proposed ecosystem, an example of a smart contract between two stakeholders from the ecosystem is developed using the PyTeal programming language and the Algorand blockchain platform. Furthermore, an application for patients that allows them to quickly test for the COVID-19 virus based on a blood sample is developed.

II. BLOCKCHAIN IN HEALTHCARE

Healthcare is a complex system. It deals with versatile data that are sensitive and confidential information about patients' condition, prescriptions, etc. [4]. Patients' data is stored within EHR and usually are transferred to different stakeholders and central data stores. Today, with the growing digitization of medical care, medical industry is faced with the inability to safely and securely distribute sensitive patient data [9]. Centralized data stores and cloud-based systems are attractive targets for cyber attack and illegal modifications [10][11]. Besides that, standards which regulate interoperability among healthcare systems are not uniform or absent, which cause difficulty to exchange data between healthcare organizations and other participants in healthcare set [12].

In general, emerged, modern technologies have significantly improved services in healthcare, and in recent years, blockchain is frequently viewed as a method of solving a number of issues in healthcare area [1]. Blockchain technology forms a part of the fourth industrial revolution and it is also big buzzword around the medical technology area [13].

Over the years, the number of patients, medical reports, analyses, results, connected medical devices has been increasing and it is increasingly difficult to handle such an infrastructure where the exchange of such data requires increased interoperability. Blockchain technology has the potential to keep address the interoperability concerns currently present in health IT systems [14] [15].

The paper [16] in details elaborate key layers of interoperability framework such as business model, platform, infrastructure. In addition, the importance of data standardization, legal framework and critical attitude towards commercialization is emphasized. Haddouti et al. [17] proposed solution called Fedidchain as innovative framework that relied on smart contracts. Experimental results show the efficiency of Fedidchain compare to previous existing centralized models of data transfer. In their paper, Reegu et al. [18], proposed blockchain-based interoperable framework based on two EHR frameworks HL7 and HIPAA enabling security and privacy for vulnerable health data.

Blockchain technology, based on principles of decentralization and cryptography, has potentials to solve data privacy, security and highly interoperable Electronic Health Record (hereinafter: EHR) [19]. At the patient side, EHR data can be easily accessible for them and whole system could become more patient-centric [20]. Healthcare patient data are securely transferred over P2P system and cloud-based solution to hospitals and healthcare providers, as in working prototype MedRec [21]. Also, solutions from US company CareCloud [22], Avaneer Health [23], and Coral Health [24] presents the use of blockchain to accelerate the care process, improve health outcomes and implementing smart contracts between patients and healthcare professionals.

Blockchain can have a global impact on clinical research and it can be used to point problems of false results. It is inevitable that blockchain will strengthen trust in clinical trials [1] [25]. The good example is Clinical Trials Intelligence founded by ClinTex [26], platform for data analytics, machine learning and smart contracts in clinical trials. Another example comes from Mayo clinic, implementing a blockchain-integrated platform for pulmonary arterial hypertension trial. The platform will provide secure, decentralized data capture, document management, study monitoring and electronic consent for the clinical trial [27].

Another field where blockchain is affecting healthcare is the pharmaceutical industry. Drug traceability and medical or drug supply chain management is provided by a distributed ledger which is shared among all the stakeholders within the supply chain [28]. Some examples come from Chronicled [29] and BlockPharma [30] which build blockchain networks that helps pharma companies ensure safety, privacy and efficiency of medical supply chains. Interesting is start-up and pilot project Modum.io AG [31] with pharmaceutical distributors where efficacy and safety of the product is paramount. The proposed system includes sensor devices that monitor the temperature during the shipment and the data is transferred to blockchain with smart contract where temperatures can be assesses automatically and notify sender and recipient.

Blockchain along with Internet of Things (hereinafter: IoT) sensors can be used for transportation, collection, and storage of vaccines, especially during Corona virus disease [32]. Vacchain System, which is proposed in the paper presents decentralized system for vaccine distribution and elimination of counterfeit vaccines.

Wearable devices and IoT have a significant role in monitoring the health of patients. These systems generate huge amounts of data that are analyzed through big data and forwarded to healthcare stakeholders. The infrastructure of the IoT systems can be realized through blockchain technology. An example of this is a system based on Cloud storage, smart contract and IoT devices is given in [32]. System provides advanced security using cryptographic techniques like ARX encryption scheme to the current IoT based remote patient monitoring system.

Despite blockchain presents numerous opportunities for health care [32] [4], it is still in the development stage and there is not yet awareness in this technology in the healthcare area.

In order to its successfully implementation, it is necessary to overcome certain challenges. These are primarily technical, organizational and legal aspects as data standardization [5] [33], laws, as well as social and cultural change [34].

III. BLOCKCHAIN ECOSYSTEM FOR HEALTHCARE

A. BMC – Business Model Canvas

In the following chapter, the Business Model Canvas applied in the healthcare industry will be described, as well as description of all its elements (Table 1). The business model is considered as the preliminary stage before entering into a business, as this should guide towards the path of achieving the successful business goal.

B. Key partners

Companies enter into partnerships with each other for many reasons, and partnerships become the cornerstone of many business models. Companies enter into alliances to optimize their business models, reduce risk or acquire resources. Key partners for a healthcare application are primarily hospitals and patients. The main role of hospitals is to update the existing database containing illness track records. Then, the patient is the most important part because he is using the app for booking appointments and buying medicines with prescriptions. Pharmacies are important partners because they are the ones issuing prescribed medicine. Prescription is done by the app/doctor after the appointment. Government regulations are provided through the Ministry of Health.

C. Key activities

A successful healthcare application requires many key activities. These are just some of the activities that a company must undertake to operate successfully. Like obtaining patient information, that activity is important because the patient is the main role in this development act.

Customer service is important because it inspires patients' user-friendly experience and makes Medical staff's jobs easier. By providing great customer service, Medical facilities can offer trust and obtain more users. Medical software development is the technical part. The company is in charge of the successful development and maintenance of the app/website, using Blockchain technologies.

D. Value propositions

The value proposition is why patients decide to use our platform. Each value proposition consists of a selected set of services that meet the requirements of a specific patient segment. When a Medical facility is transparent about its values and processes, patients gain more trust in that institution and are more likely to book their appointment in that way. If an institution does not provide high protection of confidential information, it may later lead to the loss of

Table I. BMC for the application of the blockchain in the healthcare

<table>
<tr><td colspan="5">Business idea: Offering medical support, tracking patient data, and designing a business model for the application of Blockchain in the healthcare industry
Products and services: Medical favor, laboratory results</td></tr>
<tr>
<td rowspan="2">Partners
- Pharmacies
- Patients
- Ministry of Health
- Hospital
- Healthcare providers and workers
- Medical laboratories
-Health insurance investors
-Research institutes</td>
<td>Key activities
- Research & Development
- Quality Control & Quality Assurance
-Patient information & Medical data management
- Marketing & Advertising
- Medical treatment
- Customer support
- Medical software development
-Partnership development</td>
<td rowspan="2">Value propositions
For stakeholders:
- Transparency
- Tracking all transactions
- Regulate interactions
- Monitoring all interactions in each medical institution
- Minimal risk
- Protection of confidential information
- Managing a large amount of information
For customers:
- Issuing prescriptions
- Security and trust among consumers
- Protection of personal data
- Quick response
- Keeping track of illness history</td>
<td>Relationship with users
- Quick & friendly service for the patient segment
- Save patient time
- Allow the patient to have more control over their medical records
- Pharmacies sales & support
- Technical assistance</td>
<td rowspan="2">Customer segments
- It targets patient participants who prefer to adopt and test new technologies
- Medical facilities that invest in new inventions and technology development
- Medical insurance
- Research companies
-National government</td>
</tr>
<tr>
<td>Key resources
- Funds (govt schemes, investors)
- Skilled software developers & database administrators
- Professional staff
- Facilities
- Software & Analytics</td>
<td>Channels
- Doctor inputs directly
- Medical institutions
- Corporate offices
- App store</td>
</tr>
<tr>
<td colspan="3">Cost structure
- Website development and maintenance, marketing costs, equipment maintenance costs, web designer costs, legal formalities, pharmacies costs</td>
<td colspan="2">Revenue Streams
- Free basic application for doctors and patients
- Data analysis sold to Pharmacies\Insurance companies & Research Facilities
- Sponsorships</td>
</tr>
</table>

sensitive information. Therefore, developers must understand the law of trust, what it protects, and the obligations of doctors and third parties.

E. Relationship with users

The way you connect with patients impacts their experience. We aim to establish automated relationships to improve the application and make it user-friendly. Social media is an effective tool to reach a wider audience and engage new users who would benefit from the application. What is most attractive for the users themselves is the privacy of their data and, of course, greater control over it. Certainly, what completes the user experience itself is an application that is simple and practical yet provides great and essential functionality.

F. Customer segments

The identification of the range of customers is crucial for an organization as it helps define the groups of people they aim to serve. These groups of people are known as the customer segments. Factors such as age, gender, user behavior, location, interests, and other relevant aspects are considered while grouping the customers. In our business model, we aim to serve people who require medical help, use medical services, or need appointments in healthcare institutions.

G. Key resources

In addition to these main types of resources, other important resources for medical institutions may include:

1. Technological resources - the software and hardware required to run the medical system, electronic health records, communication devices, telemedicine, etc.
2. Supply chain resources - suppliers, distribution channels, transportation, warehouses, and inventory management.
3. Reputation resources - brand image, reputation, credibility, patient satisfaction, and relationships with key stakeholders such as physicians and insurers.
4. Regulatory resources - compliance with laws, regulations, and quality standards, risk management systems, and legal support.
5. Cultural resources - organizational culture, values, and norms that influence the behavior of employees and stakeholders and contribute to the success of the business model.

Identifying the key resources and managing them effectively is essential for the Medical institution's success. It requires careful planning, allocation of resources, and continuous evaluation and improvement of the resource allocation strategy. Proper management of resources can help medical institutions to deliver high-quality care, improve patient satisfaction, reduce costs, and achieve sustainable growth.

H. Channels

This part of the business model canvas is discussing the methods of distributing a software solution and promoting it through advertising. The "distribution channels" section of a company's strategy describes how they connect with customers, not just how they deliver the product. The purpose is to not only deliver value but also to spread awareness of the product's existence. Channels are how the organization communicates with its consumers or patients and serves as the interface between the medical institution and the public, which includes patients, the Ministry of Health, and pharmacies.

Medical institutions can be an effective channel for distributing healthcare applications, especially if your app is designed for healthcare professionals or patients with specific medical conditions. By partnering with medical institutions, you can tap into their existing patient and provider networks, increasing the reach and impact of your healthcare app.

Doctor inputs can be a valuable channel for distributing healthcare applications. By partnering with doctors and other healthcare providers, you can leverage their expertise and insights to improve the effectiveness and relevance of your healthcare app. To effectively use doctor inputs as a channel, it's important to establish strong relationships with healthcare providers and offer value to both providers and patients.

I. Cost structure

Regarding cash flows, this paragraph discusses the cost structure of a business, specifically concerning creating and distributing a value proposition, maintaining customer relationships, and generating revenue streams. For a healthcare app that uses blockchain technology, the cost structure will depend on factors such as app complexity, security level, and development resources. It's important to create a budget that accounts for all potential costs associated with app development and deployment. A company can either focus on minimizing costs or providing maximum value within a selected price range.

Cost-driven business models aim to minimize costs by maintaining a lean cost structure, using low-priced value propositions, extensive automation, and outsourcing. On the other hand, value-driven business models prioritize value creation over cost implications, characterized by premium value propositions and personalized service.

J. Revenue Streams

The revenue streams section of a business model is an important component that outlines the various sources of income for a company. It identifies how a company generates revenue from its customers, including the pricing strategy, revenue models, and sales channels.

In the Business Model Canvas, the revenue streams section is directly linked to each previously defined customer segment. This means that the company's revenue streams are directly influenced by the needs and preferences of its customers. It is important for a company to carefully consider the revenue streams associated with each customer segment, as this will impact the overall financial performance of the business. It is also worth noting that revenue streams do not necessarily equate to profit earned.

While revenue is an important component of a company's financial success, it is important to also consider the costs associated with generating that revenue. For example, a company may have high revenue streams but also high costs, which can impact profitability. Therefore, it is important for a company to carefully manage both revenue and costs to maintain financial stability and achieve sustainable growth.

Sponsorships are a valuable revenue stream for healthcare apps. By offering sponsored content, research opportunities, in-app advertising, sponsorship of features or tools, or data analytics, you could generate revenue while also providing value to your users. However, it's important to ensure that any sponsorships align with your app's mission and values and that they do not compromise the integrity or security of your app or user data.

Offering a free basic version of your app for doctors and patients can be a good way to attract new users and build a user base. However, it's important to consider potential revenue streams to monetize your app, such as data monetization, affiliate marketing, or sponsored content.

Selling data analysis to pharmaceutical companies, insurance companies, and research facilities can be a viable revenue stream for this kind of app that collects and analyzes data. Keeping in mind it's important to consider the potential ethical and legal implications of data sharing and ensure that any data sharing agreements are transparent and protect user privacy.

IV. BLOCKCHAIN-BASED HEALTHCARE ECOSYSTEM

A blockchain ecosystem for healthcare is a decentralized platform that utilizes blockchain technology to manage, store, and share medical data securely and transparently. In such a system, all medical data related to a patient, such as medical history, lab results, and prescriptions, are stored in a distributed ledger, which can be accessed by authorized parties in a secure and tamper-proof way.

The benefits of a blockchain ecosystem for healthcare are numerous. Firstly, it enables patients to have full control over their medical data and who can access it. Secondly, it enhances interoperability among healthcare providers by providing a unified view of a patient's medical history. This can improve patient outcomes and reduce medical errors. Thirdly, it reduces administrative costs associated with managing healthcare data, such as paperwork and data entry.

Figure 1 shows the proposed Healthcare ecosystem based on blockchain.

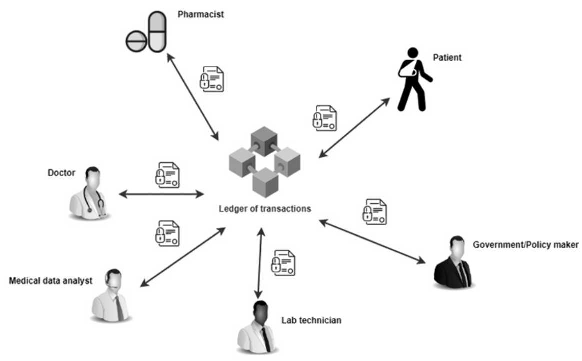

Fig. 1. Blockchain-based healthcare ecosystem

In this ecosystem, blockchain technology would be used to securely and transparently store and share medical data, allowing all parties to access the information they need to make informed decisions.

Patients would be able to control their medical data and grant access to healthcare providers as needed. This would give patients greater control over their healthcare and enable doctors to make more informed diagnoses and treatment decisions. Pharmacists could also benefit from this system by having access to a patient's medication history, allowing them to avoid potentially harmful drug interactions. Government officials and policymakers could use the data stored on the blockchain to analyze healthcare trends and make informed policy decisions. They could also ensure compliance with regulations and monitor the quality of care provided by healthcare providers. Lab technicians would be able to use the blockchain to securely store and share test results, which could be accessed by healthcare providers as needed. This would allow for faster and more accurate diagnoses, leading to improved patient outcomes.

Overall, a blockchain ecosystem that includes all the represented parties in the picture above has the potential to greatly improve the efficiency and effectiveness of the healthcare industry. By utilizing the transparency and security provided by blockchain technology, this ecosystem could lead to better patient outcomes, more informed decision-making, and a more efficient healthcare system.

V. DEVELOPMENT OF A SMART CONTRACT FOR HEALTHCARE

The following three algorithms present the smart contract created between two stakeholders in the healthcare ecosystem, the Patient and Laboratory. Algorithms are used to present the connection and the conditions that must be met for all operations to be performed and for the smart contract to be successfully created. They also show what happens in a situation if some of the conditions are not met.

```
Algorithm 1: Patient starts COVID-19 testing in Laboratory

Input: Laboratory ID, Patient ID, Patient LBO, Labaratory
If Caller == Patient
    then
    Issue an announcement (Event) that the patient is
    asking for COVID-19 testing.
else
    return error.
```

Fig. 2. Algorithm for the first operation – Patient starts COVID-19 testing in Laboratory

Figure 2 shows the first algorithm that represents the first operation performed by the patient, which is the request for testing for the Covid-19 virus. The request and the operation itself are quite simple, which is why the conditions are not complex either.

```
Algorithm 2: Laboratory accepts testing and clears previous results

Input: Laboratory ID, Patient ID, Patient LBO, Testing Fee,
CRP, WBC, LYM
If Caller == Laboratory and
  Testing Fee == 100000 and
  CRP == " " and
  WBC == " " and
  LYM  == " "
    then
    Issue an announcement (Event) that the testing fee is
    correct and Laboratory can test blood samples.
else
    return error.
```

Fig. 3. Algorithm for the second operation – the Laboratory accepts testing and clears previous results

Figure 3 shows another algorithm that represents the next operation that is performed when communicating between these two stakeholders. This operation is performed by the Laboratory and the conditions are such that they check whether the blood parameters (crp for c-reactive protein, wbc for white blood cell, lym for lymphocytes) are empty so that the results can be written into them and the Patient can be tested for the virus. The laboratory also checks whether the Patient has paid for the testing as required.

Figure 4 shows the last algorithm representing the third operation. This operation is performed by the Patient. If the LBO (insurance number) exists in the Laboratory, the blood results are obtained and the Patient is informed whether the test is positive or negative for the virus. Otherwise, the personal number of the insured is not found in the Laboratory and the Patient does not receive his results.

```
Algorithm 3: Patient receives COVID-19 test results

Input: Laboratory ID, Patient ID, Patient LBO, CRP, Patient
CRP, WBC, Patient WBC, LYM, Patient LYM
If Caller == Patient and
  Patient LBO == Patient ID
    then
    Patient CRP = CRP and
    Patient WBC = WBC and
    Patient LYM = LYM

    Issue an announcement (Event) that the patient is
    receiving COVID-19 test results, whether the results are
    positive or negative.
else
    return Patient LBO Not confirmed.
```

Fig 4. Algorithm for the third operation – Patient receives COVID-19 test results

In the Figure 5 there is a representation of all transactions after finishing all steps of the smart contract. There are two accounts in question, a patient and a laboratory that does the blood testing for COVID-19. First transaction is actually the creation of our app. Next, second and third one are the OptIn transactions that both accounts should have in order to continue onto the next main transactions. After clicking the Request testing button and choosing the antigen test another transaction will show on our AlgoExplorer. When that is done the laboratory also makes another (fourth) transaction by clicking the Start COVID-19 button. Finally, the last transaction is created when the patient requests his blood results back, the laboratory provides them immediately after the funds for the blood testing expenses are moved from the patient account to the laboratory account (Figure 6).

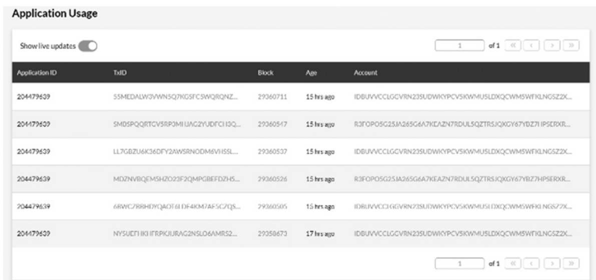

Fig. 5. Representation of all transactions after finishing all steps of the smart contract

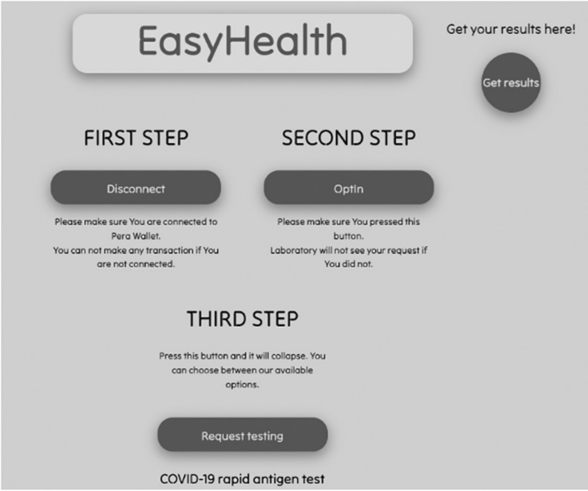

Fig. 6. EasyHealth application

An application was developed using the React framework, which should allow the Patient to request a quick test for the Covid-19 virus, after which the Laboratory, based on the blood sample, returns the test results. The front end of our EasyHealth application is shown in Figure 7.

VI. CONCLUSION

In this project we proposed:

- BMC for the application of the blockchain in the healthcare
- Blockchain-based healthcare ecosystem
- Implementation of the smart contract between the Patient and the Laboratory using PyTeal and Algorand
- User application

Future development will be related to development of the smart contracts for the all participants in the proposed ecosystem and development of the new features for the EasyHealth application. It would require a skilled team of developers, blockchain experts, and healthcare professionals to implement the proposed blockchain ecosystem, as well as ongoing maintenance and support.

LITERATURE

[1] A. Haleem, M. Javaid , R. P. Singh, R. Suman and S. Rab, "Blockchain technology applications in healthcare: An overview," International Journal of Intelligent Networks, vol. 2, no. 2021, pp. 130-139, 2021.

[2] D. Elangovan, S. C. Long, S. F. Bakrin, S. C. Tan, W. K. Goh, F. S. Yeoh, J. M. Loy, Z. Hussain, S. K. Lee, C. A. Idris and C. L. Ming, "The Use of Blockchain Technology in the Health Care Sector: Systematic Review," JMIR Med Inform, p. e17278, 2022.

[3] A. Labus, M. Radenković, Z. Bogdanović, D. Bjelica and V. Despotović, "A blockchaing system for healthcare," in 5th International Scientific Conference on Digital Economy DIEC 2022, Tuzla, 2022.

[4] G. Huang and A. A. Foysal, "Blockchain in Healthcare," Technology and Investment, vol. 12, no. 3, pp. 168-181, 2021.

[5] A. Thakur, "A Comprehensive Study of the Trends and Analysis of Distributed Ledger Technology and Blockchain Technology in the Healthcare Industry," Front. Blockchain, vol. 5, p. 844834, 2022.

[6] S. Daley, "Blockchain in Healthcare: 17 Examples to Know," 16 February 2023. [Online]. Available: https://builtin.com/blockchain/blockchain-healthcare-applications-companies.

[7] R. Garett, M. Emish and S. D. Young, "Cryptocurrency as a new method for participant compensation in research," Health Policy and Technology, p. 100746, 2023.

[8] A. A. Hessah, N. Shorog, A. Shada, A. Albatoul, A. Areej and A. Fay, “Wholesome Coin: A pHealth Solution to Reduce High Obesity Rates in Gulf Cooperation Council Countries Using Cryptocurrency,” Front. Blockchain, vol. 4, 2021.

[9] H. Saeed, H. Malik, U. Bashir, A. Ahmad, S. Riaz, M. Ilyas, W. A. Bukhari and M. Khan, "Blockchain technology in healthcare: A systematic review," PLoS One, vol. 17, no. 4, p. e0266462, 2022.

[10] M. Shuaib, N. H. Hassan, S. Usman, S. Alam, S. M. Sam and G. A. Samy, "Effect of Quantum computing on Blockchain-based Electronic Health Record Systems," in 2022 4th International Conference on Smart Sensors and Application (ICSSA), Kuala Lumpur, Malaysia, 2022.

[11] V. Mahore, P. Aggarwal, N. Andola, Raghav and S. Venkatesan, "Secure and Privacy Focused Electronic Health Record Management System using Permissioned Blockchain," in 2019 IEEE Conference on Information and Communication Technology, Allahabad, India, 2019.

[12] R. G. Sonkamble, S. P. Phansalkar, V. M. Potdar and A. M. Bongale, "Survey of Interoperability in Electronic Health Records Management and Proposed Blockchain Based Framework: MyBlockEHR," IEEE Access, pp. 158367-158401, 2021.

[13] J. Morey, "The Future Of Blockchain In Healthcare," 2021.

[14] S. Schmeelk, M. Kanabar, K. Peterson and J. Pathak, "Electronic health records and blockchain interoperability requirements: a scoping review," JAMIA Open, vol. 5, no. 3, p. ooac068, 27 July 2022.

[15] K. Tiwari, S. Kumar, P. Khanna and A. Kumar, "1 - Blockchain-based transaction validation for patient interoperability in Healthcare 4.0," Blockchain Applications for Healthcare Informatics, pp. 1-26, 2022.

[16] N. Hewett, M. van Gogh and L. Pawczuk, "Inclusive Deployment of Blockchain for Supply Chains: Part 6 – A Framework for Blockchain Interoperability," World Economic Forum, Geneva Switzerland, 2020.

[17] S. El Haddouti, A. Ouaguid and M. D. Ech-Cherif El Kettani, "Fedidchain: An Innovative Blockchain-Enabled Framework for Cross-Border Interoperability and Trust Management in Identity Federation Systems," J Netw Syst Manage, vol. 31, no. 42, 2023.

[18] F. A. Reegu, H. Abas, Y. Gulzar, Q. Xin, A. A. Alwan, A. Jabbari, R. G. Sonkamble and R. A. Dziyauddin, "Blockchain-Based Framework for Interoperable Electronic Health Records for an Improved Healthcare System," Sustainability, p. 6337, 2023.

[19] V. Rawal, P. Mascarenhas, M. Shah and S. S. Kondaka, Blockchain for Healthcare. An opportunity to address many complex challenges in healthcare, CitiusTech, 2018.

[20] S. Mehta, K. Grant and A. Ackery, "Future of blockchain in healthcare: potential to improve the accessibility, security and interoperability of electronic health records," BMJ Health Care Inform, vol. 27, no. 3, p. e100217, 2020.

[21] A. Azaria, A. Ekblaw, T. Vieira and A. Lippman, "MedRec: Using Blockchain for Medical Data Access and Permission Management," in 2016 2nd International Conference on Open and Big Data (OBD), Vienna, Austria, 2016.

[22] CareCloud, "CareCloud: Modern Healthcare Solutions," April

2023. [Online]. Available: https://www.carecloud.com/.

[23] Avaneer Health, "Unlock the Full Potential of Healthcare," April 2023. [Online]. Available: https://avaneerhealth.com/ .

[24] Coral Health, "Coral Health," April 2023. [Online]. Available: https://www.coralhealth.com/.

[25] M. Benchoufi and P. Ravaud, "Blockchain technology for improving clinical research quality," Trials, vol. 18, no. 335, 2017.

[26] ClinTex, "Clintex Whitepaper 2020. New Medicine: Faster, Safer, Smarter," ClinTex, 2020.

[27] A. Fox, "Mayo Clinic to use blockchain for hypertension clinical trial," 07 September 2022. [Online]. Available: https://www.healthcareitnews.com/news/mayo-clinic-use-blockchain-hypertension-clinical-trial.

[28] N. Zakari, M. Al-Razgan, A. Alsaadi, H. Alshareef, H. Al Saigh, L. Alashaikh, M. Alharbi, R. Alomar and S. Alotaibi, "Blockchain technology in the pharmaceutical industry: a systematic review," PeerJ Comput Sci, vol. 11, no. 8, p. e840, 2022.

[29] Chronicled, "Trust & Automation Between Companies," 2023. [Online]. Available: https://www.chronicled.com/.

[30] Blockpharma, "Blockchain drug traceability and anti-counterfeiting solution," 2023. [Online]. Available: https://www.blockpharma.com/.

[31] T. Bocek, B. B. Rodrigues, T. Strasser and B. Stil, "Blockchains Everywhere - A Use-case of Blockchains in the Pharma Supply-Chain," in 2017 IFIP/IEEE Symposium on Integrated Network and Service Management, Lisbon, Portugal, 2017.

[32] A. Koyama, V. C. Tran, M. Fujimoto, V. N. Q. Bao and T. H. Tran, "A Decentralized COVID-19 Vaccine Tracking System Using Blockchain Technology," Cryptography, vol. 7, no. 1, p. 13, 2023.

[33] S. Srivastava, M. Pant, S. K. Jauhar and A. K. Nagar, "Analyzing the Prospects of Blockchain in Healthcare Industry," Computational and Mathematical Methods in Medicine, p. 24, 2022.

[34] R. J. Krawiec, F. Quarre, J. Killmeyer, D. Housman, D. Barr, A. Israel, M. White, A. Nesbitt, L. Tsai, M. Filipova and K. Fedosova, "Blockchain: Opportunities for Health Care," Deloitte, 2016.

[35] Healthcare Information and Management Systems Society, "Blockchain in Healthcare," 2022. [Online]. Available:https://www.himss.org/resources/blockchain-healthcare.

[36] A. Panda and C. P. Jena, "Applications of Blockchain in Healthcare," International Journal of Computational Engineering Research, vol. 9, no. 2, pp. 82-86, 2019.

DApp for Food Traceability Based on PyTeal and Algorand

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Abstract—The research area of this work is the application of blockchain technologies in tracking the authenticity of organic food. This paper discusses the influence of blockchain technology as one of the modern technologies and how it can change supply chain management. In the theoretical part of the work, the concept of supply chain management in the food industry will be explained, focusing on analysing the possible application of blockchain technology. The possibilities will be looked at in detail with applications of blockchain technologies to trace the authenticity of the food. The main goal of the research is to propose an intelligent system for tracking the origin of organic food, such as coffee, based on blockchain technology. The practical part of the paper will present the traceability of organic coffee origin by developing smart contracts. Smart contracts will be developed using PyTeal programming language and Algorand blockchain platform.

Keywords - Supply Chain Management, Organic Food Traceability, Blockchain, PyTeal, Algorand

I. INTRODUCTION

When purchasing organic food, consumers have high standards for its quality and depend on certification agencies to confirm the quality and offer details about the items' sourcing. However, there are several drawbacks to organic food traceability, including issues with organic labelling, certification fraud, and worries about the openness of food information [1]. Chain of Custody (CoC) methods based on paper are used in many certification schemes. This mandates that all businesses throughout the supply chain maintain written records of the number of certified items they acquire and sell. Additionally, it necessitates the arrival of auditors to verify those paper documents. Hence, information about the authenticity of the food is critical in the organic food supply chain, as it can show pesticide use, genetically modified organisms (GMOs), fair payments, and carbon or environmental footprint. Pesticides can be toxic to humans and have acute and chronic health effects. According to the World Health Organization, pesticide exposure's health and ecological impact remain concerning. Concerning the above observations, this study aims to investigate the possibility of using blockchain technology to track the authenticity of organic food. Blockchain enhances the sources to identify potential contamination sources and swiftly stop outbreaks. Transparency may increase brand trust by validating and authenticating food provenance when utilising the Blockchain for food traceability. Additional advantages include preventing fraud and combating attacks with preventive measures that can save costs associated with food testing and increase margins.

This paper provides a theoretical review of using blockchain technologies in supply chain management and food traceability using smart contracts and blockchain platforms. The practical part shows designing an ecosystem for tracking organic coffee origin using Blockchain. Designing and development of smart contracts for the food chain are presented. A dApp is developed using PyTeal and Algorand blockchain technologies.

II. BLOCKCHAIN IN THE SUPPLY CHAIN

A. The concept of supply chain management

The supply Chain is sources of raw materials and parts, production and assembly, warehousing and inventory tracking, order entry and order management, distribution through all channels, delivery to the customer, and the information systems required to track all of these activities are just a few of the activities involved in getting a product from the manufacturer to the customer [2]. All of these processes are coordinated and integrated by supply chain management. It connects every component in the chain, including internal organisational divisions and external partners, vendors, carriers, third-party businesses, and information technology providers. The necessity of viewing the entire procedure as a single system is a crucial component of supply chain management. To ascertain the genuine capabilities of the process, any inefficiency experienced across the supply chain (suppliers, production facilities, warehouses, customers, etc.) must be evaluated [3].

Throughout the supply chain, most traceability standards describe the capability to track the essential features of a product from its origin (including its ingredients) to the final process step. The various definitions of 'traceability' encompass two or more of the following four concepts: consistency and clarity in terminology (e.g., 'tracking' vs 'tracing'), backward follow-up of ingredients (tracing), forward follow-up of products (tracking), and product history information throughout the supply chain [4]. The definition of food traceability as a logistics management component highlights that food safety and quality are quality assurance capabilities whose efficiency and effectiveness depend heavily on logistics operations [5]. While a comprehensive collection of traceability information is necessary for this procedure, the success of the recall process is also heavily dependent on the efficiency of logistical operations and the degree of integration between the various supply chain actors [6]. While other definitions of traceability emphasise the primary functionality of tracking and tracing, Bosona and Gebresenbet's report establishes a direct connection between the purpose of traceability ("checked for safety and quality control") and the conditions of applicability ("at all stages" and "at any time required"). Forward traceability (or "tracking") is distinguished from backward traceability (or "tracing") based on the direction of information flow. The distinction is best described in the context of a product recall. The capacity to track means that products can be followed from the beginning to the conclusion of the supply chain and recognised based on recall criteria.

B. Blockchain Food Traceability System

Blockchain food traceability systems enable consumers to receive any necessary food safety and quality control checks and backup data information to serve consumers' food safety needs better. These systems are part of logistics management as an information system that captures, stores, and transmits information about the collection, rearing, and production at all stages of the food supply chain. Traceability, according to Ringsberg, is the process of figuring out how to identify the root of flaws in food safety failures throughout the supply chain [7]. The primary prevention of future food safety events is thought to be accomplished by BFTS [8]. It is seen as a critical instrument for removing information asymmetry. Barcodes have been coupled with the blockchain food traceability system (BFTS) as an identifying tool to swiftly and precisely monitor food items. The Quick Response (QR) code is always written as a two-dimensional barcode on the traceability labels [9]. A QR code has excellent readability and can hold enough info. When a piece of code is physically destroyed, it is still quite readable [10]. Because they provide more data storage and encryption capabilities and environmental protection, QR codes are viewed as improved linear bar codes in developed nations. The ability to match a variety of two-dimensional code decoding software and systems, as opposed to being restricted to reader devices, is one benefit of two-dimensional code over RFID and conventional bar codes, which can be read by a wide range of devices, including smartphones [11]. The BFTS records all types of information at all levels of the food trade chain, according to the data flow and blockchain flow definition in the logistical process. The customer may use a QR code on the product label, load the system and get critical information about food traceability.

C. Using Blockchain to Track and Trace Organic Food

The coffee industry can also utilise the Blockchain to improve supply chain traceability. This is due to the immutability, traceability, and security that define blockchain technology. Big businesses frequently use this trait to boost sales and deal with the millions of brands affected by counterfeiting difficulties. The Global Financial Integrity Organization (GFIO) has conducted studies that put the yearly cost of counterfeit or pirated goods from international trade between US$923 billion to US$1.13 trillion [12]. If the Blockchain's core features are applied to the coffee supply chain, the uniqueness of the beverage can also be preserved. Blockchain can improve coffee producers' welfare, ensure quality, and decrease fraud in the sector. Customers of coffee dealers are informed of all the participants in producing the coffee before it reaches them. Customers should be able to comprehend why the company sells coffee at the current pricing by using blockchain technology since coffee traders raise payments to farmers who adhere to the company's plantation requirements. Also, it is feasible for clients to tip farmers to improve their well-being.

Using Blockchain, enterprises in the coffee industry can record production modifications on a single shared ledger, providing comprehensive data visibility and a single source of truth. Because transactions are always timestamped and current, businesses can query the status and location of a product at any time. This aids in the fight against challenges such as counterfeit goods, compliance violations, delays, and waste. In addition, immediate action can be performed during emergencies such as product recalls, and the ledger audit trail ensures regulatory compliance. In addition, by connecting Blockchain with intelligent technologies such as the Internet of Things, supply chains may automate the tracking of manufacturing, transportation, and quality control conditions. Companies may also opt to share track-and-trace data with their customers to verify their products' legitimacy and the integrity of their supply chains.

III. DESIGNING AN ECOSYSTEM FOR FOOD TRACEABILITY BASED ON BLOCKCHAIN

A. Food Traceability Platform in Coffee Supply Chain

The applied traceability platform is based on a web application accessible to all stakeholders in the coffee supply chain (farmers, factories, roasters, consumers, and supervisory authorities) (Figure 1). It enables operators to capture information from the coffee supply chain to ensure the quality of coffee and promote its marketing. The consumer will have access to the transactions in the various levels of the supply chain.

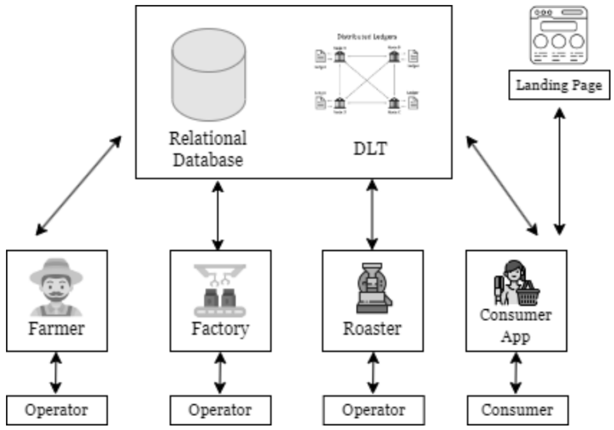

Fig 1. Traceability platform in the coffee supply chain

The key architectural components are the Backend framework, Relational Database Management System (RDBMS), and Distributed ledger technology (DLT). The development of the traceability platform is based on functional and technological needs received from Aosta valley dairy. The backend framework is the software component of the system and incorporates all the core data entry and retrieval operations [13]. The authors utilised a framework based on the Python programming language. The authors determined the required data, tables, and columns to be created in the RDBMS. MySQL is used as the database, which is hosted by Amazon Web Services (AWS). Integrating DLT and RDBMS enables the immutability of the supply chain's data by storing the required fields for identifying transactions from the relational database. The authors selected the Algorand Blockchain after analysing and evaluating several Blockchain technologies. The Algorand Blockchain is among the greenest Blockchains due to its low power consumption consensus algorithm.

In this ecosystem architecture, the various stakeholders involved in the food traceability process include:

a. Farmers and suppliers who provide the food products to be tracked
b. Regulators and certifiers who set standards and regulations for the food products and certify compliance
c. Retailers and distributors who get the food products from farmers and suppliers to consumers
d. Data analytics providers who provide insights and analysis based on the data generated by the Dapp
e. Payment providers who offer payment solutions that are integrated with the Dapp

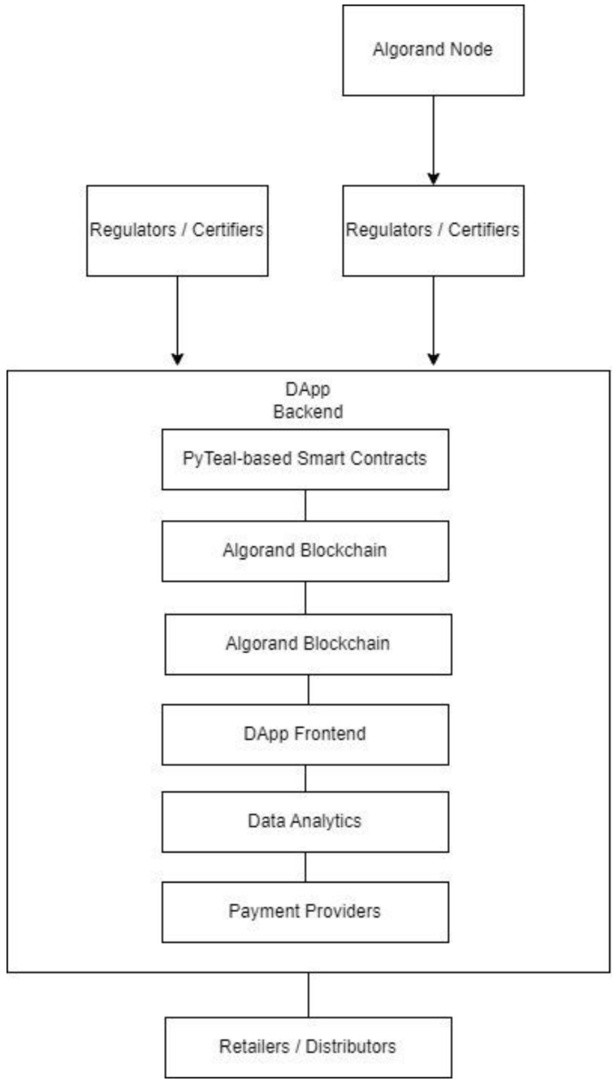

Fig 2. Ecosystem Architecture in tracking coffee

The DApp backend, which incorporates PyTeal-based smart contracts that enable food traceability on the Algorand blockchain, supports the ecosystem. The Algorand blockchain provides a secure, transparent, and immutable record of all transactions and data about tracked agricultural products. Farmers, suppliers, regulators, retailers, distributors, and consumers can interact with the DApp and access data related to the monitored food products through the DApp's frontend. The frontend is accessible via mobile and web applications. Data analytics providers have access to the data generated by the DApp to provide insights and analyses that can enhance the food traceability process. Farmers, suppliers, retailers, distributors, and other ecosystem participants can easily send and receive payments when payment providers integrate their solutions with the DApp.

B. Data Model

A data model was developed based on the organic coffee production chain, considering all supply chain phases and operators (Figure 3). The data model describes the tables and columns to be supplied with specific values in the RDBMS and DLT.

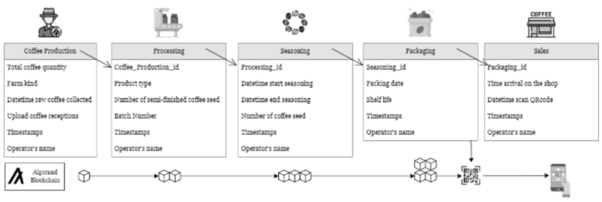

Fig 3. Principal Details recorded by operators

Automatically logged by the system are the operator's name and the transaction's timestamp. Thus, each operator must record the following data at each phase:

1. **Transporter**: The transporter begins the tour of the coffee growers and logs each quantity supplied using the existing system. The transporter arrives at the coffee producer, logs into the traceability platform, and enters the following information: the total amount of coffee collected, the type of farm (mountain pasture or valley), the date and time of raw coffee collection, and finally uploads an image containing all the quantities supplied by the farmers. The transporter sends the collected coffee to a dairy operator, who then processes it. At this step, the operator examines the most recent coffee production transactions and selects the coffee production id to handle. In addition, they describe the type of product (coffee seed or another subproduct) and the quantity of semi-finished coffee seed produced.
2. **Seasoning operator:** The semi-processed coffee seed is relocated to a unique location to mature. In this step, the seasoning operator selects the processing id containing the quantity of semi-finished coffee seeds to mature. In addition, they record the beginning and ending times of seasoning. Finally, the amount of coffee seeds labelled with CTF is recorded. The distribution operator initially selects the seasoning id and registers the packing date and shelf life. The transaction is submitted by the operator, who then obtains the QrCode. Specifically, this phase is particularly essential since the system queries and stores all associated data in the Algorand Blockchain.
3. **Sales operator or Consumer:** During this phase, the information about the shop's arrival time and the DateTime of QrCode scanning is used to determine where the coffee was purchased and to display the product's history to the final consumer on the landing page of the coffee's official website.

IV. DAPP FOR TRACKING COFFEE ORIGIN BASED ON PYTEAL AND ALGORAND

A. Business Model Canvas

<table>
<tr>
<td rowspan="2">KEY PARTNERS
➢ Farmers and suppliers
➢ Regulators and certifying bodies
➢ Retailers and distributors
➢ Data analytics providers
➢ Payment providers</td>
<td>VALUE PROPOSITION
➢ Transparency
➢ Increased trust
➢ Premium pricing</td>
<td rowspan="2">KEY ACTIVITIES
➢ Building and maintaining the PyTeal to develop smart contract
➢ Integrating the DApp with regulators and certifying bodies
➢ Providing user support for farmers, suppliers, retailers, distributors, and consumers
➢ Integrating payment solutions
➢ Conducting transactions among stakeholder in food supply chain</td>
<td>CUSTOMER RELATIONSHIP
➢ Provide Transparency
➢ Listen to Feedback
➢ Reward Customer Loyalty
➢ Offer Excellent Customer Support
➢ Collaborate with Food Producers</td>
<td rowspan="2">CUSTOMER SEGMENTS
➢ Farmers and suppliers
➢ Regulators and certifying bodies
➢ Retailers and distributors
➢ Consumers</td>
</tr>
<tr>
<td>KEY RESOURCES
➢ Algorand blockchain
➢ Software development team
➢ Marketing team
➢ Programing language for Supply Chain Management through Python</td>
<td>CHANNELS
➢ Social Media
➢ Partnerships
➢ Events and conferences
➢ Promotion on academic environment
➢ Blockhain platform algorand</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
➢ Development and maintenance costs
➢ Customer support costs
➢ Marketing and advertising costs</td>
<td colspan="2">REVENUE STREAM(S)
➢ Transaction fees
➢ Subscription Model
➢ Advertising
➢ Crowdfunding</td>
</tr>
</table>

Fig 4. Business Model Canvas

The Business Model Canvas DApp for food traceability based on PyTeal and Algorand is a decentralized application that leverages the Algorand blockchain and PyTeal (a Python library for writing Algorand smart contracts) to enable transparent and trustworthy food traceability. It relies on partnerships with farmers, suppliers, regulators, retailers, distributors, data analytics providers, and payment providers. The DApp's value proposition lies in transparency, increased trust, and the potential for premium pricing. Key activities include developing and maintaining the PyTeal smart contract, integrating with regulators and certifying bodies, providing user support, integrating payment solutions, and facilitating transactions within the supply chain. Customer relationships are built through transparency, feedback listening, loyalty rewards, excellent support, and collaboration with food producers.

The DApp targets farmers, suppliers, regulators, retailers, distributors, and consumers. Key resources include the Algorand blockchain, a software development team, a marketing team, and PyTeal. Channels utilized include social media, partnerships, events, academic promotion, and the Algorand blockchain platform. The cost structure includes development, maintenance, customer support, and marketing expenses. Revenue streams come from transaction fees, subscription models, advertising, and potential crowdfunding. Overall, the DApp enhances traceability, transparency, and trust in the food industry, benefiting all stakeholders involved.

In summary, the Business Model Canvas DApp for food traceability based on PyTeal and Algorand revolutionizes traceability in the food supply chain. It ensures transparency, fosters trust, and enables premium pricing. Through partnerships, key activities, customer relationships, targeted segments, key resources, channels, cost structure, and revenue streams, the DApp delivers its functionality effectively, reaching a wide user base and generating value for all stakeholders involved.

B. Smart contracts between stakeholders in the producing coffee

This sequence diagram depicts the interaction between the parties involved in coffee production and a smart contract that monitors the production procedure. The process's stakeholders include the coffee producer, the logistics company responsible for transporting the coffee, and the coffee roaster or purchaser (Figure 5).

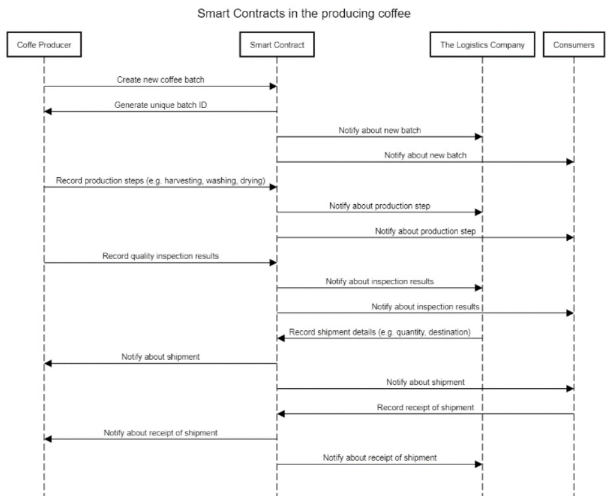

Fig 5. Sequences diagram for smart contracts between stakeholders in the producing coffee

The coffee Producer creates a new coffee batch and records the production stages using the smart contract to initiate the sequence. The smart contract generates a unique batch identifier and notifies The Logistics Company and Consumers of the new batch. The coffee Producer then continues the coffee production process while using the smart contract to capture the quality inspection results. The smart contract communicates the inspection results to The Logistics Company and Consumers.

The Logistics Company initiates the coffee shipment and documents the shipment details, including the quantity and destination, using the smart contract once the coffee production process is complete. The smart contract notifies Coffee Producers and Coffee Consumers of the cargo. Consumers receive the coffee shipment and document the receipt using the smart contract. The smart contract then alerts Coffee Producer and The Logistics Company regarding the shipment's delivery.

C. Implementation of Smart Contracts

The DApp will support two types of users: farmers and roasters. Farmers can create a new coffee batch by entering the coffee's origin, variety, and quality. Once a coffee batch is created, it will be assigned a unique identifier and added to the Algorand blockchain. Farmers can then sell their coffee to roasters by transferring the coffee batch's ownership to the roaster's address. Roasters can view the available coffee batches and choose which batches they want to buy. Once a roaster purchases a coffee batch, the ownership will be transferred to the roaster's address, and a new record will be added to the Blockchain to reflect the transaction. The smart contract defines a coffee supply chain, which allows participants to create, receive, process, pack, ship, receive at port, roast, and export coffee. The smart contract uses Algorand's stateful smart contract functionality, where participants can create and interact with a stateful application on the Algorand blockchain. The smart contract uses Algorand's PyTeal library to define subroutines for each operation. The subroutines include specific logic to check if the function is valid and the data provided is correct before approving the transaction. If the transaction is invalid, an error message is returned.

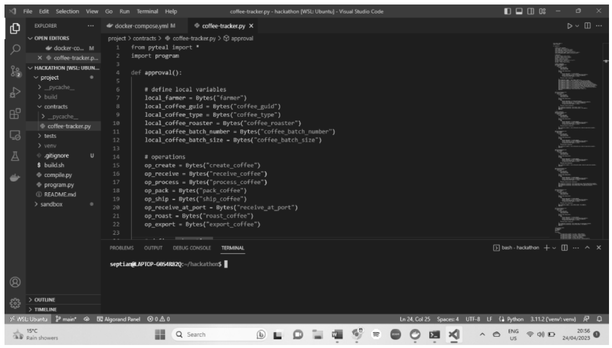

Fig 6. Smart Contracts

The program defines several constants, represented as Bytes objects, that will be used as operation codes in the Algorand smart contract. These constants include:

- create_coffee: an operation to create a new coffee batch
- receive_coffee: an operation to receive a coffee batch
- process_coffee: an operation to process a coffee batch
- pack_coffee: an operation to pack a coffee batch
- ship_coffee: an operation to ship a coffee batch
- receive_at_port: an operation to receive a coffee batch at the destination port
- roast_coffee: an operation to roast a coffee batch
- export_coffee: an operation to export a coffee batch

These operations are likely specific to the smart contract being developed and will be used in the contract's logic to determine how it interacts with the Blockchain and what actions it can perform. The local variables defined in the function, including local farmer, local coffee guid, local_coffee_type, local coffee_roaster, local_coffee batch number, and local coffee batch size, may represent data inputs or outputs for the smart contract. These variables will be used in the contract's logic to store and retrieve data related to the coffee batch.

The program module that is imported at the beginning of the code may contain additional functions and logic used in developing the smart contract. This code represents the beginning of creating an Algorand smart contract designed to manage coffee batches' creation, processing, and shipping. Overall, the contract provides a transparent and secure way of managing the coffee supply chain, ensuring that the coffee is processed, packed, shipped, and received correctly at each stage of the supply chain.

V. CONCLUSION

Creating a decentralised application (DApp) based on the PyTeal and Algorand blockchains for food tracking is a significant advancement in maintaining the safety and security of food. The DApp can successfully trace a food product's entire route from the farm to the table by utilising the transparency and immutability of blockchain technology, giving customers real-time details about its origin, quality, and safety. Using PyTeal, a smart contract language based on Python, also allowed for the user-friendly and accessible implementation of complex logic and rules. This drastically lowered the entrance hurdles for developers and made it possible for the DApp to be developed more quickly and effectively. In general, a DApp for food traceability built on the PyTeal and Algorand blockchains might revolutionise the food business and increase consumer trust and confidence in the goods they buy. It is a promising technology that might be crucial in assuring everyone's access to safe and secure food.

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REFERENCES

[1] M. van Hilten, G. Ongena, and P. Ravesteijn, “Blockchain for Organic Food Traceability: Case Studies on Drivers and Challenges,” Frontiers in Blockchain, vol. 3, Sep. 2020, doi: 10.3389/fbloc.2020.567175.

[2] L. X. Lu and J. M. Swaminathan, "Supply Chain Management," in International Encyclopedia of the Social & Behavioral Sciences: Second Edition, Elsevier Inc., 2015, pp. 709–713. doi: 10.1016/B978-0-08-097086-8.73032-7.

[3] R. R. Lummus and R. J. Vokurka, "Defining supply chain management: a historical perspective and practical guidelines Introduction to supply chain concepts," vol. 99, pp. 11–17, 1999.

[4] P. Olsen and M. Borit, "How to define traceability," Trends in Food Science and Technology, vol. 29, no. 2. pp. 142–150, Feb. 2013. doi: 10.1016/j.tifs.2012.10.003.

[5] T. Moe, "Perspectives on traceability in food manufacture," Trends in Food Science & Technology, pp. 211–214, 1998, doi: 10.1016/s0924-2244(98)00037-5.

[6] M. Bourlakis and C. Bourlakis, "Integrating logistics and information technology strategies for sustainable competitive advantage," Journal of Enterprise Information Management, vol. 19, no. 4, pp. 389–402, 2006, doi: 10.1108/17410390610678313.

[7] H. Ringsberg, "Perspectives on food traceability: A systematic literature review," Supply Chain Management, vol. 19, pp. 558–576, Sep. 2014, doi: 10.1108/SCM-01-2014-0026.

[8] S. Jin, Y. Zhang, and Y. Xu, "Amount of information and the willingness of consumers to pay for food traceability in China," Food Control, vol. 77, pp. 163–170, Jul. 2017, doi: 10.1016/j.foodcont.2017.02.012.

[9] J. Qian et al., "Food traceability system from governmental, corporate, and consumer perspectives in the European Union and China: A comparative review," Trends in Food Science and Technology, vol. 99. Elsevier Ltd, pp. 402–412, May 01, 2020. doi: 10.1016/j.tifs.2020.03.025.

[10] J. Qian et al., "Filling the trust gap of food safety in food trade between the EU and China: An interconnected conceptual traceability framework based on blockchain," Food Energy Secur, vol. 9, no. 4, Nov. 2020, doi: 10.1002/fes3.249.

[11] A. Tan and P. T. Ngan, "A proposed framework model for dairy supply chain traceability," Sustainable Futures, vol. 2, Jan. 2020, doi: 10.1016/j.sftr.2020.100034.

[12] R. Bettín-Díaz, A. E. Rojas, and C. Mejía-Moncayo, "Methodological approach to the definition of a blockchain system for the food industry supply chain traceability," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Springer Verlag, 2018, pp. 19–33. doi: 10.1007/978-3-319-95165-2_2.

[13] S. P. Adithela, S. Marru, M. Christie, and M. Pierce, "Django content management system evaluation and integration with apache airavata," in ACM International Conference Proceeding Series, Association for Computing Machinery, Jul. 2018. doi: 10.1145/3219104.3229272.

Measuring the Performance of the Innovative Potential of the Academy on the Example of Algorand WEB 3.0 Hackathon

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Abstract—Hackathons and similar events are becoming very popular ways to supplement academic learning to practice teamwork, coding, and increasingly business skills. With a short implementation time frame of typically up to 36 hours, the hackathon routing process that generates the final code or proof of concept solution is completed after the jury trial is generally concluded at these events. Stakeholder efforts were focused on the design of the hackathon and the organizational aspects of the event. The students' efforts were mainly focused on the hackathon challenge and short tasks. That influence leaves aside the potential that the results of the hackathon could bring to further influence the innovative capacity of stakeholders, especially the academic community in the context of this paper. So, the main dilemma is how to use the potential of the hackathon as a mechanism to strengthen the innovative potential in the academic community. To explore this potential, the first initial step was to identify and measure performance indicators arising from hackathons such as exploring new pedagogical approach and experimental learning, motivation, and satisfaction for the adoption of hackathons as a mechanism for a pedagogical approach to initiating innovations and perceived innovative capacity. These indicators were analyzed on the example of the Algorand Hackathon 2023. These indicators become a foundation for further research and identification of performance indicators that serve as a basis for modelling performance indicators for innovative capacities based on the hackathon.

Keywords - hackathons, outcomes, sustainability, continuation hackathon project, performance indicators, hackathon-based innovation capacity

I. INTRODUCTION

Innovation is now becoming the new "name" [1] of higher education institutions that create new processes for new value propositions to students and industries, through the creation of new models of higher education for global economies. However, small steps should be taken first and HEIs should create an environment for dealing with internal innovation potential and innovation performance, and how faculty activities such as hackathons can ultimately contribute to the internal innovation performance and innovation potential of the faculty with their results. Hackathons are growing and explosion in popularity and that led to impacted by the necessity for researchers to study them more [2].However, most research is in one way similar about how to organize and run a hackathon, how to design a hackathon for a specific purpose, how to deal with different participants, or how to run hackathons that are not solely focused on developing software [2][3][4].

When it comes to the sustainability of results and projects after hackathons, most research work focuses on tangible and technical artifacts. The paper will present the proposed initial indicators that are used to measure and monitor the performance of the hackathon, using the example of the Algorand 2023 hackathon. Following indicators are monitored: pedagogical approach and experimental learning, motivation to adopt the hackathon as a mechanism for initiating innovation at the faculty, and perceived innovative capacity, motivation to participate in the hackathon, the treatment of the hackathon as an opportunity to earn internships, scholarships or starting a startup and starting a business, as well as the post-event indicator of satisfaction with the achieved effects. In the end, on the example of these performance indicators, it is concluded that the organizer, in this case, the academy, begins to monitor and measure the indicators so that the hackathon can have a long-term impact on the internal innovative potential.

A systematic review of guidelines for long-term sustainable outcomes of hackathons is currently lacking. Also, understanding its basic mechanisms and developing support for hackathon organizers, especially regarding the sustainability of hackathon outcomes, monitoring the impact of hackathon outcomes, identifying hackathon performance, and measuring the impact of performance in generating the innovative potential of hackathon organizers and users, has not been deeply explored [4][5].

This paper has approached the hackathon in the context of the perceived hackathon as a mechanism that could bring results and outcomes to motivate participants and organizers to continuously utilize it. Especially in the context of how it could bring value to the academic staff especially innovative potential or how hackathon could serve the academic innovative potential.

This paper provides the initial steps in order to identify the key indicators of the innovative performance of the hackathon, on the example of measuring the performance of the implemented Algorand Web 3.0 hackathon at the Faculty of Organizational Sciences in April 2023. (https://bc.elab.fon.bg.ac.rs/2023/02/01/w3-algorand-hackathon-2023/).

The paper focuses on the possibility of monitoring and measuring the outcome of the hackathon. Especially an initial review of the performance that indicates the contribution of the hackathon to the innovative potential of the hackathon organizer. In addition to monitoring the various dimensions of the hackathon and numerous recommendations for the successful organization of the hackathon, conducting research before, during and after the hackathon, through questionnaires and observations, the question of what happens after the hackathon is still open and insufficiently open. How and whether the outcomes and results of the project are monitored, and whether and how the organizers and participants relate to the hackathon in terms of the sustainability of the project. Additionally important is how stakeholders could benefit from hackathon results to impact innovative potential.

II. LITERATURE REVIEW

Hackathons and similar so-called codefest, time-based, themed events or extracurricular events have become very popular and recognized ways for boosting open-minded and innovative thinking in business and at the University of computer science learning. Additionally, hackathons are placed in different domains for corporate and educational purposes and shifted focus from generating innovating ideas or software products to covering an abundant variety of different contexts ranging from corporations to higher education and civic engagement[6].

Hackathons are set to aim to tap a variety of achievements such as getting and practicing specific business skills like problem-solving and critical thinking also creating startups, innovative prototypes of products and services, and generating new project ideas or improvements in existing communities. They also aim to boost connectedness among specific domains, teach specific skills and deliver recognizing and enhancing existing talent[6][7].

Most hackathons have a main goal to focus on a specific problem, develop solutions, present solutions to participants, gain quick feedback, and rapidly change prototype designs. Over and above that, the hackathon is also a identified as model of crowdsourcing with the goal to utilize and stimulate innovation among groups with diverse backgrounds that learn from each other, share knowledge and work toward a common goal[4].

Some of the implications indicated are that hackathons are a very practical concept for capturing the values of students (initiators, organizers, participants) and that balancing the values that participants can capture becomes the focus of hackathons in the context of a shared win-win situation. If the initiators can, in addition to valuable prizes, determine and more precisely present the capture of value for users of the hackathon, the hackathon becomes more attractive for a larger number of students and encourages more effort from each of them [1].

According to the proposed classification from the literature, [2][4] hackathons might be differentiated per value that is generated, so they are categorized as communal (towards community nurturing), contributive (issue-oriented), or catalytic (towards the search for innovation).

Research of hackathons is focused on the identification and classification of outcomes or how to relate hackathon design aspects (duration, team size, stakeholder connection, and participants' skills) [8] with hackathons' tangible and nontangible outcomes. Under hackathon's tangible and intangible outcomes researchers observed code, excitement, learning, networking, interdisciplinary collaboration, and ideas, fostering awareness about hackathon themes[8]. A full list of all references considered in is available here: https: https://bit.ly/2CDIezF and whose relative merits are unclear [7]. For instance, code is very often abandoned after the hackathon competition had finished, or what outcomes bring value to participants, organizers, and stakeholders[5].

A. Elaboration of Hackathon Status and Process after Hackathon

Various hackathon design factors (name, date, duration, initiator sector, initiator type, objective, key drivers, themes, format, number of participants, gender, team composition, participant skills, problem statement, generated ideas, prizes) determine the success of the hackathon. The diversity of the participants, and the degree of openness, according to [5]especially contribute to the generation of a large number of ideas and the solution of problems, which is the richness of the hackathon.

A study conducted at the Aga Khan University (AKU) in Karachi, Pakistan tracked the progress of hacking and post-hack incubation teams. Data was collected from applications, from applications, through evaluation forms and tracking incubation team milestones. A list of factors such as the sectors the winning projects deal with, and the grants received was made. Ratings given by participants were positive, with a mean rating of 4.00 (SD = .78) out of 5 on the Likert scale. The suggestions (n = 69, 68%) from 109 participants were divided into 5 categories: workplace, access, quality, safety, and design. 15 teams were formed, 5 of which were accepted for incubation. All teams had a minimum viable product for one year. Hackathons are a reliable way to come up with effective solutions to targeted problems in various fields and using the Hackathon methodology can create a set of low-cost, innovative solutions.[5]

The literature provides recommendations for designing and setting up the "anatomy" of a successful hackathon, whether and how to implement an online, onsite or hybrid hackathon model, what are the advantages and fewer different hackathon formats. In the analysis (through questionnaires and observations, which are carried out before, during and after the hackathon), the focus is on the teams during the hackathon and tech artifacts. Additionally, for hackathon organizer seemed very important to set up the right tools such as Hackathon Platform (for instance https://devpost.com/), that enables organizer to:

- Publicize hackathon
- Define eligibility criteria and rules
- Register attendees
- Distribute critical competition updates
- Collect and record app submissions
- Mentor, Check and judge apps
- Award prizes
- Showcase projects

and Attendees also want a single destination for:

- Finding teammates
- Rules, deadlines, and competition information (data sets, developer tools, etc.) Managing submissions
- Proof of submission, so they can link to it permanently
- A forum to ask questions, get help, and engage with organizer
- The platform has to accommodate sponsors, mentors/judges, attendees, press, voters, and the public at large.

The after-effects are measured by interviews according to the principle of whether the students are satisfied with the participation, whether they have achieved the desired technical knowledge, whether was fun during the hackathon, how would they describe the experience at the hackathon and whether they would recommend the hackathon to longtime students. The given insights do not bring deeper recommendations for what to do after the hackathon and how to provide the conditions and incentives for the motivation of the organizers and participants to continue the projects after the hackathon.[1], [2], [5]–[7], [9], [10].

Motivation for the continuation of hackathons is boosted by fostering a competitive, yet cooperative, culture for talented individuals to showcase their knowledge. There are examples where hackathon organizers (academy and faculty) and partner companies create key benefits for students to motivate stakeholders and students' further engagement in hackathon projects. They provide an internship or employment also students can be recruited from hackathon events for specific research assistantships, create valuable mentorship connections with alumni, and chose to work on staff-suggested projects. This allows university units to leverage the hackathon as a source of creativity for those who need help specifically developing apps or web interfaces to augment their domain-specific research. It also allowed participants to connect with faculty, labs, centers on campus, and most importantly, with each other. [1], [4], [10], [11].

Additionally, organizers of academy and stakeholders sponsoring students to attend other hackathons, and funding-related events, and solicit greater partnerships with industry. These initiatives focus on fostering inclusive and higher levels of engagement.

In order to sustain the development of technical artefacts that were created in the hackathon, organizers have offered: Coaching and mentoring to the winning teams a showcase of technical artefacts developed during an event at a forum], post-hackathon prizes the release of the productive version of technical artefacts recruitment of new team members and grant writing However, little is known about the long-term impact that these post-hackathon activities had on outcome sustainability[2].

All teams put in a lot of effort, given the variety of projects and the limited time, not only for the winning team but for all teams, there should be a process of connection and support. Although, according to [4] it is recommended that stakeholders stay in touch with projects, there is no clear process and description, and everything is left to stakeholders to do voluntarily. This further suggests that organizers and stakeholders should provide the environment and conditions for projects to continue after the hackathon ends and that teams or projects should reach the right organizations and the right people. That is, along with networking, organizers and stakeholders should provide support for incubation and organizational changes in public and private organizations to use the solutions from the hackathon.

The most far-reaching tangible impacts of hackathons occur through follow-ups, and activities carried on by an individual or a team after the event. Follow-ups may include developing a communication (blog, poster, meeting presentation), convening the team for further work, or seeking funding[12].

There is a noticeable tendency and need for hackathons to be scaled in terms of the time dimension. That is the transition from a duration of two or three days to a longer one, all with the aim of maximizing outcomes and results, longer engagement of participants in solving more complex projects and creating the potential for the continuation of the project after the hackathon [13]. Existing research points towards a disparity between the intention to continue projects after a hackathon and their actual continuation[6]. Continuation intentions might be directed at different follow-up activities, includes technical continuation activities as well as activities related to expanding the reach of a project by attracting funding[5].

This paper gives a literature overview of the open innovation concept and the role of hackathon in its implementation. The question that will be further pursued through future research will focus on the continuation of the hackathon projects and its utilization in corporate setting. The data analysis showed us a rising interest in hackathon participation by students and companies' involvement in organization of the hackathon. This lays the foundation for future research that will have a twofold focus: on participants: reasons for participation, expectations, hackathon impact on further development, future/current employment, etc. on companies: reasons for involvement, continuation of the hackathon projects, impact of generated ideas, etc.[14].

B. The power of hackathons as a specific manner to run innovation.

Hackathons are successfully used as a new form of organizing product innovation in response to new business needs and technical changes due to their ability to create prototypes and evaluate their feasibility in a relatively short period of time. However, designing a hackathon involves careful planning ahead and considering the goals that the organizers and participants have set for the event and for themselves.

Based on the studies on hackathons and the review of the presented literature, the different goals that organizers and participants can achieve with hackathons, showed how such events can be designed to achieve specific goals and identified potential design compromises. According to the results, in addition to product innovation, hackathons can be used with great success as a tool for enriched networks within the company and preparation of employees for future changes and positions[10].

Overall, it could be summarized that hackathons bring a lot of benefits for all participants. For participants and team members it refers to team engagement and teamwork, working together on a project, playing specific roles in a team and a creative way of approaching problem-solving, learning technology together, but also business and management skills, (soft skills), developing a common understanding of software development, quickly visible results, getting feedback, acquisition of new competencies, acquisition of relationships with real problems and tasks from practice, noticing the potential for further personal and project development. On the other hand, organizers and sponsors realize benefits such as recognition and visibility, a source of innovation, community building and engagement, corporate branding, recruitment, IP development [3][15].

However, the following disadvantages are also identified from participants point of view, such us short project time, focus on the development of software and tangible artefacts, such as programs and code, high intensity of events and uneven workload and exhaustion, limitation of use of tools and technologies, variable motivation, unequal level of training of team members, lack of output usefulness and the unpredictability of further development of created solutions. Additionally, from organizers and sponsors it could be in mainly from costs side, output usefulness as potential of hackathon to generate an innovation [3][16].

III. MODELLING PERFORMANCE INDICATORS FOR HACKATHON-BASED INNOVATION CAPACITY

The main research questions in this research are:

1. What hackathon results could be measured and set as an innovation performance indicator of an academic institution?
2. How to identify and measure the indicator of innovative performance of an academic institution?
3. How to set foundation for modeling performance indicators for hackathon-based innovation capacity?

Innovative performance of an academic institution can be measured through various indicators such as[17]–[19]:

1. Research output: The number and quality of research publications, patents, and other intellectual property generated by faculty members.
2. Teaching effectiveness: The development and implementation of innovative teaching methods, curriculum, and technology-enhanced learning tools that improve student learning outcomes.
3. Industry collaborations: The extent of partnerships and collaborations with industry, government, and community stakeholders to solve real-world problems and transfer knowledge to society.
4. Entrepreneurial activities: The extent of faculty engagement in entrepreneurship activities, such as founding startups, licensing technology, or consulting, that have the potential to generate economic and social impact.
5. Reputation and recognition: The extent of national and international recognition and awards received by the faculty for its innovative activities, research, and teaching.

In addition, the innovative performance of teaching staff refers to their ability to develop and implement new teaching methods, tools, and approaches that improve student learning outcomes, engagement, and retention. It can be measured through various indicators, such as[13][17], [20]–[22]:

1. Teaching effectiveness: The extent to which teaching staff can engage students in active learning, promote critical thinking, and use feedback to improve their teaching practice.
2. Curriculum development: The development and implementation of innovative curricula, such as project-based

learning, service learning, and interdisciplinary courses that integrate different fields of study and prepare students for real-world challenges.

3. Technology-enhanced learning: The use of technology to enhance the teaching and learning experience, such as the use of learning management systems, flipped classroom approaches, and gamification.
4. Educational research: The extent to which teaching staff engage in educational research, such as assessing the effectiveness of their teaching methods, evaluating student learning outcomes, and exploring new pedagogical approaches.
5. Professional development: The extent to which teaching staff engage in ongoing professional development activities, such as attending conferences, workshops, and training sessions, to stay up to date with the latest teaching practices and technologies.

According to the literature review [2], [3], [7], [9], [10], [13], [17], [20]–[22] some specific performances derives from hackathons result are captured to analyze. Possible factors that impact to innovative performance of an academic institution were identified in Category Faculty/ Hackathon Organizer:

1. Explore new pedagogical approach & Experimental learning.
2. Motivation & Satisfaction to adopt hackathon as mechanism for pedagogical approach to drive innovation at Faculty.
3. Perceived innovation capacity.

and Category Hackathon Participants/Team such as:

1. Motivation to join hackathon and Motivation to repeat (keep) participation.
2. Hackathon as opportunity (Route to start Idea business development, Self-Employability, Employability, Assistantships, fellowships)
3. Post work: Satisfaction with post hackathon events.

Overall, innovative performance at the faculty level is essential to maintain the competitiveness and relevance of academic institutions in today's fast-changing world. It requires a supportive environment that fosters creativity, risk-taking, and collaboration, as well as adequate resources and incentives to reward innovative efforts.

IV. ANALYSIS OF PRELIMINARY RESEARCH RESULTS

The data used in this work was collected during the W3 Algorand Hackathon 2023 – W3AH'23, implemented at Faculty of organizational science in April 2023. Participation in hackathons was voluntary and everyone can propose innovative Web3 projects based on blockchain technologies and the development of smart contracts on the Algorand platform. Projects proposed new e-business ecosystems and models (for health, education, industry, banking, commerce, smart cities, etc.). W3 Algorand Hackathon 2023 – W3AH'23 was organized by Blockchain Laboratory & Student Blockchain Club, Faculty of Organizational Sciences, University of Belgrade and Blockchain Lab at UF, University of Florida, and sponsored by Algorand Foundation.

In that first stage, 33 students from Serbia provided data in the proposed survey. Results show that among 33 students, 40% are in undergraduate studies, 28% are in postgraduate studies - currently on master, 22% are graduate students, 10% are in high school. Referring to the hackathon topic, among these 33 students, 27 students provided Blockchain solutions, and 6 students were engaged in the NFT hackathon projects.

Further, 82% of participants didn't have any previous experience in the hackathon competition and 12% did.

Figure 1. shows how students rate the importance of hackathons at the faculty level. On the Likert scale (from 1 to 5, where 1 stands for unimportant and 5 stands for essential), students rate hackathons with avg rate 4.36.

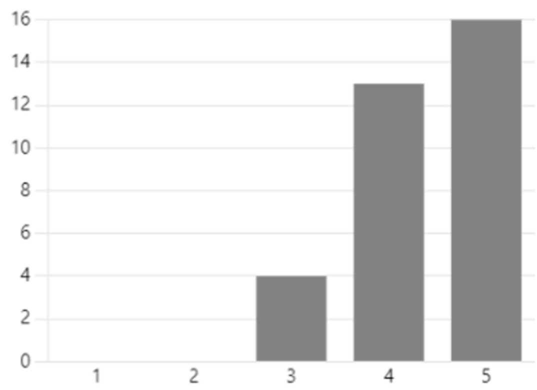

Figure1. Distribution of hackathon importance for students at the faculty level

Figure 2. shows how students rate the importance of hackathon as an opportunity to get an internship/apprenticeship? On the Likert scale they could rate from 1 as very unimportant to 5 as very important. Results show that the Average Rating is 4.26.

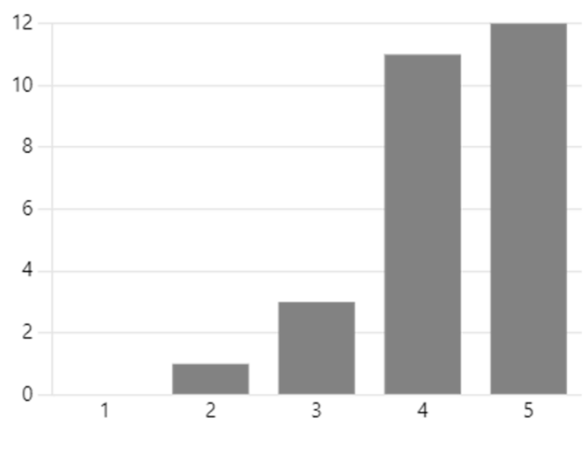

Figure 2. Distribution of importance of hackathon as opportunity for internships or apprenticeships.

Figure 3. shows how students rate importance that hackathon organizer should provide post hackathon event (Post hackathon events engagement in the community. It could be perceived as additional mentorship, sponsoring students to attend other hackathons, funding related invents, soliciting partnership with industry.) (1 Very unimportant, 5 Very important). Results show that the Average Rating is 4.2 and 67% of students rated it as "High" importance.

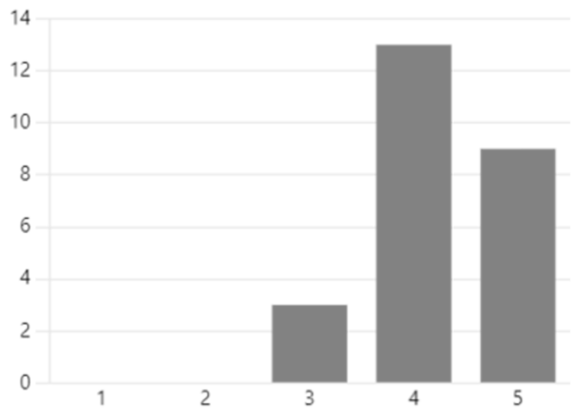

Figure 3. Distribution of how important is that organizer provide post hackathon event.

V. CONCLUSIONS

This paper aimed to foster an understanding of how useful joint scientific efforts would be to improve the performance of value creation and value capture for innovation in hackathons. It analyzes who organizes hackathons, who participates in them, for what purpose and in what context, and how to motivate a continuation of hackathon projects and implicate boosting internal innovative academic performance. The obtained results have yet to be confirmed by quantitative studies using a larger and more diverse data set. This is just an initial step, and the findings form the basis for future research on this topic and demonstrate the utility of the concepts for understanding the phenomenon of discovering and measuring the innovative academy indicators of hackathon-based innovation capacity.

This paper tries to present how the innovative potential can be improved by the results of the hackathon and set the first steps into modelling performance indicators for hackathon-based innovation capacity.

It is a challenging area and will be continued and used as a basis for further research.

REFERENCES

[1] Z. Seidametova, Z. Abduramanov, and G. Seydametov, “Hackathons in computer science education: monitoring and evaluation of programming projects,” Educ. Technol. Q., vol. 2022, no. 1, pp. 20–34, Feb. 2022, doi: 10.55056/etq.5.

[2] A. Nolte et al., “You Hacked and Now What? Exploring Outcomes of a Corporate Hackathon.”

[3] E. P. P. Pe-Than, A. Nolte, A. Filippova, C. Bird, S. Scallen, and J. Herbsleb, “Corporate hackathons, how and why? A multiple case study of motivation, projects proposal and selection, goal setting, coordination, and outcomes,” Human-Computer Interact., vol. 37, no. 4, pp. 281–313, 2022, doi: 10.1080/07370024.2020.1760869.

[4] M. A. Medina Angarita and A. Nolte, “What do we know about hackathon outcomes and how to support them? – a systematic literature review,” Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 12324 LNCS, no. August, pp. 50–64, 2020, doi: 10.1007/978-3-030-58157-2_4.

[5] S. Temiz, “Open innovation via crowdsourcing: A digital only hackathon case study from Sweden,” J. Open Innov. Technol. Mark. Complex., vol. 7, no. 1, pp. 1–14, Jan. 2021, doi: 10.3390/joitmc7010039.

[6] A. Nandi and M. Mandernach, “Hackathons as an informal learning platform,” SIGCSE 2016 - Proc. 47th ACM Tech. Symp. Comput. Sci. Educ., pp. 346–351, 2016, doi: 10.1145/2839509.2844590.

[7] G. Briscoe and C. Mulligan, “Digital Innovation: The Hackathon Phenomenon”.

[8] D. Cobham, C. Gowen, K. Jacques, J. Laurel, and S. Ringham, “From appfest to entrepreneurs: academic member of staff: undergraduate student”.

[9] A. Nolte, I. A. Chounta, and J. D. Herbsleb, “What Happens to All These Hackathon Projects?-Identifying Factors to Promote Hackathon Project Continuation,” Proc. ACM Human-Computer Interact., vol. 4, no. CSCW2, Oct. 2020, doi: 10.1145/3415216.

[10] E. P. P. Pe-Than, A. Nolte, A. Filippova, C. Bird, S. Scallen, and J. Herbsleb, “Designing Corporate Hackathons With a Purpose,” IEEE Softw., no. January, pp. 15–22, 2019.

[11] E. P. P. Pe-Than, A. Nolte, A. Filippova, C. Bird, S. Scallen, and J. Herbsleb, “Corporate hackathons, how and why? A multiple case study of motivation, projects proposal and selection, goal setting, coordination, and outcomes,” Human-Computer Interact., vol. 37, no. 4, pp. 281–313, 2022, doi: 10.1080/07370024.2020.1760869.

[12] A. Stoltzfus et al., “Community and Code: Nine Lessons from Nine NESCent Hackathons,” F1000Research, vol. 6, no. September, p. 786, 2017, doi: 10.12688/f1000research.11429.1.

[13] “Sci-Hub | Factors influencing innovation performance in higher education institutions. The Learning Organization, 27(4), 365–378 | 10.1108/tlo-12-2018-0205.” https://sci-hub.se/10.1108/tlo-12-2018-0205 (accessed Mar. 11, 2023).

[14] Ž. Sari, V. Obradovi, Z. Bogdanovi, A. Labus, and S. Mitrovi, “Crowd-Based Open Innovation in Telco Operators: Readiness Assessment for Smart City Service Development,” Serbian J. Manag., vol. 17, no. 1, pp. 179–196, 2022, doi: 10.5937/sjm17-36913.

[15] M. Calco and A. Veeck, “The Markathon: Adapting the Hackathon Model for an Introductory Marketing Class Project,” Mark. Educ. Rev., vol. 25, no. 1, pp. 33–38, Jan. 2015, doi: 10.1080/10528008.2015.999600.

[16] I. Attalah, P. A. Nylund, and | Alexander Brem, “Who captures value from hackathons? Innovation contests with collective intelligence tools bridging creativity and coupled open innovation,” 2023, doi: 10.1111/caim.12552.

[17] W. A. Butt, A. Shariff, S. Khan, and A. I. Mian, “Global Surgery Hackathons: A Case Study From Pakistan,” Surg. Innov., vol. 28, no. 4, pp. 496–501, Aug. 2021, doi: 10.1177/15533506211018619.

[18] J. Falk et al., "The Future of Hackathon Research and Practice," Nov. 2022.

[19] M. Proročić, "Open innovations and the role of hackathons."

[20] M. UFFREDUZZI, "Hackathon as emerging innovation practice: exploring opportunities and challenges through 8 in-depth-case studies," 2017.

[21] M. A. Asiedu, H. Anyigba, K. S. Ofori, G. O. A. Ampong, and J. A. Addae, "Factors influencing innovation performance in higher education institutions," Learn. Organ., vol. 27, no. 4, pp. 365–378, 2020, doi: 10.1108/TLO-12-2018-0205.

[22] Z. Covic and H. Manojlovic, "Developing key competencies through hackathon based learning," SISY 2019 - IEEE 17th Int. Symp. Intell. Syst. Informatics, Proc., pp. 167–172, Sep. 2019, doi: 10.1109/SISY47553.2019.9111513.

Revolutionizing the Real Estate Ecosystem with Blockchain: Opportunities, Challenges, and Future Prospects

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Abstract—Blockchain technology is revolutionizing the real estate sector by offering a decentralized and transparent method for tracking and transferring asset ownership. This study examines the potential of blockchain in transforming real estate transactions, addressing drawbacks of the conventional market such as lack of transparency, middlemen involvement, and lengthy timeframes. The paper explores the use of blockchain in real estate, including legal and regulatory considerations, advantages, and disadvantages. It concludes that blockchain has the power to improve real estate administration, simplify fractional ownership, and create new investment opportunities, ultimately benefiting stakeholders and increasing productivity.

Keywords - real estate, blockchain

I. INTRODUCTION

An important economic sector that has always made a substantial contribution to Gross domestic product (GDP) growth is the real estate market. However, because of technological improvements, the real estate sector has undergone a substantial shift. Blockchain is one of the technologies most likely to upend the real estate industry [1]. Recently, there has been a lot of interest in the use of Blockchain technology because of its potential to streamline and enhance several real estate industry sectors. Blockchain, a distributed ledger technology, eliminates the need for middlemen and enables safe and open transactions. Numerous opportunities for increased real estate transaction efficiency, transparency, and cost savings are presented [2].

Blockchain plays an important role in the real estate sector [3]. This research study aims to investigate the potential benefits, drawbacks, and results of adopting blockchain to change the real estate sector. The study will also discuss how Blockchain will impact various players in the real estate industry, including buyers, sellers, investors, and brokers. The discussion of the challenges and limitations involved with implementing blockchain technology in the real estate sector will cover regulatory and legal frameworks, data privacy problems, and security issues. The study will also take into account how future developments in blockchain technology, such as the development of smart contracts, the tokenization of real estate assets, and the emergence of decentralised real estate platforms, may alter the real estate industry. The current state and challenges of the real estate market will be briefly covered in the paper, followed by a full analysis of Blockchain technology and its potential applications in the industry [5]. The main goal of this research paper is to teach readers how Blockchain technology can change the real estate industry and how different stakeholders might be impacted. One intriguing aspect of blockchain technology that holds great promise for revolutionizing the real estate ecosystem is non-fungible tokens (NFTs). NFTs have gained considerable attention and popularity in recent years, primarily in the realm of digital art and collectables. However, their application in real estate has the potential to disrupt traditional practices, offering new opportunities for investors, developers, and homeowners. The results of this study will be helpful to academics, legislators, and real estate experts who are attempting to comprehend the advantages and disadvantages of incorporating Blockchain technology in the real estate market.

II. LITERATURE REVIEW

Long recognised for its lack of transparency, high expenses, and cumbersome paperwork, the real estate sector researchers have shown the real impact of blockchain in real estate [4]. As a result of blockchain technology, which offers a decentralised, secure, and transparent platform for transactions, the real estate sector may go through a significant transformation. The potential of blockchain technology in the real estate sector has been examined in several studies. Numerous advantages of blockchain technology have been cited in these studies, including improved efficiency, decreased fraud, increased transparency, and the emergence of new business models [5]. However, the existing research also highlights several challenges and limits with blockchain technology, such as privacy issues, technical restrictions, and regulatory barriers [8]. For instance, the lack of defined regulatory norms and legal frameworks may make it difficult to deploy blockchain technology in the real estate industry. Technical problems like scalability and interoperability may also limit the potential of blockchain technology in the real estate industry.

III. BLOCKCHAIN TECHNOLOGY AND REAL ESTATE

The real estate sector is ripe for disruption, and blockchain technology presents many possibilities for change [1]. By offering a safer, more open, and more effective way to transact in real estate, blockchain technology has the potential to completely transform the sector. The real estate ecosystem could undergo a revolution thanks to blockchain technology in several ways, including:

Property ownership:

Blockchain technology can be used to create a tamper-proof digital ledger that records property ownership, making it easier to track and transfer ownership [7]. This could eliminate the need for intermediaries such as real estate agents and lawyers, making the process more efficient and cost-effective.

Tokenization:

Real estate assets can be tokenized using blockchain technology, allowing for fractional ownership of properties. As a result, more people will be able to invest in and finance real estate, increasing its accessibility and affordability.

Fractional ownership:

Blockchain technology can enable fractional ownership of real estate, allowing investors to own a fraction of a property rather than the entire property [4]. This could open new investment opportunities for smaller investors and make real estate investment more accessible.

Smart Contracts:

Smart contracts automate the transfer of assets and the payment of payments using self-executing contracts. Smart contracts can simplify the purchasing and selling process in the real estate sector, do away with the need for middlemen, and lower transaction costs.

Property management:

Blockchain technology can be used to create a decentralized property management system, enabling property owners to manage their properties more efficiently and securely.

Enhanced Transparency:

Enhanced transparency is provided by blockchain technology, which enables the tracking of transactions and ownership data in real time. This lowers the possibility of fraud and boosts confidence in the real estate industry.

Title deeds:

Physical documents that can be misplaced or falsified can be replaced with safe, tamper-proof digital title deeds thanks to blockchain technology.

Improved Security:

Blockchain technology provides greater security, making it more challenging for hackers to access the system and steal confidential data.

A.Blockchain Technology

Blockchain technology is a distributed ledger system that allows for secure, transparent, and immutable transactions [10]. The technology relies on a network of computers to validate and record transactions in a decentralized manner, eliminating the need for intermediaries such as banks or brokers. The technology offers numerous benefits, including improved security, increased efficiency, and enhanced transparency.

B. Opportunities

There are many advantages to using blockchain technology in the real estate sector. The main benefit is improved effectiveness. Many property transaction processes can be automated using blockchain, cutting down on the time and expense required in these transactions [2]. By eliminating the need for middlemen, smart contracts can further simplify the procedure. Increased transparency is another benefit of blockchain technology. The use of this technology makes it simpler to trace the ownership of properties and lowers the danger of fraud by creating an immutable record of all transactions [5]. Additionally, by fostering greater confidence among participants, this transparency can facilitate industry commercial transactions. Numerous prospects exist for the real estate ecosystem to be revolutionised by blockchain technology. Here are a few of them:

Reduced Transaction Costs:

Blockchain technology can help reduce the transaction costs associated with real estate transactions. In a traditional real estate transaction, intermediaries such as real estate agents, lawyers, and banks are involved, which increases the transaction costs [5]. However, with blockchain technology, the need for intermediaries can be eliminated as the technology can facilitate direct transactions between buyers and sellers. This can help reduce the costs associated with intermediaries and reduce the time taken to complete a transaction.

Increased Transparency:

One of the main benefits of blockchain technology is its ability to provide a transparent system. In the real estate industry, transparency is crucial as it can help reduce fraudulent activities and increase trust between parties. Blockchain technology can help provide a transparent system by allowing all parties involved in a transaction to view and verify the information stored on the blockchain [5].

Efficiency:

Many of the laborious procedures involved in real estate transactions can be automated thanks to blockchain technology, which boosts productivity and lowers costs. Smart contracts, for instance, can automate the process of confirming and transferring property ownership, doing away with the need for middlemen.

Security:

Blockchain technology provides a secure platform for real estate transactions. It uses cryptographic algorithms to ensure that all transactions are tamper-proof, making it difficult for fraudsters to manipulate the system.

Fractional Ownership:

Blockchain technology enables fractional ownership of real estate assets. It allows investors to buy and sell fractional ownership shares, making it easier for small investors to invest in real estate.

C. Challenges

Despite the numerous opportunities offered by blockchain technology, the technology is not without its challenges. The current real estate practices face various challenges related to inefficiency, lack of transparency, and fraud. These challenges are mainly due to the involvement of multiple stakeholders, complex processes, and the lack of a standardized system for data management and transactions [3]. One of the main challenges in the real estate industry is the lack of transparency, which makes it difficult for buyers and sellers to verify the authenticity and accuracy of the property data [4]. This often leads to disputes and delays in the transaction process. Another challenge is the high transaction costs and the involvement of intermediaries, such as lawyers and notaries, which increases the overall cost of the transaction [5]. Some of the challenges that need to be addressed include:

Lack of Standards:

The lack of standards for blockchain technology in real estate makes it difficult for stakeholders to adopt and implement the technology [5]. There is a need for a standardized framework to ensure interoperability and compatibility across different blockchain platforms.

Regulatory Framework:

The lack of a clear regulatory framework is one of the biggest challenges facing the adoption of blockchain technology in the real estate industry [5]. Regulations need to be developed to address issues such as tokenization, smart contracts, and ownership records.

Integration:

Blockchain technology needs to be integrated with existing real estate systems and platforms, which can be a complex and time-consuming process [5].

Adoption:

Blockchain usage in the real estate industry is still in its infancy. Stakeholders need to be made aware of and educated about the advantages and potential of blockchain technology.

Technical Expertise:

The adoption of blockchain technology requires technical expertise, which may be a challenge for some real estate professionals.

Data Privacy:

Blockchain usage in the real estate industry is still in its infancy. Stakeholders need to be made aware of and educated about the advantages and potential of blockchain technology [5].

Standardization:

The lack of standardization in the blockchain industry can make it difficult for real estate professionals to choose the right platform or technology.

D. The Potential of Blockchain Technology

Blockchain technology can completely transform the real estate industry by strengthening security, speeding up transactions, and cutting costs. Blockchain technology has the potential to completely transform the real estate sector by offering a safe, open, and effective platform for transactions and data management, despite its difficulties and limitations. More effort needs to be done in the areas of standardisation, research, and practical application if blockchain technology is to fully realise its [5]. The adoption of blockchain technology in the real estate sector depends on standardisation [6]. Standards for data management and transactions must be created to guarantee the interoperability and compatibility of various blockchain platforms. Additionally, this would improve transparency and lower the possibility of fraud. Additionally, research is required to determine blockchain technology's potential for use in the real estate sector as well as to overcome its difficulties and constraints [8]. More empirical research is required to better understand how blockchain technology will affect the real estate sector, including how it will affect costs, efficiency, and transparency of transactions. The adoption of blockchain technology in the real estate sector depends on its practical use. To show the viability and scalability of blockchain technology in the real estate sector, real-world projects and experiments are required [7]. Additionally, this would make it easier to pinpoint the obstacles and constraints on a technological, legal, and regulatory level that need to be overcome [8]. Blockchain technology has the following potential applications in real estate:

Increased Efficiency:

Blockchain technology has the potential to increase the efficiency of the real estate industry significantly. With the automation of processes, the time taken to complete a transaction can be significantly reduced. This can help increase the number of transactions and improve the overall efficiency of the industry [8].

Increased Transparency and Security:

Blockchain technology can help increase the transparency and security of the real estate industry. With a transparent system, fraudulent activities can be reduced, and trust between parties can be increased. This can help improve the overall reputation of the industry. This can help prevent fraud, reduce the risk of hacking, and increase transparency [9].

Faster Transactions:

By doing away with middlemen like banks and brokers, blockchain can hasten real estate deals. By doing this, transaction times may be shortened from months to days or even hours.

Increased Liquidity:

Blockchain can enable fractional ownership of real estate through tokenization. This would allow individuals to invest in real estate assets without having to buy entire properties, which can help increase accessibility and liquidity in the real estate market. Tokenization of real estate assets can help increase liquidity in the real estate market [8]. With the ability to buy and sell real estate assets as tokens, more people can invest in real estate assets. This can help increase the number of buyers and sellers in the market, leading to increased liquidity.

Smart Contracts:

Smart contracts are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code. Smart contracts can help automate the real estate transaction process and eliminate the need for intermediaries. This can help reduce the time and costs associated with real estate transactions.

Global Transactions:

Without the use of middlemen or currency conversions, blockchain can allow real estate transactions to take place across international borders without any issues. This may facilitate the expansion of the real estate sector to a global clientele [9].

IV. CONCLUSION

In conclusion, blockchain technology has the potential to transform the real estate ecosystem. Blockchain technology has the evident potential to completely transform the real estate market. The full real estate transaction process might be streamlined using blockchain-based systems. They can facilitate the matching of buyers and sellers and offer a safe, transparent platform so that everyone can keep track of the status of a transaction [9]. Additionally, fractional ownership may be made possible through blockchain, making real estate assets more accessible to a larger spectrum of investors. The utilization of NFTs in the real estate ecosystem holds immense potential to revolutionize the industry. From fractional ownership and enhanced liquidity to global market access and fractional rental income, NFTs can unlock new opportunities for investors and homeowners alike. While there are challenges to overcome, such as regulatory hurdles and security concerns, the future prospects are promising. As blockchain technology and NFT adoption continue to evolve, the real estate industry can embrace this transformative technology to create a more efficient, accessible, and inclusive ecosystem. The peculiarity of blockchain is that it's frequently challenging to predict where the technology will lead. The majority of people are aware of how blockchain technology has the power to revolutionise the banking industry, but they frequently ignore how it could affect real estate. Nevertheless, there are a variety of ways that blockchain could alter real estate deals in the future, for better or worse. Smart contracts built on the blockchain can also execute real estate contracts automatically, eliminating the need for middlemen and reducing the likelihood of fraud and errors. The adoption of blockchain in real estate, however, faces significant challenges [10]. A big barrier is the dearth of knowledge and instruction regarding blockchain technology among real estate professionals. Additionally, the integration of blockchain with existing systems can be difficult and expensive. Finally, blockchain in real estate appears to have bright prospects. Numerous blockchain-based real estate initiatives are already underway globally, and the real estate blockchain business is expected to expand dramatically in the years to come. The real estate sector will continue to benefit from new prospects presented by blockchain technology as it develops [10].

Real Estate is developing day by day with the help of blockchain technology. Blockchain technology has potential benefits for the real estate industry. Although there is potential for blockchain technology in the real estate market, more work needs to be done before it can be fully utilised. Blockchain technology has the potential to transform the real estate market, making it more efficient, transparent, and accessible to a wider audience—despite the numerous challenges that stand in the way of its deployment. Despite these challenges, blockchain technology has a promising future in the real estate industry and has the potential to significantly boost the sector's productivity, openness, and liquidity.

REFERENCES

[1] Robleza, H. (2021) How blockchain technology is revolutionizing the property market, RealtyBizNews. Available at: https://realtybiznews.com/how-blockchain-technology-is-revolutionizing-the-property-market/98761882/

[2] Arruñada, B. (2020) “Prospects of blockchain in contract and Property,” Disruptive Technology, Legal Innovation, and the Future of Real Estate, pp. 35–55. Available at: https://doi.

org/10.1007/978-3-030-52387-9_3.

[3] Garcia-Teruel, R.M. (2020) "Legal challenges and opportunities of blockchain technology in the real estate sector," Journal of Property, Planning and Environmental Law, 12(2), pp. 129–145. Available at: https://doi.org/10.1108/jppel-07-2019-0039.

[4] Liebkind, J. (2022) How blockchain technology is Changing Real Estate, Investopedia. Investopedia. Available at: https://www.investopedia.com/news/how-blockchain-technology-changing-real-estate/

[5] Bhat, B.A. and Gupta, N. (2022) "Integration of blockchain tokenisation in real estate," Applications, Challenges, and Opportunities of Blockchain Technology in Banking and Insurance, pp. 213–230. Available at: https://doi.org/10.4018/978-1-6684-4133-6.ch013.

[6] Malonson, J. (2022) Blockchain technology is revolutionizing the real estate industry, Entrepreneur. Entrepreneur. Available at: https://www.entrepreneur.com/money-finance/blockchain-technology-is-revolutionizing-the-real-estate/424715

[7] Latifi, S., Zhang, Y. and Cheng, L.-C. (2019) "Blockchain-based real estate market: One method for applying blockchain technology in commercial real estate market," 2019 IEEE International Conference on Blockchain (Blockchain) [Preprint]. Available at: https://doi.org/10.1109/blockchain.2019.00002.

[8] Makridakis, S. and Christodoulou, K. (2019) "Blockchain: Current challenges and prospects/applications," Future Internet, 11(12), p. 258. Available at: https://doi.org/10.3390/fi11120258.

[9] Redolfi, A. (2022) Council post: The future of real estate transactions on the blockchain, Forbes. Forbes Magazine. Available at: https://www.forbes.com/sites/forbesbizcouncil/2021/10/27/the-future-of-real-estate-transactions-on-the-blockchain/

[10] O'Brien, R.T., Henry, W. and Massey, R. (2023) Blockchain in commercial real estate, Deloitte United States. Available at: https://www2.deloitte.com/us/en/pages/financial-services/articles/blockchain-in-commercial-real-estate.html

Applying Multi-Criteria Decision Making to Prioritization of Web 3.0 Development Factors

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Abstract—— In more recent times, blockchain and Web 3.0 have taken the world by storm. Conversations have been sparked with regards to its use cases as such web developers are beginning to integrate these solutions into web-based systems. Most important of all, it is easy to consider blockchain as a distributed world computer that will change the way we look at the internet. In this paper, we present analytic hierarchy process (AHP) as a tool for ranking Web 3.0 factors and which of those are pertinent for consideration by developers and specialists in the area. We apply the multi-criteria decision making to prioritization of Web 3.0 development factors. Policy recommendations are indicated in the study.

Keywords - blockchain, Web 3.0, AHP, multi-criteria decision making, web development, software engineering

I. INTRODUCTION

A paradigm shift towards decentralization within numerous sectors of the innovative industry and society has taken the world by storm. Proponents of this concept believe that Web 3.0 has the potential to transform the internet, the experience of individuals, provide security in the FinTech world, as well as handing back ownership of data to those who create it [1], [2]. In spite of the growing conversations, and quest to understand this paradigm (as seen in Figure 1, highlighting the Google search trends for the keyword "Web 3.0" over time), some scholars believe the theme is yet to take off [3].

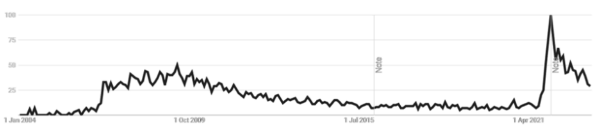

Fig. 1. Google Search Trends (Web 3.0) – 2004 - 2023

As per the Gartner Hype Cycle, which is a visual representation of the disillusionment with respect to emerging technologies and to describe the life cycle of such technologies [4], [5], a comparative overview of 2021 and 2022 (figures 2 and 3 respectively) reveals the presence of concepts related to the Web 3.0 world which were classified under the Peak of Inflated Expectations. It can be observed that the hype around Web 3.0 peaked during 2022 and this phenomena according to researchers has been linked to the decentralized nature of the innovative technology [6].

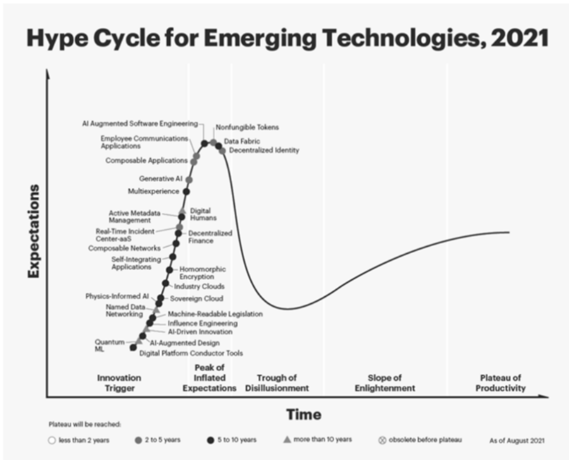

Fig. 2. Gartner Hype Cycle for Emerging Technologies 2021 – (Source: Gartner Inc.[1])

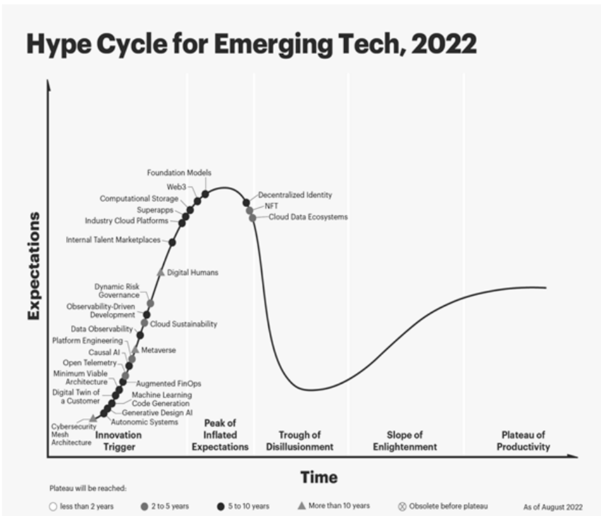

Fig. 3. Gartner Hype Cycle for Emerging Technologies 2022 – (Source: Gartner Inc. [2])

The rise of Web 3.0, with blockchain technology as its backbone has created avenues for developing areas such

[1] Gartner Inc. (n.d.), 3 Themes Surface in the 2021 Hype Cycle for Emerging Technologies, https://www.gartner.com/smarterwithgartner/3-themes-surface-in-the-2021-hype-cycle-for-emerging-technologies

[2] Gartner Inc. (n.d.), What's New in the 2022 Gartner Hype Cycle for Emerging Technologies, https://www.gartner.com/en/articles/what-s-new-in-the-2022-gartner-hype-cycle-for-emerging-technologies

as the Metaverse, decentralized applications (dApps), decentralized exchange (DEX), decentralized autonomous organizations (DAO) or decentralized autonomous corporations (DAC) built on blockchain architectures such as Ethereum, WAX, Hive, BNB Chain, Polygon, EOS, Solana, Thundercore, Arbitrum, Flow, Ronin, Cardano, Tezos, and many others. Tools (high level languages) such as Vyper, Solidity are used by developers for writing smart-contracts and these are interfaced with popular programming languages like JavaScript, Python, and PHP to create these decentralized applications [7], [8]. Developers applications based on Web 3.0 strive to develop trustless solutions that improve and optimize business processes [9], [10]. The process of developing such applications come with challenges such as choosing the right architecture, as well as the ease in combining separate services to create a seamless user experience. Thus, prioritization of all the relevant driving factors is an essential component in any project management workflow or business process. In light of the rate of development, the gradual integration of Web 3.0 and the need for prioritizing the development process, this research asks the question: What are the key factors to be considered by developers when building a Web 3.0 applications and of what order of importance are they to developers?

II. BLOCKCHAIN AND WEB 3.0

Many hope it will arrive as an announced messiah that will save us from cookies, trackers, advertising, and data theft by large centralized companies. However, Web 3.0 is still in its infancy, and it's hard to know if whatever has been said and promised will become true. Web 3.0 is developing exponentially, which additionally provides to the cybersecurity issues it imposes. There is a non-stop shift withinside the Internet architecture, from a read/write version to a more modern version called Web 3.0. Global organizations are exploring Web 3.0 possibilities of their enterprise processes [11]. New internet technology are required for assembly the growing human wishes. Web is used now no longer simplest for human wishes, however additionally for communique among humans or machines. The essential homes of current internet technology are integrated, person orientated and offering wealthy content. However, swiftly changing human wishes and technology are because of faster, greater interactive and smart internet technology [12].

There currently exist numerous usability techniques that has been used successfully over the years to determine how Web 3.0 Popular usability attributes include satisfaction, efficiency, and effectiveness amongst others. It is realized some of these attributes are quantitative while others are subjective (qualitative) in nature such as satisfaction and attractiveness attributes. A study claimed that most times quantitative attributes are usually based on user performance while subjective attributes are based on the way users view the app [13]. Usability researchers have always had difficulty when making decisions on which technique to apply during usability evaluation purposes out of the numerous techniques that exist. It is realized that most of these techniques consume resources in terms of time and money. The problem is on how to evaluate numerous usability attributes at once, saving resources and also getting better results.

This work tends to approach usability evaluation from a wider perspective, taking numerous attributes into consideration as well as the quantitative and qualitative aspects simultaneously using Multi Criteria Decision Making techniques. The usability evaluation issue had been identified to be a Multi-Criteria Decision Making (MCDM) problem, which is a subset of the general Operational Research (OR) models that are used for solving problems involving high uncertainty and different ideas, data and information [14].

In this paper the Consensus Mechanism, Carbon Neutrality, Market Capitalization (in USD), Ubiquity of the Metaverse, Blockchain Network Latency, Programming Language Ease, Access to Developer Community, Comprehensible Documentation, Cross-Blockchain Interoperability, Vision and Goals of Blockchain of Choice are the different types of factors of Blockchain where these has got prioritized. The MCDM problem aimed at choosing or deciding on suitable measurable usability constructs from various substitutes and criteria. The focus of this study is to rank all the criteria and criteria identified in the usability hierarchical model by using the Analytic Hierarchy Process (AHP), a decision-making technique which allows important ranking and prioritization to be done based on sets of multi-level criteria [15]. It is worth noting that the use of blockchain technology in conjunction with the AHP is still in the early stages of development and is not yet widely adopted. Further research and development will be necessary to fully realize the potential benefits of this combination.

III. METHOD

Analytic Hierarchical Process (AHP) is a relevant mathematical technique that is used to solve MCDM problems, where a choice has to be made from a number of alternatives based on their relative importance [15]. It was developed by Saaty in the 1970's from mathematical and psychological principles. It relies on the judgments of experts to derive priority scales through pairwise comparison of decision elements at each level as shown

This study utilized a multi-criteria decision-making (MCDM) method, specifically the Analytic Hierarchy Process (AHP), to prioritize and rank Web 3.0 development factors. The study population consisted of experts in Web 3.0 development or related fields, who were knowledgeable about the various factors that impact the development of Web 3.0 applications.

Data for this study was collected using a survey questionnaire, which contained a list of Web 3.0 development factors that respondents were asked to compare and prioritize the various factors in the questionnaire. The study data was obtain from 11 respondents. Respondents were university students that were into blockchain development. As per the AHP method, pairwise comparison matrices were used to assess the relative importance of Web 3.0 development factors. Pairwise comparison results that did not meet the Saaty Consistency Index were eliminated. The geometric mean of the consistent pairwise comparisons was determined for all factors to generate a unified weight for ranking.

Based on the analysis of the survey data, a prioritized list of Web 3.0 development factors was obtained. The factors were ranked in order of importance as per the experts, based on the weights assigned to them in the AHP analysis. The prioritized list was used to provide guidance for developers and specialists in the area.

The study demonstrated the effectiveness of using the AHP method as a tool for prioritizing and ranking Web 3.0 development factors. The prioritized list of factors can be used by developers and specialists to guide their decision-making process and ensure that they focus on the most important factors in the development of Web 3.0 applications.

IV. RESULTS

The results of the study indicates that the most important factor for Web 3.0 development is the consensus mechanism, which had a weight of 20.0% (as seen in Table I). This suggests that experts in the field consider the underlying technology that enables blockchain to be a decentralized and trustless system as the most critical aspect of Web 3.0. This can be linked to the consideration of gas fees during transactions be it with proof-of-stake (PoS) or proof-of-work (PoW) consensus frameworks [16], [17]. Blockchain consensus mechanisms are important to programmers since they influence the functionality, shared maintenance as well as control of the blockchain. Programming language ease had the second-highest priority with a weight of 14.4%, indicating that developers and specialists value the ease of use and accessibility of the programming languages used to build Web 3.0 systems. Solidity is known to be the most popular and well-used smart contract language due to factors such as its object-oriented nature [18], [19]. Other languages used by developers include Obsidian, Python, PHP, Go, JavaScript, Java [20], [21].

Blockchain network latency had a weight of 13.8% and was ranked third in importance, highlighting the importance of the speed and reliability of blockchain networks. As such, network latency plays a crucial role in the success of any Web 3.0 deployment [22]. Access to developer communities was also considered crucial, with a weight of 13.6%, as it provides opportunities for collaboration, knowledge sharing, and innovation. Cross-blockchain interoperability was given a weight of 9.1%, suggesting that developers and specialists recognize the importance of building blockchain systems that can work seamlessly with other blockchain networks.

Comprehensible documentation had a weight of 8.4% and was ranked sixth in importance, emphasizing the need for clear and concise documentation to facilitate the development and adoption of Web 3.0 systems. Vision and goals of blockchain of choice were also considered essential, with a weight of 7.8%, as it helps to ensure that the blockchain system aligns with the objectives of the organization or community. Ubiquity of the metaverse had a weight of 5.5%, highlighting the importance of building Web 3.0 systems that are accessible across different platforms and devices.

Factors related to environmental sustainability, such as carbon neutrality, had a weight of 4.2%, indicating that they were given a lower priority in this study. Market capitalization had the lowest priority with a weight of 3.2%, suggesting that experts in Web 3.0 development do not consider it a crucial factor for the development of blockchain-based systems.

Table I. Pairwise comparison

Construct	***Weight***	***Rank***
Consensus Mechanism	20.00%	1
Programming Language Ease	14.40%	2
Blockchain Network Latency	13.80%	3
Access to Developer Community	13.60%	4
Cross-Blockchain Interoperability	9.10%	5
Comprehensible Documentation	8.40%	6
Vision and Goals of Blockchain of Choice	7.80%	7
Ubiquity of the Metaverse	5.50%	8
Carbon Neutrality	4.20%	9
Market Capitalization	3.20%	10

Overall, these results provide valuable insights into the factors that developers and specialists consider essential for the development of Web 3.0 systems. They can be used to guide decision-making processes, prioritize resources, and allocate funding for the development of Web 3.0 systems.

V. CONCLUSION

The study ranked the criteria and sub-criteria in a usability hierarchical model using AHP, a technique based on mathematical and psychological principles. This approach was used as a result of the complex nature involved in evaluating both the quantitative and qualitative usability attributes simultaneously. Opinions were elicited from decision makers which comprised of Web 3.0 developers and the users. Consistency ratio for all participants were computed to get reliable and valid opinions. Based on results of analysis, efficiency had the highest rank with 20% which is Consensus mechanism followed by effectiveness with 14.4%, 13.8%, 13.6% and so on ranked lowest with 3.2%

which is Market capitalization.

The AHP methodology was found to be more efficient than the traditional methods of usability since numerous attributes were evaluated at the same time thereby saving cost, time and other resources. It was also realized that based on the findings of this study, the AHP was a helpful tool in enabling effective and efficient decisions to be made by users and developers and their prioritization about the multi criterion decision making to prioritization of Web 3.0 factors.

However, it is important to consider the potential trade-offs and limitations of using blockchain technology in conjunction with the AHP. For example, the setup and maintenance of a blockchain-based AHP system could require significant resources and expertise, which may not be practical or cost-effective in all situations. In addition, the use of blockchain technology may introduce additional complexity and potential points of failure into the decision-making process. It may also be necessary to carefully consider issues related to data privacy and security when using blockchain technology in conjunction with the AHP, involve more decision makers in the opinion elicitation process both from the Industry and the Academia. The data analysis can be done by using AHP tool for organizing and analyzing complex problems, so using it with Web 3.0 and blockchain technologies would require a person to be adept at analyzing and interpreting data.

Web 3.0 and blockchain technologies would require the developers to be adept at identifying and analyzing problems, developing and evaluating potential solutions, and implementing effective solutions. This study can be extended by considering other usability attributes or factors that are essential during and after system development. More respondents can also be involved in the opinion gathering process to get judgements from a larger group of decision makers to make more valid judgements. More so, involves creating a hierarchy of factors and evaluating their relative importance, so its use with Web 3.0 and blockchain technologies may require a person to be able to communicate and collaborate effectively with others in order to reach consensus on a hierarchy of factors. Future research will extend the research to compare various cryptocurrencies as per the factors indicated in the study.

REFERENCES

[1] U. W. Chohan, "Web 3.0: The Future Architecture of the Internet?," Available at SSRN, 2022.

[2] A. K. Goel, R. Bakshi, and K. K. Agrawal, "Web 3.0 and decentralized applications," Materials Proceedings, vol. 10, no. 1, p. 8, 2022.

[3] C. Vernando, H. Hitojo, and R. Steven, "The Essential Factors of Web 3.0 Affecting 7 Layers of Decentralized Web in Business or Industry," in 2022 International Conference on Information Management and Technology (ICIMTech), IEEE, 2022, pp. 189–194.

[4] S. Adams, "Surfing the hype cycle to infinity and beyond," Research-Technology Management, vol. 62, no. 3, pp. 45–51, 2019.

[5] C. V. Almario, "The effect of digital health technology on patient care and research," Gastroenterology & hepatology, vol. 13, no. 7, p. 437, 2017.

[6] C. Chen et al., "When digital economy meets web 3.0: Applications and challenges," IEEE Open Journal of the Computer Society, 2022.

[7] A. Agarwal, K. Tak, P. Lamshal, A. Nithin, N. C. Kolupoti, and U. Krishna, "EMPLOYING A DECENTRALIZED APPLICATION BASED ON WEB 3.0".

[8] K. C. Chan, X. Zhou, R. Gururajan, X. Zhou, M. Ally, and M. Gardiner, "Integration of blockchains with management information systems," in 2019 International Conference on Mechatronics, Robotics and Systems Engineering (MoRSE), IEEE, 2019, pp. 157–162.

[9] S. C. Figueiredo, "Rhetoric in the metaverse," Convergence, vol. 29, no. 1, pp. 81–96, 2023.

[10] V. H. Lakhani, L. Jehl, R. Hendriksen, and V. Estrada-Galinanes, "Fair Incentivization of Bandwidth Sharing in Decentralized Storage Networks," in 2022 IEEE 42nd International Conference on Distributed Computing Systems Workshops (ICDCSW), IEEE, 2022, pp. 39–44.

[11] A. Doğan, İ. Söylemez, U. Özcan, and S. K. İşleyen, "Web 3.0 in Decision Support Systems," in The Fifth International Management Information Systems Conference, 2018.

[12] S. Silva, "Web 3.0 and Cybersecurity–Short Paper," ARIS2-Advanced Research on Information Systems Security, vol. 2, no. 2, pp. 39–49, 2022.

[13] E. Folmer and J. Bosch, "Architecting for usability: a survey," Journal of systems and software, vol. 70, no. 1–2, pp. 61–78, 2004.

[14] J.-J. Wang, Y.-Y. Jing, C.-F. Zhang, and J.-H. Zhao, "Review on multi-criteria decision analysis aid in sustainable energy decision-making," Renewable and sustainable energy reviews, vol. 13, no. 9, pp. 2263–2278, 2009.

[15] A. Presley and P. Fellows, "An analytic hierarchy process model for evaluating and comparing website usability," International Journal of Business Information Systems, vol. 12, no. 2, pp. 123–139, 2013.

[16] M. Atiquzzaman, N. Yen, and Z. Xu, Big data analytics for cyber-physical system in smart city: BDCPS 2019, 28-29 December 2019, Shenyang, China, vol. 1117. Springer Nature, 2020.

[17] S. Wadhwa, "Empirical Analysis on Consensus Algorithms of Blockchain," in Cyber Intelligence and Information Retrieval: Proceedings of CIIR 2021, Springer, 2022, pp. 507–514.

[18] R. Taş and Ö. Ö. Tanrıöver, "Building a decentralized application on the ethereum blockchain," in 2019 3rd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT), IEEE, 2019, pp. 1–4.

[19] J. Zakrzewski, "Towards verification of Ethereum smart contracts: a formalization of core of Solidity," in Verified Software. Theories, Tools, and Experiments: 10th International Conference, VSTTE 2018, Oxford, UK, July 18–19, 2018, Revised Selected Papers 10, Springer, 2018, pp. 229–247.

[20] M. Coblenz et al., "Obsidian: Typestate and assets for safer blockchain programming," ACM Transactions on Programming Languages and Systems (TOPLAS), vol. 42, no. 3, pp. 1–82, 2020.

[21] A. Krishna, A. Aich, C. Hegde, and others, "Analysis of customer opinion using machine learning and NLP techniques," International Journal of Advanced Studies of Scientific Research, vol. 3, no. 9, 2018.

[22] V. Elagin, A. Spirkina, M. Buinevich, and A. Vladyko, "Technological aspects of blockchain application for vehicle-to-network," Information, vol. 11, no. 10, p. 465, 2020.

Blockchain Ecosystem for the Real Estate Industry

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Abstract—Blockchain is a fast-rising technology that has the potential to change how we pay for things, verify information, or buy or sell. Today, we see how blockchain has an impact on many industries, and real estate is one of them. Some of the issues that this industry is facing now are a lack of liquidity, complicated transactions, and many frauds in process. The purpose of this paper is to focus on the theoretical explanation of the blockchain ecosystem within the real estate industry. In other words, how blockchain, combined with smart contracts, can be used in the real estate sector and how this industry can benefit from using this technology We start with an explanation of the blockchain technology itself and then explain how this technology can be implemented in the real estate industry. The special focus of this paper is the theoretical example of a system for real estate transaction processing that uses blockchain technology.

Keywords - blockchain, real estate, smart contracts, tokenization

I. INTRODUCTION

Let's consider one of the biggest problems that everyone faces at least once in their life, and that is buying real estate. Namely, in this situation, we have a representative who sells the real estate and who, as a rule, should also be the last owner as well. However, in order to determine this, it is necessary to have recorded all previous transactions for the selected real estate, and this information is stored and verified by the institutions responsible for this. In this way, we could protect ourselves from fraud; however, what we can still notice today are cases of real estate being sold twice or by people who are not the owners. This is where blockchain technology could help: a distribution system where multiple parties keep information that they can guarantee has not been changed. Using smart contracts for transactions can exclude any intermediaries in the process, such as banks, for example. But smart contracts can also provide a more secure way to do transactions.

This paper should provide some theoretical knowledge of how blockchain can be used in the real estate industry. A new innovative business model for the application of blockchain in real estate is being developed. Furthermore, a blockchain ecosystem for the real estate industry is proposed.

II. BLOCKCHAIN

The first big appearance of the blockchain was around 2008, when an anonymous individual or group of individuals called Satoshi Nakamoto wrote a paper about a digital currency called Bitcoin that was based on blockchain technology[1]. The blockchain is "distributed storage of timestamped documents where no party can tamper with the content of the data or the timestamps without detection." [2]. It is based on a P2P network, which means that two or more nodes can communicate together without a third party involved. All transactions in this P2P network need to be validated. A blockchain consists of data sets that are composed of a chain of data packages (blocks), where a block comprises multiple transactions [3]. Blocks contain block headers with metadata such as block number, the hash value of the previous block header, timestamp, nonce value, size of the block, and block data, a list of transactions that were included in a block. This concept ensures the integrity of the entire blockchain.

Blockchain technology can be developed in three ways: as a private blockchain system, a public blockchain system, or a consortium blockchain system. The public blockchain system is organized as a decentralized open-source system within which democracy rules; that is, there is no authority that controls it. It can be used by anyone who wants to participate in basic activities within the blockchain network. Disadvantages of public blockchain systems include higher energy consumption for maintenance as well as the existence of malicious programs that aim to steal tokens. The implementation of a private blockchain allows only verified users to access the network. Unlike public blockchains, private ones are centralized and controlled by their users. In a consensus blockchain system, the consensus process is regulated in advance by a selected set of nodes.

Smart contracts can be defined as the computer protocols that digitally facilitate, verify, and enforce the contracts made between two or more parties on the blockchain [4]. Smart contracts refer to a series of computer codes and protocols that can automatically execute and enforce an agreement when the specified conditions between two parties are met. They enable the immutability and trustworthiness of blockchain transactions without intermediaries.

III. BLOCKCHAIN IN REAL ESTATE

Many people today, when they hear about blockchain, think about cryptocurrencies, but there are now many research papers that are all about how this technology can have an impact on other fields. The real estate sector is one of them. When we talk about real estate, the categories that blockchain technology can impact the most are land administration and real estate asset tokenization. The land administration category is about blockchain-based applications that are linked with land and title registration systems. The token is technologically connected with the cadastral data (geo-data) and property rights, including leases, mortgages, superficies, and other encumbrances and liens. The connection of title records with real estate and property rights is ensured by relevant blockchain records done by trusted third parties who have the authority to certify ownership, deeds, and other transactions with property rights. This is also called a hybrid approach, meaning that "it appears to offer a way to overcome blockchain adoption challenges by minimizing disruption while maximizing the benefits powered by smart contracts". [5] [6]. Tokenization refers to digitally representing real estate as a blockchain-based token. The token should represent property with all its obligations and rights.

In the previous part, we explained what smart contracts are, and here are some examples of how using smart contracts can be useful in the real estate industry. One of the advantages of using smart contracts is that they can have multiple signatures, which can be helpful because there could be more parties involved in the transaction process. For example, a smart contract can be designed to proceed with transactions with at least two signatures, so if the buyer and seller don't trust each other, they can then involve a third party. If conditions are met and both buyer and seller agree that everything is right, they can both sign and the transaction can proceed. On the other hand, when conditions are met but, for some reason, the buyer backs up, or vice versa, the seller can have a third-party sign the transaction, and the transaction will proceed. Another advantage of using smart contracts is that they are time-locked, which means they can delay transactions until the time that is set in the contract.

Using blockchain technology, it is possible to develop a system for monitoring the flow of documents for the transfer of real estate. It is possible to develop an online application in which users can attach all the complete documentation required for the transfer of real estate ownership. In this way, intermediaries such as real estate agencies or notaries could be excluded. [7]

When talking about the real estate sector, which includes renting out properties, blockchain with smart contracts can be used for automatic rent payments and thus enable secure collaboration between landlords and property owners.

IV. BLOCKCHAIN ECOSYSTEM IN REAL ESTATE

A. Business Model Canvas (BMC) for blockchain in the real estate industry

Customer segments. Customer segments can be defined as "the different groups of people or organizations that an enterprise aims to reach and serve" [8]. Customer segments that would benefit from using blockchain systems are people or companies that want to buy, sell, or rent real estate in a more transparent and secure way. Government institutions, especially the regulatory bodies that are responsible for land administrations, together with banks, would also benefit from using blockchain technology.

Key partners. Key partners are builders, investors, real estate agencies, banks, and government institutes. Also, technology companies develop application programming interfaces and software development kits [8].

Value proposition. Tokenizing real estate assets with the help of smart contracts is an alternative option to raising capital that simultaneously guarantees transparency, security, accessibility, and instant liquidity. Tokenization is a way to digitally represent ownership rights to real-world assets in the form of a token on a blockchain [9]. This way customers would have the possibility to trade tokens faster, in a secure and transparent way. It would also allow them to track transaction history and prevent fraud. Also, with smart contracts, customers would feel much safer because transactions would only proceed if all preconditions were met.

Revenue streams. Revenue is generated through transaction commissions, a platform fee, and cryptocurrency conversion.[9]

Key activities. Some of the key activities would be developing user interfaces, application programming interfaces (APIs), software development kits (SDKs), P2P networks, cloud data storage, and databases. Also programming smart contracts and wallet integrations with Know-Your-Customer (KYC) and Anti-Money Laundering (AML) protection [9].

Key resources. Key resources that we would need are a team of software and blockchain developers, and blockchain infrastructure. An adequate workspace with work equipment and storage is also needed.

Channels. Customers could be reached through advertising on various websites and mobile applications for selling or renting real estate assets. Social networks can also be used for communication between platforms and customers.

Customer relationship. Social media can be used to promote platforms but also to create a community of customer support for every question and help that customers need. Also included in developing loyalty programs would be privacy, security, tokenized reward points, exchange or selling reward points, and discounts for token transactions [10].

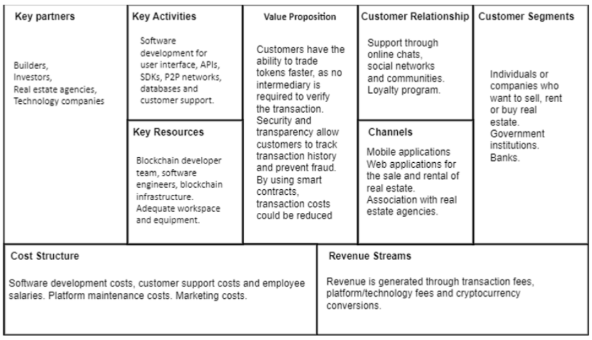

Fig. 1. Business Model Canvas for blockchain in real estate

Cost Structure. The cost of developing a blockchain system. Platform maintaining cost. Salaries and workplace maintenance costs. Marketing cost for promoting platform. The price of the token is based on the value of the property itself, but what would make a difference is less cost of the expenses for intermediaries.

B. Blockchain ecosystem in the real estate industry

Blockchain can be enabled to improve the transparency of a system enabling regulators to catch and prevent fraudulent behavior. Some of the transaction costs for real estate can include title search fees, land transfer taxes, legal fees, agent fees, listing fees and notary fees [11]. Although blockchain cannot reduce all costs, some of these costs can be avoided by implementing this technology. In the previous part, when we talked about blockchain in real estate, we mentioned a hybrid approach to using blockchain technology, and based on that, we can propose a system that can be developed with automated transactions such as buying and selling a property. The whole process of buying and selling a property can be divided into a few phases. First, the buyer and seller make an agreement and initiate the property transaction. Then, with the approval of the notary, both parties sign the contract. After the contract is signed, the buyer transfers the payment to the seller's account, and here is where banks could be involved. When money is transferred, a transfer of ownership may be initiated as well. In this phase, the system will notify the local cadastral office to initiate the process of transfer of ownership and inform tax administration about the change of ownership. A taxpayer is obligated to pay the tax for the transfer of absolute rights. And after taxes are paid, the seller gets ownership of the property, and here is where we can say the whole process is complete. All documents and records about the transaction are added to the blockchain. The third parties that would have access to the system as well would be notaries and real estate agents. Real estate agents are needed to connect buyers and sellers, and the notary "conducts all the legal affairs related to the transfer of ownership, including administrative activities such as obtaining a real estate folio document from the cadaster as a proof of ownership, as well as initiating the procedure for registration." [12]

In this article, we propose a blockchain system for real estate that integrates various services for stakeholders in the real estate sector (Fig. 2.):

- **Builders and investors-** Builder or investor can be a person or a company that invests/build property for selling or renting purposes. There are many ways that globalization has impacted the real estate industry, and some of them are cross-border investments, but also off-shoring in certain parts of the supply chain [13] Blockchain can be used for tracking transactions through all supply chains, and this data would be available to all stakeholders in the blockchain system. Builders can also use blockchain technology with smart contracts to activate actions automatically, such as payment to a contractor, when an agreed-upon milestone has been reached. Evidence of this can also be automatically shared with authorized government institutions. [14] This way, all transactions would be more transparent, and this process would be more time and cost-efficient.
- **Sellers/Real estate agencies.** Property can be sold or rented by the individual who owns it or by the real estate agency that represents the rights of the owners of the property. The sellers can use the blockchain to tokenize their assets. There are several ways in which a real estate asset can be fractionalized, including joint ownership, physical subdivision, timeshares, and others. [15] These tokens can then be transferred using smart contracts. When we talk about renting, real estate agencies can use blockchain to create smart contracts that could automate cash flow between buyer, agency, and owner [16].
- **Banks**. Banks in the real estate industry act as trusted third parties when it comes to financial transactions within this sector. Banks also play an important role in giving loans for purchasing properties. Today, this process requires a lot of paperwork and time for risk management to check and verify whether loans should be allowed. With blockchain, all this information about properties or information parties involved can be brought to one place. This way, banks could use blockchain, where structured and standardized data can form the input for internal workflows and analyses, to better understand the risks associated with real estate. [17] Banks could also participate as trusted third parties when smart contracts with multiple signatures are designed, this way, banks can monitor or check financing easier.
- **Government institutions.** Government institutions play a limited role in regulating the real estate market. Some of the methods and instruments that government institutions use are legislation, taxation, licensing of market participants, transaction costs and procedures, and similar. [18] Tracking and maintaining real estate records is difficult and time-consuming. This system can also be vulnerable to record tampering. Blockchain technology with smart contracts can be used to record the data of all buyers and sellers, with chronological details of transactions. In this case, the Ministry of Justice would have a

system for transferring real estate between citizens that is less prone to fraud. Even if an authorized person alters the data, the blockchain infrastructure will show its details to impose transparency. This could also prevent corruption within government institutions. On the other hand, these records will be available to all stakeholders in the blockchain system; for example, if the buyer is interested in buying a property, he will use the system to search the property and see all records of the owner for proper verification of the land. [19]

- **Real estate customers.** Real estate customers can be individuals or companies that want to buy or rent property. Customers can use blockchain applications to get all the real-time data necessary for the desired property. Using smart contracts can help when buying properties that are under construction. The buyer can deposit money into the account on the blockchain, and when he gets the property, the money for the developer will be automatically unlocked [20]. This way, the buyer is assured that his money will transfer only if he has the right to the property.

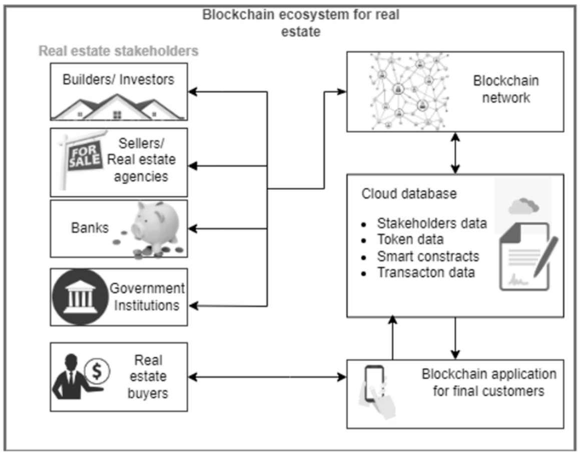

Fig. 2. Blockchain ecosystem for the real estate industry

V. CONCLUSION

Blockchain technology is a distributed ledger with growing lists of records (blocks) that are securely linked together via cryptographic hashes. Today, blockchain technology is considered to have several benefits for different sectors, such as real estate. The lack of transparency, high transaction costs, and the need for digitalization in commercial real estate companies give blockchain its game-changing potential.

The focus of this paper was on the benefits of including blockchain technology in the real estate sector, but there are also some challenges to this kind of system that need to be mentioned. One of them is the verification of the identities of the parties involved. If blockchain technology is implemented, it needs to address this issue, or it needs to check the real identities of the parties involved. Another issue that needs special attention while developing blockchain technology combined with smart contracts is the control of the legality and effectiveness of the contract. This means that a smart contract only checks the fulfillment of the preconditions [21]. Based on this, we can say that before we can overcome all these challenges, the "hybrid approach" should make perfect sense, where blockchain technology together with traditional institutions could make the real estate system much more secure and valid. But if we think in the long term, some transactions in real estate, such as buying or selling properties, could be done without an intermediary.

The system could be designed just to notify all relevant institutions that need to be involved, such as a notary to conduct all the legal affairs related to the transfer of ownership, a bank about the payment, a cadaster to register the transfer of rights, and the tax administration to calculate taxes [12]. This way, all data would be available to all stakeholders in the blockchain system, and this would enable full transparency of the process. Since this system is based on smart contract features, work could include the implementation of this system using the Algorand blockchain platform for tracking transactions in the proposed ecosystem. Smart contracts will be coded using PyTeal programming language.

REFERENCES

[1] Satoshi Nakamoto. Bitcoin: A peer-to-peer electronic cash system.2008.

[2] M. Di Pierro, "What Is the Blockchain?," in Computing in Science & Engineering, vol. 19, no. 5, pp. 92-95, 2017, doi: 10.1109/MCSE.2017.3421554.

[3] Nofer, M., Gomber, P., Hinz, O. et al. Blockchain. Bus Inf Syst Eng 59, 183–187 (2017). https://doi.org/10.1007/s12599-017-0467-3

[4] S. Wang, L. Ouyang, Y. Yuan, X. Ni, X. Han and F. -Y. Wang, "Blockchain-Enabled Smart Contracts: Architecture, Applications, and Future Trends," in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 49, no. 11, pp. 2266-2277, Nov. 2019, doi: 10.1109/TSMC.2019.2895123.

[5] Anniina Saari, Jussi Vimpari, Seppo Junnila, Blockchain in real estate: Recent developments and empirical applications, Land Use Policy, Volume 121, 2022,106334,ISSN 0264-8377, https://doi.org/10.1016/j.landusepol.2022.106334.

[6] Konashevych, Oleksii. "General Concept of Real Estate Tokenization on Blockchain: The Right to Choose" European Property Law Journal, vol. 9, no. 1, 2020, pp. 21-66. https://doi.org/10.1515/eplj-2020-0003

[7] Tikhon P. Podshivalov, Improving implementation of the Blockchain technology in real estate registration, The Journal of High Technology Management Research, Volume 33, Issue 2, 2022, 100440, ISSN 1047-8310, https://doi.org/10.1016/j.hitech.2022.100440. (https://www.sciencedirect.com/science/article/pii/S1047831022000153)

[8] MORKUNAS, Vida J.; PASCHEN, Jeannette; BOON, Edward. How blockchain technologies impact your business model. Business Horizons, 2019, 62.3: 295-306.

[9] SCHAUBMEIER, Christian. Blockchain and Business Model Innovation: An analysis of opportunities and the innovation process/submitted by Christian Schaubmeier, BSc. 2019. PhD Thesis. Universität Linz.

[10] BEZOVSKI, Zlatko; JOVANOV, Tamara; TEMJANOVSKI, Riste. The impact and the potential disruption of the blockchain technology on marketing. Journal of Economics, 2021, 6.1: 13-23

[11] Mashatan, A., & Roberts, Z. (2017). An Enhanced Real Estate Transaction Process Based on Blockchain Technology. Proceedings of Americas Conference on Information Systems (AMCIS) 2017, Boston, MA.

[12] Sladić, G., Milosavljević, B., Nikolić, S., Sladić, D., & Radulović, A. (2021). A blockchain solution for securing real property transactions: a case study for Serbia. ISPRS international journal of geo-information, 10(1), 35.

[13] BARDHAN, Ashok; KROLL, Cynthia A. Globalization and the real estate industry: issues, implications, opportunities. 2007.

[14] THOMSON REUTERS PROJECTS, and CAVENDISH MAXWELL. Blockchain for Construction/Real Estate with paper. April 2018. Available at: https://mena.thomsonreuters.com/en/articles/blockchain-for-construction-and-real-estate.html (Last visit: May 2023)

[15] BAUM, Andrew. Tokenisation–the future of real estate investment. The Future of Real Estate Initiative, 2020, 61.

[16] Saari, A.; Junnila, S.; Vimpari, J. Blockchain's Grand Promise for the Real Estate Sector: A Systematic Review. Appl. Sci. 2022, 12, 11940. https://doi.org/10.3390/app122311940

[17] Wouda, H.P. and Opdenakker, R. (2019), "Blockchain technology in commercial real estate transactions", Journal of Property Investment & Finance, Vol. 37 No. 6, pp. 570-579. https://doi.org/10.1108/JPIF-06-2019-0085

[18] Laskowska, Elwira & Torgomyan, Sevak, 2016. "The Role of Government in the Housing Market," Problems of World Agriculture / Problemy Rolnictwa Światowego, Warsaw University of Life Sciences, vol. 16(31), pages 1-8, December.

[19] ALI, Toqeer, et al. A transparent and trusted property registration system on permissioned blockchain. In: 2019 International Conference on Advances in the Emerging Computing Technologies (AECT). IEEE, 2020. p. 1-6.

[20] KALYUZHNOVA, Nadezhda. Transformation of the real estate market on the basis of use of the blockchain technologies: opportunities and problems. In: MATEC web of conferences. EDP Sciences, 2018. p. 06004.

[21] Garcia-Teruel, Rosa M., Legal Challenges and Opportunities of Blockchain Technology In The Real Estate Sector (December 16, 2020). Journal of Property, Planning and Environmental Law: Volume 12 Issue 2, 2020, Available at SSRN: https://ssrn.com/abstract=4304743

Decentralized Autonomous Organizations: State and Perspectives

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Abstract—The concept of Decentralized Autonomous Organizations has gained significant attention in recent years due to their potential to transform the way we organize and govern ourselves. This paper presents a thorough review of DAOs, including their history, membership structures, voting mechanisms, and various applications. We also delve into the legal implications of DAOs, exploring the current legal landscape, regulatory frameworks, and legal challenges they face. Furthermore, we conduct an analysis of current trends and offer our perspective on the primary obstacles that hinder widespread adoption. In conclusion, DAOs hold enormous potential to impact society, but further research and development are necessary before their potential can be fully realized.

Keywords - DAO, blockchain, governance, token

I. INTRODUCTION

Decentralized Autonomous Organizations (DAO) are a new form of organizational structure that has emerged with the rise of blockchain technology. They distribute the decision-making power among members rather than concentrate it within a central authority [1]. As DAOs are becoming more prevalent in the blockchain space, there is a need to understand their governance structures and assess their effectiveness in promoting new forms of collaboration and value creation.

This paper seeks to investigate the current state of DAO technology, as well as discuss its main challenges and possible future uses in different fields. Our goal is to contribute to a better understanding of this emerging technology and take part in further research and innovation in this area.

II. DAO CONCEPTS AND TECHNOLOGY

A. DAO – Definition

DAO, or decentralized autonomous organization, is a digital organization that exists on a decentralized blockchain network [2]. It leverages the power of smart contracts and tokens for governance while all decisions are taken by a consensus of all members [3]. The goal of the DAO technology is to eliminate middlemen and create democratic, transparent, and efficient ways of organizing [4]. However, DAO technology is still in its early stages of development, and many legal, technical, and social challenges need to be resolved before the technology reaches its full potential.

B. Historical Background

The concept of DAO can be traced back to the development of blockchain technologies and the creation of Bitcoin in 2008 [5]. The idea of a self-governing organization that operates without a centralized authority gained popularity in the Ethereum community in 2015 when smart contracts were implemented, enabling the creation of self-executing code for automating organizational functions [6]. The first DAO, also known as "THE DAO", was started in 2016 and raised over $150,000,000 in community funds before it was hacked, resulting in a big crisis in the Ethereum community [7]. The crisis was later solved with a hard fork of the network [8]. Nevertheless, the initial failure of "THE DAO" didn't stop the technology from growing and developing, with new use cases appearing in many different industries.

C. Technical Aspect

DAO is built on top of a decentralized blockchain network, usually Ethereum, but also on other smart blockchains such as Algorand, Avalanche, and Binance Smart Chain. They use smart contracts to self-execute pieces of code that enforce the rules and guidelines of the organization. These smart contracts are implemented into the blockchain, making them transparent, immutable, and resistant to any censorship or tampering [9]. DAO usually uses a system based on tokens, in which members of the organization hold tokens that represent their ownership and the right to vote. These tokens are also stored on the blockchain and can be freely traded and exchanged. Governance in DAO is commonly managed through decentralized decision-making, where members can suggest, vote and enforce activities or changes in the organization [10]. Some of the technical challenges which DAO is facing include scalability, interoperability, and security [11].

D. Membership

A DAO can have any rule set and type of membership, but in this paper, we will mention the two most common ones.

1) Token-Based membership

In this type of membership, members hold tokens or digital assets representing their part of the ownership in the organization [12]. These tokens are often issued during the initial launch of the DAO. They can be bought, sold, or traded on decentralized exchanges without limitations. This allows anyone to become a member, and no central authority can forbid anyone from taking part in the DAO.

2) Share-Based membership

As opposed to Token-Based membership, Shared-Based membership is more permissioned and is usually used for human-centric organizations such as charities. In this type of membership, a prospective member is required to submit a proposal to join the DAO; depending on the organization, they might need to offer value in terms of assets or services [13].

E. Voting Mechanisms

DAO voting is usually done on the blockchain where the DAO is deployed. Members participate in the voting by interacting with the smart contract through a web interface or a decentralized application [14][15]. Nowadays, this process is simplified by companies such as “Aragon.org” which offers user-friendly interfaces for DAO voting [16]. Depending on the DAO rules, members may be required to spend or “burn” tokens for each vote, or they only may be required to hold a specified amount of tokens to have a vote.

1) Token-Weighted voting

In this case, DAO members hold voting power which is proportional to the number of tokens they hold [17]. This means that members with more tokens have a greater say in decision-making. While this way of voting is the simplest and most transparent, it has flaws. It could lead to centralization of power, as members could pool together 51% of the tokens and influence decision-making. In addition, minor stakeholders may encounter challenges in having their viewpoints adequately reflected or considered.

2) Quadratic voting

This mechanism allows members to vote on a decision multiple times, but every additional vote increases its cost quadratically [18]. The main purpose of this system is to ensure that voters who do not have a significant interest in the issue cannot overpower a smaller group of voters who hold a strong and passionate stance on the subject [19]. Nefarious actors may avoid this obstacle by spreading their tokens onto different accounts and voting. Verification of the identity of every member would decrease this risk, but it could create issues with the onboarding of new members.

3) Conviction voting

Conviction voting is a mechanism based on the continuous expression of the aggregated preference of the community [20][21]. In this case, the weight of the vote increases in correlation with the time it remains unchanged. Members are allowed to change their opinion, but doing so sacrifices the previously accumulated weight of the vote. While this mechanism prevents individuals with large stakes from overpowering minorities and reduces centralization, it is susceptible to “last-minute attacks,” in which a group of members swings the outcome to their favor by changing the vote just before the voting is closed.

III. EXAMPLES OF USAGE

A. Current Projects

Uniswap is a decentralized protocol that enables users to trade tokens on the Ethereum blockchain [22]. It was launched in November 2018 and has since become the most popular trading protocol on the network. Its popularity can be attributed to its ease of use and utility. This protocol does not require users to go through Know-Your-Customer (KYC) verification, and it does not have a centralized authority that charges fees for the trades. Instead, it applies a 0.3% fee from each trade which is allocated to the members who are providing the liquidity necessary to execute trades. Uniswap DAO is a decentralized autonomous organization that governs the protocol with the help of its native token, UNI. The DAO is responsible for managing the development of the protocol, as well as making decisions related to its governance, such as changes to the protocol fees, allocation of funds from the treasury, and the addition of new tokens. These decisions are made through a system of on-chain voting and token staking. The Uniswap DAO is a textbook example of a very successful and innovative community-driven project.

Its native token, UNI, is used for voting on governance proposals, which means that anyone holding it is a part-owner of this protocol and has a voice in its future development [23][24].

Decentraland is a decentralized virtual reality platform running on the Ethereum blockchain [25]. Its users can create, participate in, and monetize the application's content and activities. The entirety of this virtual world is split into blockchain-based parcels, which users can claim ownership of. Landowners have the power to control what content is published on their portion of the land. The users entirely control this project through its DAO [26]. Holders of MANA, NAMES, or LAND tokens can participate in the DAO, which is responsible for managing the development of the platform, as well as making decisions such as:

- Size of marketplace fees
- Policy Updates
- Future LAND auctions
- Allocation of funds from the treasury

The voting takes place on Decentraland DAO's governance interface, which is hosted on their website at: https://governance.decentraland.org/ [27].

AAVE is an Ethereum-based decentralized non-custodial liquidity protocol in which users can participate as depositors or borrowers [28]. Depositors provide liquidity to the market to earn a passive income through interest, while the borrowers are borrowing assets without any need for traditional financial intermediaries. All AAVE operations are handled through the use of smart contracts which are transparent and immutable. Since its creation, the protocol was controlled by its DAO. Anyone holding its native token AAVE can discuss, propose and vote on upgrades to the protocol.

B. Possible Uses

While DAOs have already been used in various applications, such as crowdfunding and investment management, their potential applications are far-reaching and continue to be explored.

1) Gaming

One potential use of DAO technology is in the gaming industry. DAOs can provide a way of crowdfunding and developing community-run gaming projects. Investors can contribute funds, and in exchange, they will receive tokens that represent their ownership of the project. These tokens can be freely traded to other interested investors. Every token holder could be involved in the project, by voting on and submitting ideas for game features as well as providing feedback on the progress.

2) Real Estate

Another potential use of DAO technology could be in the Real Estate market. Investors could pool together and purchase expensive properties, while investors would own only a fraction of each. This could make real estate investments more accessible to a wide range of potential investors. Each share would be presented as a token on the blockchain, and each token holder would have a vote and the possibility to suggest what should be done with the property. Whether the property should be rented out, renovated, or sold, is democratically decided by the group.

3) Local Community Governance

The usage of DAO does not need to be strictly connected to investing, it may also be used as a tool for making democratic decisions. A community, such as a neighborhood, for example, can group up and create their DAO. Together, they can set the criteria and price for becoming a member, as well as rules for the voting procedures. A smart contract is then written with all of this in mind. Each member who is eligible, and donates a pre-set amount to the DAO, can be awarded a token that allows them to submit proposals and vote through a smart contract. If a proposal wins a majority of the votes, then funds from the treasury can be allocated for its realization. This can lead to more transparency, accountability, and fairness in a local community.

4) Healthcare

The health sector is massively benefitting from the rapid development of technologies such as Artificial Intelligence, the Internet of Things, big data, and such. Despite these advancements, access to health services, pricing, and interaction with medical professionals have remained mostly unchanged. DAOs could offer a new way of governance in the sector, which would allow for more transparency, and community participation and avoid spending resources on unnecessary expenses such as executive bonuses, as they will no longer be required.

IV. LEGALITY

A. Regulatory Challenges

DAO represents a unique regulatory challenge because they are not traditional legal entities and work autonomously through self-executed code. This can create trouble for regulators, especially in cases of possible illegal activity. The nature of decentralization in a DAO makes it harder to identify perpetrators of such activities, as decision-making is distributed between all members [29]. Furthermore, a lack of clear legal frameworks can instigate fear in participants of a DAO, especially when it comes to their legal rights and obligations. Potential new participants may be hesitant to engage with this technology due to the same reason. The fact that DAOs can operate in any jurisdiction around the world digitally, presents a huge challenge for the regulators. To tackle these concerns, it will be necessary for regulators to establish a fresh legal structure that is specifically designed to accommodate the unique properties of DAO. The frameworks should provide clarity on the legal standing of a DAO and the legal responsibilities of its participants. To achieve a viable solution, regulators, legal professionals, and DAO developers must work together and establish a regulatory structure that is fair and transparent for all parties.

Each of the present-day DAOs needs to have a legal structure or a so-called “DAO Legal Wrapper” to attract investments from a venture fund, sign agreements with contractors, or list tokens on a centralized exchange [30]. Different DAOs are incorporated as different entities based on their type or business model. Some are incorporated as foundations, some as associations while some are non-profit or for-profit LLCs. So far, only a small number of countries allow the incorporation of DAO, all with different conditions and regulations. Some of the countries which do are: Switzerland, Wyoming (USA), Panama, Liechtenstein, etc.

Wyoming is one of the few states in the USA which recognizes DAOs as legal entities. DAO LLC's business structure protects DAO members from unlimited liability for DAO’s actions and it allows the DAO to interact with the “real world” in a manner compliant with the law. Wyoming law allows the LLC to be managed algorithmically through a smart contract, but it has to be previously indicated in the articles of the organization. Under the applicable law, the underlying smart contract must be able to be updated, modified, or upgraded. To keep its status, DAO LLC needs to approve at least one proposal in one year, otherwise, it will be dissolved[30][31]. This requirement may create issues for projects which do not often vote on decisions. While Wyoming allows for the creation of for-profit DAOs, it is generally advised to avoid token-based voting systems as freely traded tokens may be deemed a security by the U.S. Securities and Exchange Commission.

As opposed to Wyoming, Switzerland does not have special regulations for DAO, but its existing legal frameworks offer a good environment for the creation of one. Under their law, a DAO with a predefined purpose and rules may be formed as a Swiss Foundation [32][33]. If the DAO takes any activities which do not match its pre-defined purpose, relevant regulatory authorities may interfere. This solution is ideal for long-term projects such as protocol development or charity projects, as the creation of for-profit DAOs is not allowed.

B. Taxation Issues

The nature of most DAOs allows anyone with an internet connection to participate. People from different countries and different jurisdictions can all be part of the same organization. This fact creates issues, as each country and jurisdiction can have a different understanding of DAO and tax their respective citizens differently.

Most of the current DAOs are unregistered and do not have a certain legal status in their respective countries. With a lack of exact laws, legal experts often try to fit DAOs into a mold of traditional organizations, which may end up hurting their members. Depending on the country a member resides in, they may even be in breach of local laws.

In the case of the USA, DAO members are taxed on a pass-through basis, which means that the DAO itself is not subject to federal income tax, instead, all of the income, gains, losses, and deductions are passed through to its members who then report their share on their tax reports [34][35].

If a DAO token is classified as a security by the SEC, it becomes subject to the same tax treatment as other securities, such as stocks and bonds. This means that any gains or losses from the sale or exchange of tokens would be subject to capital gains tax.

V. TRENDS AND MAIN CHALLENGES

Decentralized autonomous organizations (DAO) have appeared as a new way of managing decentralized systems and communities through blockchain technology. In the past years, the concept of DAO gained great attention due to the emergence of Decentralized Finance (DeFi) applications. The rise of DeFi was the main driver of the development and adoption of DAO, as it provides a new solution necessary for the management of these decentralized applications (dApps). Not only that, but DAO allows for safer and more transparent management of assets and properties, minimizing the need for intermediaries and increasing the control of participants. Currently, most of the biggest DAO projects are directly tied to DeFi. Recent trends in DAO technology also include the development of new protocols and standards to help with the interoperability and collaboration between different blockchains and DAOs. In addition, there's been a trend in creating more pleasant user experiences through the development of easy-to-use graphical interfaces and governance tools.

Some of the main challenges which DAO is facing are:

Legality. As was mentioned previously in the text, the lack of worldwide legal recognition presents a challenge for the technology, and it may impact future adoption if it isn't solved.

Technical Complexity. To run a DAO, users require a high level of technical expertise, which raises the entry barrier for adoption by the wider masses.

Voting Issues. DAO relies on effective governance and voting to ensure that all decisions are made democratically. However, these mechanisms are also vulnerable to manipulation or corruption, which can undermine the legitimacy of the Organization. Common problems include voter apathy, the sale of votes, and 51% attacks.

Security. DAOs are vulnerable to issues such as hacking, fraud, or insider attacks. Organizations need to prepare and implement effective risk management strategies to mitigate risk and protect assets.

User Acquisition. To be successful, DAOs need to attract a mass of users who are willing to invest or participate in the organization. This would require a significant marketing and outreach effort, as well as a value proposition that incentivizes users to join and be active in the DAO.

VI. CONCLUSION

The emergence of Decentralized Autonomous Organizations (DAO) has uncovered a potential to bring groundbreaking innovation in the realm of blockchain technology and organizational structures. This technology offers a new solution for decentralized decision-making, trustless governance, and community-driven management of resources. The combination of these properties allows the revolution of the way organizations are structured and managed, by eliminating intermediaries, reducing costs, and increasing transparency and accountability.

Analysis of different current and future usages of DAO in this paper highlights the potential benefits and challenges which the technology is facing. On the positive side, DAOs can enable more democratic and transparent decision-making, while increasing efficiency in resource allocation. On the negative side, they face various legal, technical, social, and security vulnerabilities, which slow down their expansion. Finding solutions to these challenges is essential for further development.

As technology continues to mature, its impact on the economy and society can become increasingly important. Further research is necessary to explore the potential of DAO in different contexts and to design appropriate mechanisms needed for their efficient implementation and governance.

Overall, the potential applications of DAOs are vast and varied, and their full potential is yet to be realized. As research and development in this field continue to evolve, DAOs will likely become increasingly prevalent and transformative in various domains.

REFERENCES

[1] Wang, S., Ding, W., Li, J., Yuan, Y., Ouyang, L., & Wang, F. Y. (2019). Decentralized autonomous organizations: Concept, model, and applications. IEEE Transactions on Computational Social Systems, 6(5), 870-878.

[2] Hassan, S., & De Filippi, P. (2021). Decentralized autonomous organization. Internet Policy Review, 10(2), 1-10.

[3] El Faqir, Y., Arroyo, J., & Hassan, S. (2020, August). An overview of decentralized autonomous organizations on the blockchain. In Proceedings of the 16th international symposium on open collaboration (pp. 1-8).

[4] Merkle, R. (2016). DAOs, democracy and governance. Cryonics Magazine, 37(4), 28-40.

[5] Hassan, S. & De Filippi, P. (2021). Decentralized Autonomous Organization. Internet Policy Review, 10(2). https://doi.org/10.14763/2021.2.1556

[6] Buterin, V. (2014). A next-generation smart contract and decentralized application platform. white paper, 3(37), 2-1.

[7] Dhillon, V., Metcalf, D., Hooper, M., Dhillon, V., Metcalf, D., & Hooper, M. (2017). The DAO hacked. blockchain enabled applications: Understand the blockchain Ecosystem and How to Make it work for you, 67-78.

[8] Harvey, C. R. The DAO. 2023-02-20]. https://people. duke.edu/~ charvey/Teaching/697_2019/Presentations/DAO. pdf.

[9] Cieplak, J., & Leefatt, S. (2016). Smart contracts: A smart way to automate performance. Geo. L. Tech. Rev., 1, 417.

[10] Han, J., Lee, J., & Li, T. (2023). Dao governance.

[11] Faqir-Rhazoui, Y., Arroyo, J., & Hassan, S. (2021). A comparative analysis of the platforms for decentralized autonomous organizations in the Ethereum blockchain. Journal of Internet Services and Applications, 12(1), 1-20.

[12] Rosenberg, A. (2022). Getting down with DAOs: decentralized autonomous organizations in bankruptcy. American Bankruptcy Institute Journal, 41(7), 12-51.

[13] Park, S. Y., Chun, K. N., & Kim, M. S. (2022). Understanding decentralized autonomous organizations (DAOs) as a reaction to corporate governance problems. Digital Strategy Review.

[14] Singh, M., & Kim, S. (2019). Blockchain technology for decentralized autonomous organizations. In Advances in computers (Vol. 115, pp. 115-140). Elsevier.

[15] Jentzsch, C. (2016). Decentralized autonomous organization to automate governance. White paper, November.

[16] Aragon | Build Better, Together. (n.d.). https://aragon.org/

[17] Kurniawan, W., Jansen, S., & van der Werf, J. M. Voting Mechanism Selection for Decentralized Autonomous Organizations.

[18] Allen, D. W., Berg, C., Lane, A. M., & Potts, J. (2020). Cryptodemocracy and its institutional possibilities. The Review of Austrian Economics, 33, 363-374.

[19] Benhaim, A., Hemenway Falk, B., & Tsoukalas, G. (2023). Balancing Power in Decentralized Governance: Quadratic Voting under Imperfect Information. Available at SSRN.

[20] Faqir-Rhazoui, Y., Arroyo, J., & Hassan, S. (2021). A comparative analysis of the platforms for decentralized autonomous organizations in the Ethereum blockchain. Journal of Internet Services and Applications, 12(1), 1-20.

[21] Faqir-Rhazoui, Y., Gallardo, J. A., & Hassan, S. (2021). A Comparative Analysis of the Adoption of Decentralized Governance in the Blockchain Through DAOs.

[22] Uniswap Protocol. (n.d.). Uniswap Protocol. https://uniswap.org/

[23] Uniswap Interface. (n.d.). https://app.uniswap.org/#/vote

[24] Introducing UNI. (2020, September 16). Uniswap Protocol.

https://blog.uniswap.org/uni

[25] Welcome to Decentraland. (n.d.). https://decentraland.org/

[26] Laeeq, K. (2022). Metaverse: why, how and what. How and What.

[27] Decentraland DAO. (n.d.). https://governance.decentraland.org/

[28] Open Source Liquidity Protocol. (n.d.). https://aave.com/

[29] Garcia Rolo, A. (2019). Challenges in the Legal Qualification of Decentralised Autonomous Organisations (DAOs): The Rise of the Crypto-Partnership?. Revista de Direito e Tecnologia, 1(1), 33-87.

[30] Brummer, C., & Seira, R. (2022). Legal wrappers and DAOs. Available at SSRN.

[31] Mondoh, B. S., Johnson, S. M., Green, M., & Georgopoulos, A. (2022). DECENTRALISED AUTONOMOUS ORGANISATIONS: The Future of Corporate Governance or an Illusion?. Aris (Aristeidis), Decentralised Autonomous Organisations: The Future of Corporate Governance or an Illusion.

[32] Schuppli, B., & Jafari, G. A. (2021). Piercing the digital veil: A case study for a DAO legal framework under Swiss law. J. Intell. Prop. Info. Tech. & Elec. Com. L., 12, 331.

[33] Riva, S. (2019). Decentralized Autonomous Organizations (DAOs) as Subjects of Law–the Recognition of DAOs in the Swiss Legal Order. Master's Thesis.

[34] Shakow, D. J. (2018). The Tao of the DAO: Taxing an Entity that Lives on a Blockchain. Tax Notes, 160, 18-23.

[35] Brunson, S. D. (2022). Decentralized Autonomous Organizations and Futureproofed Tax Status. Available at SSRN 4168200.

The Role of Blockchain in Innovative Fintech Services

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Abstract—Most financial institutions have started applying Blockchain technology in the financial market with the aim of reducing transaction costs and increasing operational efficiency. As part of open banking, this technology is designed to improve financial services for its users. For customers, this technology will mean better ways to spend, borrow and invest. Clients will be able to get financial products better adapted to their needs, which would lead to a reduction in costs. In this paper, modern trends in the application of Blockchain technology in the field of banking and financial services are followed. Based on the reviewed literature, an analysis of the application of blockchain technologies in financial services was made, taking into account the advantages and disadvantages of this technology. Numerous studies conducted on the application of Blockchain technology in the financial market have shown that this technology can be applied to financial fields and financial products and that it can protect data security, especially in the data trading aspect. Today, large IT firms and companies invest large financial resources for the implementation and development of this technology.

Keywords - financial technologies, blockchain technologies, financial services, open banking

I. INTRODUCTION

Financial technologies ("fintech") have a very important place in financial markets around the world today. In fact, these are information technologies that serve the financial sector. Their role is to enable the improvement of the already existing way of financial business. A developed information environment is necessary for the successful implementation and application of these technologies. The rapid development of information technology, internet connectivity and smartphones has an impact on the banking and financial services sector. The combination of financial technology (fintech) and blockchain affects the modernization and transformation of services in digital banking and financial services [1]. Financial technologies in the banking sector are not new. Banks as participants and bearers of the permanent development of the modern financial market must accept the fact that financial technologies are by no means a competition, but a great help in stimulating the development of timely solutions in order to overcome the difficulties that already exist but also those that will certainly arise during the development of technology. According to Tadić Živković [2], the Balkan countries have slow economic development, where the dominance of banks within the financial system is pronounced. For these reasons, the financial systems of these countries are suitable for the development and implementation of new financial technologies. Given that the spectrum of application of new technologies in these developing countries is much wider, financial institutions have a unique opportunity to take the initiative in their development and to secure a stable position for themselves in the future. There is no single definition of financial technologies because they can be intended for end users or companies themselves. According to German authors from 2017, financial technologies describe companies or company representatives that complement the provision of financial services with modern innovative technologies [3]. In the financial market, the banking sector as it existed until now is beginning to disappear because an increasing number of financial services find their way to end users without the mediation of banks, so banks should recognize their opportunity in time. There may be a chance for banks to implement new technologies in small innovative companies that would contribute to preserving market share and improving bank operations. Available data from the last report of four large auditing institutions indicate that banks are more afraid of losing market share than of uncollectible claims. In order to survive, banks need to notice changes on a global level in time and adjust their operations to new trends, in order to preserve their position on the financial market [2]. For the reconstruction of the banking and financial sector, it is necessary to interconnect financial technology (FinTech) and blockchain technology [4]. FinTech is considered one of the most significant revolutions in the financial industry. It has progressed very quickly, thanks in part to the sharing economy, favorable legislation and advances in information technology [5]. Finance and technology are involved in a long-term FinTech development process based on new technologies [6]. Mobile and digital payment systems are key to the further development of FinTech. FinTech companies are rapidly gaining ground around the world. They offer service options in a number of areas such as payment systems, asset management, credit solutions and insurance services. This technology is well designed to support businesses to efficiently and resourcefully adapt to the needs and conditions of the financial market [7].

II. LITERATURE REVIEW

We can distinguish financial technologies according to their application to different business segments. Those segments are [3]:

- *financing* (financial technologies provide the opportunity for funds to be equally available to individuals and the economy);

- *asset management* (the concept is more recent and represents the possibility of an individual who is not ready to take risks to freely access information about trading on the stock market and freely download the trading patterns of existing brokers from the stock market [8];

- *payment systems* (Alternative forms of payment are increasingly end-user focus primarily due to the speed of the transaction. A typical such example is the peer-to-peer (P2P) money transfer. This method of money transfer does not exclude banking institutions, but in the future it could seriously threaten the banking industry in combination with blockchain technologies and cryptocurrencies. Money transfer is fast and funds are available immediately. The recipient has the option to decide whether to leave the received money undistributed or to pay it into his bank account. Banks in Serbia accepted this challenge and responded to it, so in 2019 they implemented an instant payment system. Funds are transferred from account to account in just a few seconds, 365 days a year. One of the ways of instant payment for goods and services in shops is to scan a QR code, which is a two-dimensional graphic symbol on a mobile phone, by scanning which payment is made to the seller or even to the manufacturer. China is the world's largest user of payments made by mobile phones and even street vendors. At the markets, by scanning the code, payment is made directly to the producer's account, whereby the buyer or seller settles later. Blockchain technologies and crypto-currencies describe financial technologies that offer virtual currencies as an alternative to existing money [3]. This technology represents a much broader concept than cryptocurrencies. It can be used in other systems and not only in the financial market [2];

- *other financial technologies* (applied in the field of insurance, search and comparative analysis with the help of internet search engines, development of new technologies, IT solutions and infrastructure). Research has shown that banks and financial institutions are undergoing a major transformation in order to keep up with modern and digital technological changes. Numerous studies have forced the conclusion that FinTech, supported by blockchain technology, will lead to major changes in investment standards that offer useful information about clients. Blockchain in FinTech is based on capital and decentralization and as such can provide a much more efficient banking alternative than the current alternative [1]. Research shows that most banks are currently focused on blockchain technology to accelerate the promotion of economic growth and the development of green technologies. The results indicate that by overcoming the shortcomings in the Bitcoin system and blockchain technology, financial processes can be managed in a more efficient way than in the already existing system. Blockchain technology has the potential to optimize the global financial infrastructure, improving the efficiency of existing financial systems [9]. Blockchain technology, as a new technique that has appeared in recent years, is widespread in all sectors of society, especially in financial institutions [10]. Blockchain technology was first invented by Nakamoto in 2008 (Satoshi Nakamoto in 2008). Years. He tried to design a decentralized system of electronic cash transactions in order to solve the double payment problem and to improve the security of information verification [11]. This is the reason why blockchain technology quickly found its place in the financial sector. The advantage of blockchain technology such as decentralization, openness, autonomy, information resistant to unauthorized use and anonymity is that it can reduce the operating costs of a commercial bank and somewhat improve the efficiency of capital utilization [12]. Blockchain systems possess a number of attractive attributes for the banking and financial services markets. These systems are resilient and can operate as decentralized networks that do not require an operating system and have no single point of failure. Because they work using open source distributed protocols, they have integrity and do not need to trust a third party to execute transactions. Public blockchain systems are transparent, as all changes are visible to all parties [13]. Blockchain based on five principles: computational logic, peer-to-peer transmission, record irreversibility, distributed database and pseudonymous transparency, has enormous potential to significantly influence the transformation of the financial services industry. With the increasing operations of decentralized banking, insurance, trade finance, financial markets and cryptocurrency markets based on blockchain, the impact of blockchain on the entire business sector is increasingly attracting the attention of scholars from around the world [14]. With the reduction in complexity and costs of implementation and the increasing number of pilot projects, Blockchain is becoming a technology that is increasingly acceptable. Perceptive executives and managers should see how technology fits into their business and how it can improve their business and create an edge over competitors. [15, 16, 17, 18]. In the banking and financial services sector, blockchain technology can streamline business processes while creating secure, reliable records of contracts and transactions [13]. Blockchain technology will certainly influence the transformation of the banking and financial sector to a large extent, given that information technology enables equal P2P communication, as well as communication with mass media. Blockchain allows the public to send and receive money instantly, securely and with a low transfer fee for fast transactions without third-party intervention, which reduces or eliminates the chances of hacking. The digitization of banking and financial services is incomplete without all the components of the fourth industrial revolution: blockchain networks and the comprehensive preparation of financial technology companies for the digital platform and other services. Digitized banking services strongly challenge old business models and tradition-based processes with faster response times and skills in offering secure and simple payment transactions [19]. The banking and financial services industry has noticed the many benefits of blockchain technology.

III. ANALYSIS OF BLOCKCHAIN APPLICATION IN FINTECH

Financial technology (fintech) refers to financial innovations that create new business models, applications, processes, or products through technology. These innovations can have a significant impact on financial markets, financial institutions, or financial service [20]. Modern fintech deal with the creation of tools for tracking cash flows, accounts, advances in the insurance industry, and provide analytical and infrastructure tools for financial institutions. Blockchain technology can speed up the process and make it more secure. Using blockchain technology, both parties can see and track all document changes online during the lending process. Moreover - the distributed blockchain guarantees the complete integrity of the process. As a result, it offers customers a safer, cheaper and more efficient way to borrow funds. The development of blockchain solutions for financial services can lead to several benefits for the industry. Blockchain in financial services has also led to the introduction of decentralized finance, better known as DeFi (Decentralized Finance). DeFi is a form of finance powered by blockchain technology that aims to remove third party from financial services through the use of smart contracts. Blockchain technology brings new solutions and advantages in financial technologies, taking into account that blockchain finds application in [21], [22].

Security and Transparency- With blockchain in financial services, transparency and security can be ensured simultaneously. Blockchain has the property of immutability, which means that data cannot be changed. Ensures that all data is secure, authentic and accurate. Several blockchain networks support Zero-Knowledge Proof technology as a privacy solution for their blockchains. It enables the verification of financial data without disclosure.

Blockchain technology helps ensure the integrity of a distributed system, but at the same time provides real-time transparency and cost savings through the use of a consensus algorithm [23]. Blockchain technology is a decentralized, coded security system that enables the development of new digital platforms and services using this development technology. Most research studies have shown that security is the most significant barrier to the adoption of blockchain technology. Since the digital world is full of known and unknown cyber threats, critical data must be protected immediately [24]. According to Yaqoob, et.al, the security threat is 51% [25]. For these reasons, all State Governments and relevant departments should develop and implement laws that will allow people to profit from Blockchain, but strictly prohibit the use of Blockchain for criminal purposes such as capital control, terrorist financing and money laundering [24].

Reduced Cost- With blockchain in finance, many costs can be reduced. Blockchain technology is a form of DLT (Distributed ledger technology), which can help increase transparency and reduce costs while ensuring security. Financial service providers such as banks can also implement smart contracts into their systems to reduce costs.

Collaboration- Removes the third party from the transaction. By providing a ledger that no one manages, blockchain would have the ability to provide specific financial services. One of these services is payment or securitization, without the need for a bank. Blockchain enables the use of tools such as "smart contracts", self-executing contracts based on the blockchain [26].

Effectively Control Risks-By applying blockchain, each stakeholder is treated as a node. Hence: peer-to-peer (P2P) transactions can be enabled, eliminating the need for third parties. Fund management and credit risks are reduced as all transactions are recorded online. Smart contracts help transactions settle quickly, and data immutability improves reliability. The application of blockchain makes it easier for financial service providers to deal with all risks.

Blockchain creates new risks, but also helps mitigate existing risks by promoting accountability, maintaining record integrity, and providing an irrefutable record [27]. Based on analyzes of the impact of the implementation of blockchain technology (BCT) on the accuracy, reliability, visibility, incorruptibility and timeliness of processes and transactions in the supply chain, it can be said that it is suitable for improving robustness, transparency, accountability and decision-making in risk management [28].

Instant Settlments- In the current financial system, some payments can take up to a week to clear. The reason for this is mainly the presence of third parties in the system. By applying blockchain, peer-to-peer (P2P) transactions are possible. This implies the elimination of third parties as smart contracts will be able to successfully manage transactions. As the "layers" of the system will be reduced, transactions will be faster and easier.

Instant payments have the potential to become widely used in the euro zone. The extent to which this will be achieved depends on the environment in which we live and on the speed at which the transformation will take place, which depends from country to country. [29].

Better Auditting- With the implementation of blockchain, the audit process can be simplified. Blockchain records are immutable, so auditors can check them to make sure compliances are being met correctly and what exactly is going on in that financial organization. Transparency will be maintained with the help of blockchain. Any suspicious transaction can be easily traced.

Blockchains can definitely be a huge help to the audit system, in terms of increasing efficiency and improving auditor procedures. Auditors are provided with a better insight into the state of the client they audit during the entire financial year. Despite technological advances in the form of blockchain, auditors still have reason to investigate in order to detect corruption of management personnel and verify the verifiability of accounts [30].

In recent years, many companies are trying to find the way how to use blockchain to create better financial services or improve existing ones. There are many applications of blockchain in finance, including [22]:

RTP solutions- Sending money will only take a matter of minutes. Implementing RTP has been risky with the traditional banking process, but Blockchain accelerates the implementation process. As a result, irrespective of any app used for money transfer, transactions will happen securely.

Cross-border Payments- While setting up to collect or fund transfer across other countries, the limitations make the process slow, tiresome and challenging. With Blockchain, the restrictions can be melted. In addition, it is an entirely internet-based operation which removes the need for an additional setup cost.

Smart Contracts & Recurring Payments- For SaaS (Software as a service) & B2B industries, smart contracts will help secure credible transactions that can be released based on a completed action, event, or conditions. It is useful when the goods are delivered, and the funds are released in the logistics.

Lending platforms- Fintech blockchain solutions make loans more accessible to both lenders and borrowers. However, with blockchain in finance, borrowers can directly deal with lenders about the interest rate, installments and duration of the transaction with the help of immutable smart contracts. Borrowers and lenders can negotiate terms on smart contracts.

Invoice Management and Billing Solution- A significant number of companies are adopting electronic invoicing, but they lack the standards needed to execute invoice financing in a simplified manner. With blockchain in finance, companies can upload invoices to the blockchain via smart contracts.

Fund Investment- Currently investing in funds is very time-consuming and expensive. The current procedure involves manual processes that use multiple databases. With blockchain, providers can store users' legal, personal and public information on the blockchain. This could: reduce the possibility of errors and fraud, introduce transparency and thus facilitate access to data.

Financial Record Keeping- Companies plan to use blockchain to store immutable records of financial-related information such as: financial history, profits earned, distribution of dividends. Smart contracts allow different stakeholders to gain access to relevant information. Therefore, blockchain helps companies bring transparency to financial systems.

Keeping accurate and up-to-date records is vital to business success. Good records help to reduce losses, manage cash, fulfill all legal, regulatory and tax obligations and improve financial analysis [31].

IV. OPEN BANKING

A. Concept of open banking

Behr analyzes the importance of information exchange between lenders. Information from the public credit register of the central Albanian bank, related to access to credit, cost of credit and credit performance. The results of the analysis indicate that the sharing of information through the central registry does not affect the access or cost of loans, but contributes to the improvement of loan performance. Loans approved after the introduction of the credit register have a 3% lower chance of becoming problematic. The effect of information exchange is more pronounced among borrowers who reuse loans and in areas where banking market competition is less, which indicates that information exchange between lenders improves loan performance mainly by disciplining borrowers to repay the loan due to their concern about access to loans in the future [32]. Behr and Sonnekalb find that the effect of information sharing is more pronounced among repeat borrowers and conclude that the disciplinary effect of information sharing is stronger for clients who have already secured a relationship with the lender [33].

Based on the research results of many authors, it can be said that credit information sharing improves bank loans ([34, 35, 36] and credit quality [34, 33]. The degree of banking market concentration reduces the effect of credit information sharing on bank loans. The results are robust to control possible interactions between credit information sharing and management [36].

Fosu et al. during the study of the impact of the exchange of credit information on the rate of loan defaults in banks based in developing countries came to the conclusion that the sharing of credit information reduces the rate of loan defaults, that the relationship between the sharing of credit information and the rate of loan defaults is conditioned by the concentration of the banking market and that the quality of management at the country level, it does not have a strong role in moderating the impact of credit information sharing on the loan default rate[37] .

Banks and lenders are required to share information about consumers as part of open banking, enabling them to provide customers with specialized services tailored to their requirements and financial situation. This can be done while maintaining privacy, integrity and security using blockchain technology. Open banking refers to the use of APIs to share financial data and services with third parties. Third parties typically provide technology, a service or an app to the bank's customers that makes use of the shared financial data and services. The shared financial data comprises e.g. the statements and transaction records belonging to the banks customers. This data cannot be made openly available, but it is only shared at explicit request of the customer. Open banking provides the technological infrastructure and the legal frameworks to make such consent-driven sharing happen. Every financial institution currently has its own internal system in which information about consumers is stored. Since open banking requires opening APIs for other financial institutions to consult information about that customer, it is necessary for them to be on a decentralized and shared platform. Each authorized financial institution must develop an API that allows other financial institutions to access customer information when requested. This will result in costly and time-consuming processes for participants. Fig. 1. provides a current view of how open banking works. [38]

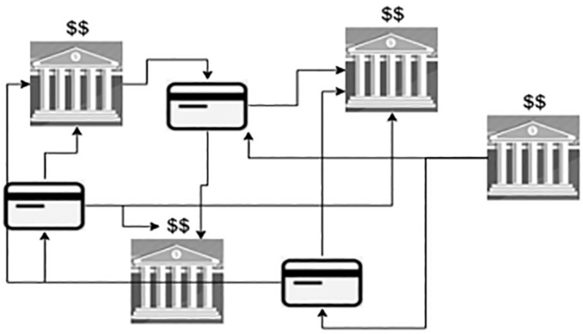

Fig. 1. Current overview of the functioning of open banking

The second scenario shows how open banking could work, minimizing operational costs for all participants by improving control and regulation of central banks, as well as more efficient updating when needed. This scenario refers to open banking using blockchain technology whose platform is decentralized and whose APIs are universal. The central bank will be able to supervise financial institutions in accordance with their regulatory means. Smart contracts will guarantee that the protocol is followed. The client will also benefit from controlling their own data and authorizing the sharing of information that requires access for personalized and better services. In this model, the user has full control over all their data in an efficient manner, having the ability to grant and revoke access at any time. Fig. 2. provides a current view of how open banking could work using blockchain technology [39].

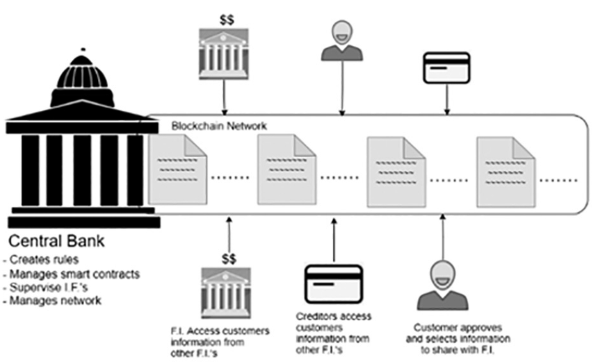

Fig. 2. An illustration of how open banking could work using blockchain technology

B. Advantages of open banking

Secure Payments- Data security is vital, so it is understandable that consumers may believe their data is not safe if it is now available to third parties and companies. However, this is not the case – Open Banking actually has security at its core. Not only has consumer identity significantly been approved in recent years, but all the data is also encrypted and stored securely.

Better Customer Experience- One of the main goals of open banking is to improve financial services for consumers, and one way it achieves this is by creating a better customer experience. Less time-consuming form-filling means making payments and managing personal finances has never been easier

Centralised Information- The 2018 changes in Open Banking mean consumers can now get more services in one place as their information, previously only available to banks, is now kept in a central location for others to access if/ when is necessary.

Instant Payments- Funds travel quickly with Open Banking, meaning you will receive the money instantly rather than taking a while to process. Not only is this great for a business' cash flow, but it also reduces the risk of failed transactions which can be costly.

C. Disadvantages of open banking

Relatively new- While APIs have been around for some time, open banking is a relatively new concept. This means a lot of trial and error situations are yet to come.

Lack Of Consumer Trust- Some people are not great at dealing with change, especially when it comes to technology. As open banking is still relatively new, it will take a while for some consumers and businesses to come around to the idea of it.

Safety Concern- Whilst open banking is secure, it is understandable that some people will be skeptical, especially as it involves personal financial data. The key is to highlight the secure nature of this system, emphasizing that their data is safe. It is however imperative that consumers know the importance of checking the authenticity of any open banking software they use before they start [39].

V. CONCLUSION

By reviewing the relevant available literature, it can be said that the financial market has recognized the importance of the development and implementation of financial technologies that will enable the development of many innovative individuals to find their place in the financial sector and to realize themselves in the financial market, given that the opportunities for the application of financial technologies are great. Through the application of fintech, there are great opportunities for business improvement through getting closer to the end users, which requires adequate legal regulations.

Then financial institutions would become safe havens for users. The financial services industry is traditionally known for its legacy systems. There are banks whose systems are 30-40 years old and which are outdated, so their obsolescence is precisely the reason for them to innovate and improve their systems by accepting blockchain, which would allow them to save considerable funds. By implementing and applying new financial technologies, banks would not only become more efficient, but would also be given the opportunity to trade faster and cheaper on the financial market.

Research shows that Blockchain technology will have a wide application in financial fields in the future, considering that Blockchain technologies enable decentralization, openness, autonomy, information resistant to unauthorized use and anonymity, which can reduce the cost of doing business for a commercial bank and somewhat improve the efficiency of using financial capital. At present, blockchain technology has been widely applied in the financial market, especially as a financial record, cross-border payment and asset-backed securitization, as a technology that has great advantage in the information transaction sector. Research shows that this technology is revolutionary and that as such in the future it should be widely used in the financial sector as well as in all segments of life.

Following the trends of Blockchain application and taking into account the advantages and disadvantages of this technology, it can be said that Blockchain has all the prerequisites to make its full contribution to changing the banking system, both in the world and in Serbia. The conclusion is that all research activities are aimed at the maximum use of all the available potential of Blockchain, which is a good support for financial systems in the future. The implementation of Blockchain in financial infrastructure can solve some financial issues much more efficiently than existing financial systems.

Research shows that the comprehensive transformation of the financial industry brings with it major changes in the regulatory sense, which requires the development of comprehensive and precisely defined legal regulations, especially in the open banking sector, given that digitization and the widespread use of information technologies bring numerous risks related mainly to Internet security. Special attention should be paid to the security of the entire system, especially in the segment of protection against hacking. The challenge of creating effective protection has yet to be faced and adequate solutions have to be sought.

Blockchain technology still faces various challenges and shortcomings today, but it is still the most promising technology in the banking and financial sector with the tendency to become the leading technology in the banking sector.

So the future of blockchain technology can only be brighter [1].

REFERENCES

[1] Kumari, A., Devi, N. C. (2022).) Kumari, A., & Devi, N. C. (2022). The Impact of FinTech and Blockchain Technologies on Banking and Financial Services. Technology Innovation Management Review, 12(1/2).

[2] Тадић Живковић, Д.: (2019): Фinansijske tehnologije i inovacije kao ključni faktor daljeg razvoja bankarstva na Бalkanu, Zbornik radova sa VII Internacionalnog naučnog skupa EKONBIZ, 146-155, Univerzitet u Istočnom Sarajevu

[3] Dorfleinter, G., L. H. (2017). Definition of FinTech and Description of the FinTech industry. Springer International Publishing AG 2017

[4] Badr, M.A.A. (2020): Industry 4.0 and its Implications for the Financial Sector. Procedia Computer Science, 177:496-502. DOI: https://doi.org/10.1016/j.procs.2020.10.068

[5] Lee, I. (2018): Fintech: Ecosystem, Business Models, Investment Decisions, and Challenges. Business Horizons, 61(1): 35-46. DOI: 10.1016/j.bushor.2017.09.003.

[6] Arner, D.W., Barberis, J.N., & Buckley, R.P. 2016. The Evolution of FinTech: A New Post Crisis. Geo. J. Int'l L, 47: 1271. DOI: https://doi.org/10.2139/ssrn.3211708

[7] Karaçallık, D. (2018): Effects of Digital Transformation on Fintech Systems

[8] Pan, W., Altshuler, Y., & Pentland, A. (2012). Decoding Social Influence and the Wisdom of the Crowd in Financial Trading Network. Proceedings of the 2012 ASE/IEEE International Conference on Social Computing and 2012 ASE/IEEE International Conference on Privacy, Securit, (стр. pp.203-209). (Computer Society, Washington, DC

[9] Cocco, L., Pinna, A., Marchesi, M. (2017): Banking on blockchain: Costs savings thanks to the blockchain technology. Future internet, 9(3), 25

[10] Swan, M. (2015): Blockchain: Blueprint for a new economy, O'Reilly Media, Inc, 2015.

[11] Underwood, S. (2016): Blockchain beyond bitcoin, Commun. ACM. 59 (2016) 15-17.

[12] Yli-Huumo, J., Ko, D., Choi, S., Park, S., Smolander, K. (2016): Where is current research on blockchain technology? — a systematic review, PloS one 11 (2016) e0163477

[13] Treleaven, P., Brown, R. G., & Yang, D. (2017). Blockchain technology in finance. Computer, 50(9), 14-17

[14] Pal, A., Tiwari, C.K. and Behl, A. (2021), "Blockchain technology in financial services: a comprehensive review of the literature", Journal of Global Operations and Strategic Sourcing, Vol. 14 No. 1, pp. 61-80. https://doi.org/10.1108/JGOSS-07-2020-0039

[15] Behl, A., Dutta, P., Luo, Z. and Sheorey, P. (2021), "Enabling artificial intelligence on a donation-based crowdfunding platform: a theoretical approach", Annals of Operations Research, pp. 1-29.

[16] Choudhury, A., Behl, A., Sheorey, P.A. and Pal, A. (2021), "Digital supply chain to unlock new agility: a TISM approach", Benchmarking: An International Journal.

[17] Behl, A. (2020), "Antecedents to firm performance and competitiveness using the lens of big data analytics: a cross-cultural study", Management Decision

[18] Behl, A., Dutta, P., Lessmann, S., Dwivedi, Y.K. and Kar, S. (2019), "A conceptual framework for the adoption of big data analytics by e-commerce startups: a case-based approach", Information Systems and e-Business Management, Vol. 17 Nos 2/4, pp. 285-318

[19] Mekinjić, B. (2019): The impact of Industry 4.0 on the Transformation of the Banking Sector. Journal of Contemporary Economics, 1: 8-17. DOI: http://dx.doi.org/10.7251/JOCE1901006M

[20] C. Baliker, M. Baza, A. Alourani, A. Alshehri, H. Alshahrani and K. -K. R. Choo (2023): "On the Applications of Blockchain in FinTech: Advancements and Opportunities," in IEEE Transactions on Engineering Management, doi: 10.1109/TEM.2022.3231057

[21] LeewayHertz, Akash Takyar, (n.d.). U: How can blockchain revolutionize the finance sector?, [Accessed 18.05.2023.] from https://www.leewayhertz.com/10-use-cases-of-blockchain-in-finance/

[22] M2P Fintech, (Apr 28, 2022). U: Blockchain and Fintech-Use cases and Applications, [Accessed 18.05.2023.] from https://m2pfintech.com/blog/blockchain-and-fintech-use-cases-and-applications/

[23] Ko, T., Lee, J., & Ryu, D. (2018). Blockchain technology and manufacturing industry: Real-time transparency and cost savings. Sustainability, 10(11), 4274.

[24] (Sonal Trivedi, S., Mehta, K., Sharma, R. (2021): Systematic Literature Review on Application of Blockchain Technology in E-Finance and Financial Services, Journal of Technology Management & Innovation vol.16 no.3 Santiago dic. 2021, http://dx.doi.org/10.4067/S0718-27242021000300089).

[25] Yaqoob, S., Khan, M. M., Talib, R., Butt, A. D., Saleem, S., Arif, F., & Nadeem, A. (2019): Use of blockchain in healthcare: a systematic literature review. International journal of advanced computer science and applications, 10(5).

[26] CBINSIGHTS, (October 18, 2022). U: How blockchain could disrupt banking, [Accessed 18.05.2023.] from https://www.cbinsights.com/research/blockchain-disrupting-banking/.

[27] Journal of Accountancy, Tysiac, K. (August 4, 2020). U: Evaluating blockchain and internal control through a COSO lens, [Accessed 18.05.2023] from https://www.journalofaccountancy.com/news/2020/aug/evaluating-blockchain-and-internal-control-coso.html

[28] Chowdhury, S., Rodriguez-Espindola, O., Dey, P. Budhwar, P. (2022): Blockchain technology adoption for managing risks in operations and supply chain management: evidence from the UK. Ann Oper Res (2022). https://doi.org/10.1007/s10479-021-04487-1

[29] Hartmann, M., Hernandez-van Gijsel, L., Plooij, M., Vandeweyer, Q. (2019): Are instant payments becoming the new normal? A comparative study, ECB Occasional Paper Series No 229 / August 2019

[30] Anwar, S., Shukla, V. K., Rao, S. S., Sharma, B. K., & Sharma, P. (2019): Framework for financial auditing process through blockchain technology, using identity based cryptography. In 2019 Sixth HCT Information Technology Trends (ITT) (pp. 099-103). IEEE.

[31] BusinessQueensland (n.d.). U: Financial record keeping, [Accessed 18.05.2023.] from https://www.business.qld.gov.au/running-business/finance/essentials/record-keeping

[32] Behr, P. (2021): The Effect of Information Sharing between Lenders on Access to Credit, Cost of Credit and Loan Performance – Evidence from a Credit Registry Introduction, Journal of Banking & Finance 36(11):3017–3032 DOI:10.1016/j.jbankfin.2012.07.007

[33] Behr, P., Sonnekalb, S. (2012): The effect of information sharing between lenders on access to credit, cost of credit, and loan performance – Evidence from a credit registry introduction, Journal of Banking & Finance, Volume 36, Issue 11, 2012, Pages 3017-3032,

[34] Jappelli, T., Pagano, M. (2002): Information sharing, lending and defaults: Cross-country evidence, Journal of Banking & Finance, Volume 26, Issue 10, 2002, Pages 2017-2045, ISSN 0378-4266, https://doi.org/10.1016/S0378-4266(01)00185-6.

[35] Brown, M., Jappelli, T., Pagano, M. (2009): Information sharing and credit: Firm-level evidence from transition countries, Journal of Financial Intermediation, Volume 18, Issue 2, 2009, Pages 151-172, ISSN 1042-9573, https://doi.org/10.1016/j.jfi.2008.04.002

[36] Fosu, S. (2014): Credit information, consolidation and credit market performance: bank-level evidence from developing countries, International Review of Financial Analysis, Volume 32, 2014, Pages 23-36, ISSN 1057-5219, https://doi.org/10.1016/j.irfa.2014.01.002

[37] Fosu, S., Danso, A., Agyei-Boapeah, H, Ntim, C., Adegbite, E. (2020) Credit information sharing and loan default in developing countries: the moderating effect of banking market concentration and national governance quality. Review of Quantitative Finance and Accounting, 55 (1), 55–103. doi:10.1007/s11156-019-00836-1

[38] GFT, Zanutim, N. L. (februar 1. 2022): How can open banking be applied in blockchain?, [Accessed 18.05.2023.] from https://blog.gft.com/blog/2022/02/01/how-can-open-banking-be-applied-in-blockchain/

[39] Yes.ie, Ian Lowenthal, I. (jul 24., 2020):The Pros and Cons of Open Banking, accessed May 2023 from https://blog.yes.ie/savings-and-investments/the-pros-and-cons-of-open-banking/

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DIGITAL PROJECT-BASED LEARNING

Classroom Layouts for Technology-based Active Learning Spaces

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Abstract—Are the traditional straight-row-of-desks classrooms suitable for actual active learning pedagogies? If not, how shall they be? This project aims to answer these two questions and, in this first step, surveys existent active learning spaces. It starts with the seminal SCALE-UP, followed by TEAL, PAIR-up, and TILE projects. These layouts generally encompass round tables with nine seats, moving tables and chairs, 360º wall-covered whiteboards, and an equal assortment of projectors/monitors so every student sees the information. Other exemplary cases are addressed, for instance, McGill University's principles for designing rooms for active learning. Although it is not an active learning space, a recent ground-breaking proposal is addressed: "teaching in the round". Concluding, flexibility is the keyword in actual learning spaces. Rooms must mutate into different configurations according to the type of class. However, tables should be round and equipped with utilities for students' work.

Keywords - active learning spaces, classroom layout, educational technology

I. INTRODUCTION

Active learning is rooted in constructivist theory and focused on student-centered, collaborative learning [1, 2]. It gained momentum in the last twenty years of century XX, to which Bonwell and Eison's report significantly contributed [3]. In addition, the Bologna Process, which developed in the early years of century XXI, contributed to its dissemination in Europe. Nowadays, a simple internet search reveals that active learning is worldwide spread.

The Bologna Process relied on active learning, aiming for students to acquire transferable competencies that the job market was asking for and that traditional lecturing was not delivering. This strategy was accompanied in Japan [4]. One question, however, arises: what is? What characterizes it?

What is active learning? Simply put [3], active learning involves "students in doing things and thinking about the things they are doing" (p. iii). The distance from traditional lecturing starts to become evident due to the emphasis on thinking, while lecturing is more assimilating (whether thinking or not). Higher-order cognitive processes, such as analyzing, evaluating, and creating, must be presented in students' activities [5, 6]. Active learning characterization helps in defining the picture [3]:

- students are involved in more than passive listening;
- students are engaged in activities (e.g., reading, discussing, writing);
- there is less emphasis placed on information transmission and greater emphasis placed on developing student skills;
- there is greater emphasis placed on the exploration of attitudes and values;
- student motivation is increased (especially for adult learners);
- students can receive immediate feedback from their instructor;
- students are involved in higher-order thinking (analysis, synthesis, evaluation).

Nonetheless, it was found that scholars do not understand well or apply active learning appropriately, having a superficial approach to the concept, limited to the strict application of a project or solving a problem in the classes [4], which is manifestly reductive if the objective is students' acquisition of transferable competences.

Active learning has its merits, mainly in keeping students engaged in their learning work and complementing their technical competencies with transferable skills. By the end of the learning path, students are better equipped and ready for jobs. Active learning, however, has hurdles, some extrinsic, some intrinsic. Among the extrinsic difficulties, which are heavily centered on the teacher, one may find [3]:

- "the powerful influence of educational tradition;
- faculty self-perceptions and self-definition of roles;
- the discomfort and anxiety that change creates;
- the limited incentives for faculty to change."

while the intrinsic are (p. v):

- "the difficulty in adequately covering the assigned course content in the limited class time available;
- a possible increase in the amount of preparation time;
- the difficulty of using active learning in large classes;
- a lack of needed materials, equipment, or resources."

Although this scenario, another under looked question emerges: does active learning work in rooms designed for traditional lecturing? Which prompts a subsequent question: if not, what should be active learning spaces' desirable layout, acknowledging the high involvement of educational technology nowadays, especially in higher education?

This article starts by summing up the traditional lecturing classrooms, the given view, and then surveys room layouts purposefully designed for technology-based active learning, all in the present century.

II. THE GIVEN VIEW

Traditional classrooms were designed to follow the traditional teaching method: lecturing, or exposition. The communication follows a one-sense flow from the lecturer to the students. The lecturer's speech, what he writes on the whiteboard, projected slides and videos, and teaching information stream from the front of the room towards students (Fig. 1). Eventually, students may answer questions prompted by the lecturer. Therefore, the traditional classroom layout has straight rows of desks where the receivers sit, facing the front of the classroom, where the lecturer lays, together with the whiteboard, and video projector, i.e., the transmitters. The lecturer may walk around the aisles, ensuring that all students are attentive. In the teaching-learning system, teaching dominates. Students learn individually. Thus, their attention is of paramount importance. The straight row of desks limits turning heads, side conversations, and other kinds of distractions which could disturb students' assimilation. At least since the 19th century, this has been the given view of a classroom layout.

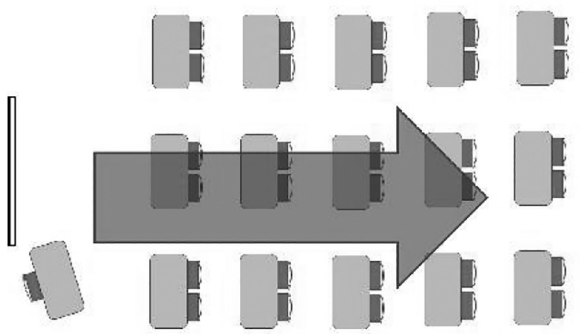

Fig. 1 Traditional classroom layout composed of rows of desks, where the students sit, facing the front of the room where the lecturer, whiteboard, and video projector is.

The test of time has come to sanction the traditional layout as effective (otherwise, it would probably have already been changed). Although it should be the nature of the task that must direct the classroom arrangement, Wannarka and Ruhl [7] conclude that "students display higher levels of appropriate behaviour during individual tasks when they are seated in rows" (p. 89) when compared to sit in groups or semi-circles. Appropriate behaviour means "following teacher's directions (speaking only with permission, keeping hands to self, etc.) and attending to academic tasks".

III. ACTIVE LEARNING CLASSROOMS LAYOUTS

Traditionally, only gifted students could attend higher education. Does this profile still hold nowadays? Do the highly demanding jobs in post-higher education training accommodate individually brilliant students? The trend of higher education democratization and the demands of the job markets have challenged the traditional lecturing process and called for new ways to make students learn (the focus changed from teaching to learning). As a result, active learning pedagogies have also entered the higher education ecosystem. However, active learning differs from traditional expositive lecturing and demands appropriate spaces. Costa, et al. [8] summarize the two approaches distinctions in Table I.

Table I. Differences between the traditional classroom and the active learning room, according to costa, et al. [8].

Feature	***Traditional Classroom***	***Active Learning Room***
Teacher's positioning in the room	Usually in the forefront of the room because it centers attention	Undefined positioning, which invites the teacher to walk around the room and interact with students to support teaching activities
Desks	Limited reconfiguration flexibility, which makes teamwork difficult	Students sit around the tables, which favours teamwork
Projection display	One single screen under control and usually accessible only by the teacher	Variable number of screens (from none to one per group of students) accessible to teachers and students
Whiteboards	Whiteboards at the front of the room, writing materials with the teacher	Writing boards scattered around the room walls or with wheels, autonomous use by students
Noise	Considered a disruptive element in the class	Natural, it is a consequence of the students' interaction and involvement
Mobility	Non-existent; students sit at fixed desks, and the teacher with little space to move around	Stimulated; stimulated by the type of furniture (e.g., wheelchairs) and the availability and spatial distribution of pedagogical resources

In the technological era, where advances in smart devices dominate higher education students, redesigning classroom spaces has been advocated to contribute to more active learning and increase student involvement [9].

Technology creates opportunities, accelerating students' learning and preparing them for a professional life within companies. Five factors encourage the technological trend [10]:

- generation Z is already acquainted with using technology and, for this reason, expects to take advantage of it in higher education classrooms and projects;
- technology generates opportunities and effectiveness at work;
- most students, teachers and parents want higher education with a meaningful approach;
- scientific studies are discovering how learning can take place more effectively;
- flexibility in sharing and accessing content are requirements of the nowadays students.

The demand to innovate on classrooms stems from the need to share knowledge among everyone. This vision dominates several factors, from better-placed desks and chairs, new collaborative software and "students who practised self-directed learning more easily adapted online. And transparent, meaningful, and open channels of communication between schools, students, teachers and parents were incredibly important" [11]. COVID-19 and emergency remote teaching introduced irreversible changes, which may not be ignored.

Some higher education institutions have been devoting research aiming to identify and test the most suitable classroom layouts for active learning pedagogies, which are detailed in the following sections.

A. SCALE-UP

SCALE-UP, firstly, Student-Centered Activities for Large-Enrollment University Physics [12], then Student-Centered Activities for Large Enrollment Undergraduate Programs [1], and, more recently, Student-Centered Active Learning Environment with Upside-Down Pedagogies [13], was a pioneering project, developed at the end of century XX, to design a classroom for active and collaborative learning, aiming to increase STEM students' success. The room was designed to improve student interaction while they work on assignments. The lecturer freely observes, asks questions, and clarifies misgivings while circulating through the classroom. In the project's phase II, according to the layout of a SCALE-UP room, students are allocated by threeelement groups at round tables (180 cm diameter) with nine seats to discuss their work (cf. Fig. 2). In addition, some whiteboards are arranged so the group can draw schemes and align their thinking. The instructor station was firstly on a rolling cart. Considering technology, each group has one laptop computer to search on the internet and projectors.

SCALE-UP rooms had the novelty of being classrooms without a defined front [14]. Besides North Carolina State University, many more universities worldwide adopted the SCALE-UP room configuration for active learning purposes, sometimes adding small changes [1, 13].

B. TEAL

TEAL stands for Technology-Enabled Active Learning. It was implemented at MIT by the beginning of century XX and grounds on the SCALE-UP project, encompassing policentrically designed rooms with round tables for student work. There are 13 in the room. The TEAL room adds technology to the SCALE-UP room, providing a "media-rich environment, " including videos with 2D and 3D visualizations, desktop experiences, web-based home assignments, and conceptual questions using PRS, personal response system [15].

C. PAIR-up

Grounded on the SCALE-UP and the TEAL active learning classrooms layouts, by the end of the first decade of century XXI, the University of Minnesota has built pilot rooms based on the PAIR-up model (Pedagogy-rich; Assess learning impact; Integrate innovations; Revisit emerging technologies). The PAIR-up rooms have two main girders: 1) space flexibility, i.e. the room should transform into different configurations, and 2) student-centered teaching because the ultimate objective is to improve students' learning [16, 17]. The first two rooms had 45 for Electrical Engineering/Computer Science (Fig. 4) and 117 seats for Biological Sciences. The tables have nine seats for three student groups teamwork. These are laptop-based rooms, and there are 360º glass marker boards.

PAIR-up rooms provide flexible active learning rooms. There are demountable wall systems, which allow for flexing the room according to the needs. In addition, the ALCs employ reconfigurable low-profile flooring with internal power and cable management to accommodate reconfiguring technology and wiring in the room (cf. Fig. 4 and Fig.5).

Fig. 2 SCALE-UP room at the North Carolina State University; 99 seats.

Fig. 3 An example of a TEAL room at MIT, including the nine-seat tables, 360º whiteboards and video projectors; the desktop experiments are visible in the foreground. Photo from [15].

Fig. 4 PAIR-up room at the University of Minnesota. Photo from [17].

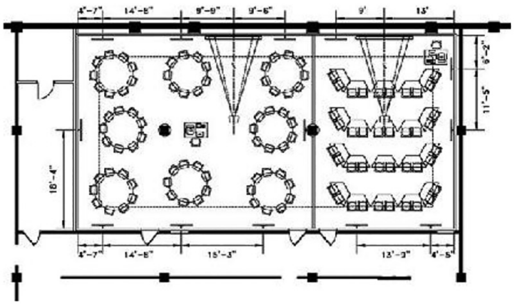

Fig. 5 The PAIR-up room is flexible. Demountable walls and wheeled furniture are crucial for swift layout changes. Schema from [17].

D. TILE

TILE (Transform, Interact, Learn, Engage) is an approach to teaching that incorporates inquiry-driven, team-based learning to increase teacher and student engagement. TILE instructors gain an understanding of these pedagogies through well-designed workshops, one-on-one consultations, and focused technology training. This professional development support enables instructors to create and deliver courses best suited to the learning needs of students in TILE classrooms.

TILE rooms were implemented by the University of Iowa around 2010 and ground on the SCALE-UP and TEAL projects, encompassing the nine-seat tables, power sockets and network access [18]. Each table has three laptops. As depicted in Fig. 6, the walls have multiple whiteboards which cover 360º. Each table has three networked laptops and its own dedicated wall-mounted monitor that can display data from a laptop on the table, the instructor's screen, or work from other laptops around the room (cf. Fig. 6). The instructor's station is in the centre of the room.

Fig. 6 Detail of a table in a TILE room, remarking one laptop per group of three students. Photo from [18].

E. WSU's G10 Room

In the building The Spark, Washington State University has three classrooms specifically designed for active learning classes. One is the G10 room with 126 seats (Fig. 7). Each table has six places. Students sit in a U-shape around the table, i.e., they occupy three sides of the rectangular tables, so everyone sees others' faces. The free side has a large flat panel and a PC. Connecting personal laptops to project in the flat panel is also possible. To improve flexibility in the space, the chairs are wheeled, and the alleys are spacious for circulation. Nonetheless, the tables are fixed. The room also encompasses two projectors with large screens for all classroom visibility.

Fig. 7 Washington State University's Spark G10 active learning classroom. Students view. Photo from [19].

F. McGill's "Principles for Designing Teaching and Learning Spaces"

Around one decade ago, McGill University established its "Principles for Designing Teaching and Learning Spaces" [20]. It is worth sharing the five principles in full:

1. academic challenge: learning spaces should allow students to actively engage with content and include a range of technologies that support multiple modes of teaching and learning;
2. learning with peers: learning spaces should provide features that permit students to work both individually and in collaboration with one another;
3. experiences with faculty: learning spaces should facilitate communication and interaction between students and faculty;
4. campus environment: learning spaces should be consistent with the university's culture and priorities as reflected in the campus master plan, follow university design standards, and be designed with future flexibility in mind;
5. high-impact practices (HIPs): learning spaces exist within a larger campus context; there should be an ease of transition between spaces so as to better support highimpact practices inside and outside the classroom.

These principles intersect with five dimensions for proper operationalization: layout, furniture, technologies, acoustic, and lighting/color. They are detailed in full in Table 2.

TEAL inspired McGill's active learning rooms. Fig. 8 depicts an exemplary room, McIntyre 325 [21]. The tables have eight seats for individual or group work. There is plenty of space for working materials and laptops, and the armless chairs are wheeled, which allows multiple configurations. The instructor's desk is at the center of the room. Sightlines are not obstructed, and circulation and moving around the tables is easy. All tables have microphones and power outlets. One wall has a large whiteboard.

Table II. McGill's "Principles for designing teaching and learning spaces" (partial) [20].

	Layout	***Furniture***	***Technologies***	***Acoustics***	***Lighting/Color***
Academic challenge: promote individual, active engagement with content	Work surfaces for notebooks, laptops, and textbooks.	Comfortable furniture. Varied furniture to support different types of tasks and preferences.	Access to infrastructure (e.g., printing, power for student laptops). Access to resources (e.g., LMS, internet, virtual labs, specialized software). Multiple sources and screens for simultaneous display of different learning materials	Acoustic design to avoid distraction from outside and inside sources.	Appropriate lighting forindividual work. Intentional use of colour to promote focus.
Learning with peers: promote active engagement with one another	Promote face-to-face communication (e.g., two rows of students on a tier, small groups). Individuals can move about easily. Unobstructed sightlines	Flexible seating(e.g., fixed chairs that rotate, movable tables and chairs, tablet chairs on wheels). Intentional use of furniture of different heights and shapes.	Shared workspaces (e.g., writable walls, digital workspace).	Sound zones support multiple simultaneous conversations. Appropriate amplification available (e.g., student table microphones).	Different lighting patterns to support different activities. Using colour to define groups' use of space.
Experiences with faculty: promote interaction and communication	Easy access to all students (e.g., multiple aisles, unobstructed sightlines).	The podium does not interfere with sightlines, movement and interaction while being large enough for instructional materials. Flexible furniture to support different teaching strategies (e.g., movable, variable heights).	Screen sharing. Ability to control classroom technologies away from the podium (e.g., remote mouse, wireless projection).	Sound zones support multiple simultaneous conversations. Appropriate amplification available (e.g., wireless audio amplification).	Different lighting patterns to support multiple types of teaching tasks. Colours distinguish purposes (e.g., where chairs go, what groups work on what surfaces/ with whom).

Fig. 8 Active learning purposefully designed classroom at McGill University. The McIntyre 325. Photo from [21].

G. "Teaching in the Round" by David Harlan

David Harlan, an academic on theatre, shows, in a workshop, delivered at Washington State University, how a rounded classroom should be managed [22]. The appositeness of the workshop is that David Harlan delivers it in the proper rounded room, staging evidence of its pros and revealing the necessary mastery that the instructor must hold during his performance.

The room is composed of a central circular open space, like an arena, where the presenter moves, a mobile lectern, and fixed tables and seats arranged in circles around the central space, as depicted in Fig. 9. Such architecture contributes to the conversion of a traditional lecture into a theater play.

Fig. 9 Washington State University's Spark G45 rounded room. Main view from the floor. Photo from [23].

The presenter must keep the audience attentive and engaged all the time. The rounded room is designed for such purposes, but some tactics and warnings disclosed by David Harlan are required to accomplish the objectives effectively. Therefore, some previous staging work is required. Besides their scientific and technical abilities, the teacher must sum theatrical skills. In summary:

- field-of-view: this is the first concern raised by the particular room design; the presenter always has someone at his back; the solution is movement;
- motion: the arena should be divided into quarters; the quarters help the presenter organize their moving (round stages have no corners!); the lecturer should split their time among the quarters and should not repeat the same moving patterns during the talk; diversity is the key to an engaging talk; moving must be coordinated with the presentation; the presenter should not move when is presenting an idea or concept but move when he changes to another idea or concept;
- positioning and lighting: keep in the circle and avoid walking in the aisles because the lighting is designed to focus inside the circle; the remaining space, aisles and seats, are in the penumbra and it is difficult to see the lecturer's face (which should be avoided); the exception is when the lecturer wants to give "the stage" to students (e.g. because they are discussing lively); in such cases "disappear" into the aisle darkness;
- eyes focus: expand the circle of attention; do not focus on the front only; extend attention to other senses besides vision; hearing is 360º and may help to understand if the audience behind is engaged or not; this way, the presenter may feel that someone is drifting away, and, at that point, he may redirect the focus to that person and hook him into the presentation again (which is common in traditional rooms, but here it is 360º);
- interactions: during questions and answers with the audience, approach the person who posed the questions, and then move away in the opposite direction in the circle repeating the question (for the micro and recording if that is the case); in the opposite point turn again to the questioner; thus, the lecturer has most of the audience again in front of him, and the focus still is the questioner and his questions; in this way, the lecturer has created an atmosphere for discussion encompassing most of the audience; if many questions happen at the same time, or if the attendants start discussing each other, the lecturer let it flow and intervene to moderate the excesses; if that is not desirable, select the questioners and speak to one at a time, breaking the dispute.

Typical comments from the attendees:

- sense of proximity;
- permanent movement around;
- gestures;
- evokes imagination.

The round room is a suitable space for discussions, debates, and performances. Even expositive lectures may gain improved liveliness as long as they are adequately rehearsed.

IV. CONCLUSION

Flexibility is the keyword that emerges. Furniture must be movable, mainly chairs, allowing different layout configurations. This is possible only in a spacious room, as students and faculty must circulate freely.

The tables must be round so everyone can see each other and seat around nine students. It should provide power sockets, cable internet access, and ample space for working materials and laptops. An interesting aspect of this quartercentury survey is that personal laptops substituted desktop computers.

The instructor's desk should be placed in the center of the room, minimizing the distance to the students. Sightlines must not be obstructed.

Walls also have roles. Either large glass whiteboards or projection screens usually occupy them. Thus, the room arrangement must ensure the sightlines are clear.

The detailed analysis of these projects, proof-of-concept, and examples permits the identification of good practices on acoustics, lighting, and suitable technology to support students' work and learning. In addition, the consideration of McGill University's principles is a must.

For future improvement, maybe bring the idea of the central arena in the round room to the active learning spaces, increasing their flexibility and allowing more performative lectures.

REFERENCES

[1] R. J. Beichner, "History and evolution of active learning spaces," New Directions for Teaching and Learning, vol. 2014, no. 137, pp. 9-16, 2014, doi: 10.1002/tl.20081.

[2] P. Baepler, J. D. Walker, D. C. Brooks, K. Saichaie, and C. I. Petersen, A Guide to Teaching in the Active Learning Classroom. Sterling, Virginia: Stylus Publishing, 2016.

[3] C. C. Bonwell and J. A. Eison, Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports. Washington DC: Association for the Study of Higher Education.; ERIC Clearinghouse on Higher Education, 1991.

[4] H. Ito and S. Takeuchi, "The demise of active learning even before its implementation? Instructors' understandings and application of this approach within Japanese higher education," Education Inquiry, vol. 13, no. 2, pp. 185-204, 2022/04/03 2022, doi: 10.1080/20004508.2020.1860283.

[5] L. W. Anderson et al., A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. New York: Addison Wesley Longman, 2001.

[6] D. R. Krathwohl, "A revision of Bloom's taxonomy: An overview," Theory Into Practice, vol. 41, no. 4, pp. 212-218, 2002/11/01 2002, doi: 10.1207/s15430421tip4104_2.

[7] R. Wannarka and K. Ruhl, "Seating arrangements that promote positive academic and behavioural outcomes: a review of empirical research," Support for Learning, vol. 23, no. 2, pp. 89-93, 2008, doi: 10.1111/j.1467-9604.2008.00375.x.

[8] M. J. Costa, C. Moura, J. Silva, and R. Oliveira, "Salas de aula que potenciam a aprendizagem ative," IDEA Digital, vol. 36, 2021-04-22. [Online]. Available: https://idea.uminho.pt/pt/ideadigital/entradas/Paginas/entrada36.aspx

[9] D. C. Brooks, "Space matters: The impact of formal learning environments on student learning," British Journal of Educational Technology, vol. 42, no. 5, pp. 719-726, 2011, doi: 10.1111/j.1467-8535.2010.01098.x.

[10] Steelcase Education, Blended Learning Ideabook, 2016. [Online]. Available: https://www.steelcase.com/content/uploads/2018/08/Blended-Learning-Ideabook-PDF.pdf.

[11] Steelcase Education, "How to design hybrid and blended learning environments," 2020-08-20. [Online]. Available: https://www.steelcase.com/research/articles/topics/learning/how-todesign-hybrid-and-blended-learning-environments/

[12] R. Beichner et al., "Case study of the physics component of an integrated curriculum," American Journal of Physics, vol. 67, no. S1, pp. S16-S24, 1999, doi: 10.1119/1.19075.

[13] A. V. Knaub, K. T. Foote, C. Henderson, M. Dancy, and R. J. Beichner, "Get a room: The role of classroom space in sustained implementation of studio style instruction," International Journal of STEM Education, vol. 3, no. 1, p. 8, 2016/05/05 2016, doi: 10.1186/s40594-016-0042-3.

[14] R. Talbert and A. Mor-Avi, "A space for learning: An analysis of research on active learning spaces," Heliyon, vol. 5, no. 12, 019, doi:10.1016/j.heliyon.2019.e02967.

[15] Y. J. Dori, J. Belcher, M. Bessette, M. Danziger, A. McKinney, and E. Hult, "Technology for active learning," Materials Today, vol. 6, no. 12, pp. 44-49, 2003/12/01/ 2003, doi: 10.1016/S1369-7021(03)01225-2.

[16] A. Whiteside and S. Fitzgerald, "Designing spaces for active learning," Implications, vol. 7, no. 1, 2009. [Online]. Available: https://www.researchgate.net/publication/237439438_Designing_Spaces_for_Active_Learning.

[17] A. Whiteside, L. Jorn, and A. H. Duin, "Using the PAIR-up model to evaluate active learning spaces," EDUCAUSE Quarterly Magazine, vol. 32, no. 1, 2023-02-27 2009. [Online]. Available: https://er.educause.edu/articles/2009/3/using-the-pairup-model-toevaluate-active-learning-spaces.

[18] S. Van Horne, K. Saichaie, and C. Murniati, "Assessing teaching nd learning in technology-infused TILE classrooms at the University of Iowa," EDUCAUSE Learning Initiative (ELI) / Seeking Evidence of Impact (SEI) Case Studies, July 12, 2012. [Online]. Available: https://library.educause.edu/resources/2012/7/assessing-teaching-andlearning-in-technologyinfused-tile-classrooms-at-the-university-ofiowa

[19] Washington State University - Academic Outreach & Innovation. "Spark G10." [Webpage]. https://li.wsu.edu/buildings-andspaces/general-university-classrooms/classroom-specs/spark-g10/ (accessed 2022-11-12, 2022).

[20] A. Finkelstein, J. Ferris, L. Winer, and C. Weston, "Principles for Designing Teaching and Learning Spaces," 2019, June 17. [Online]. Available: https://www.mcgill.ca/tls/files/tls/principles_for_designing_teaching_and_learning_spaces_june_17_2019.pdf

[21] McGill University - Teaching and Learning Services (TLS). "McIntyre 325." [Webpage]. https://www.mcgill.ca/tls/spaces/classrooms/mcintyre-325 (accessed 2023-04-29, 2023).

[22] Washington State University - Academic Outreach & Innovation. "Teaching in the round." [Video]. YouTube. https://youtu.be/FZN8EFTSA88 (accessed 2022-11-12, 2022).

[23] Washington State University - Academic Outreach & Innovation. "Spark G45." [Webpage]. https://li.wsu.edu/buildings-andspaces/general-university-classrooms/classroom-specs/spark-g45/ (accessed 2022-11-12, 2022).

Project-based Learning with Mattermost in Higher Education

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Abstract—This paper explores the use of Mattermost platform in project-based learning, examining how both teachers and students can use it and benefit from it. The aim of this research is to display implementation and setting up the platform and development of an application used to extract system and usage data that will be analyzed by professors. Mattermost is a proven tool for promoting effective communication and collaboration in project-based learning activities by improving students' critical thinking and problem-solving skills. Despite the potential benefits of the platform, currently there are no available analytics tools for the open-source version of Mattermost. The conclusion of this paper is that it is required to develop custom application that requires ETL procedures for data preparation before analysis can be conducted and certain actions based on it taken.

Keywords - project-based learning, e-education, information technologies, project management

I. INTRODUCTION

Fast paced society, intertwined with technology has created a demand for all people to become technically literate and to continually learn more. This presents a challenge for students of information technologies, software development, e-business, and many other fields. It also affects faculties and departments who need to adjust to these fast changes and modern trends. Traditional offline teaching is becoming outdated since the attention span of young adults becomes shorter, and it causes lack of motivation and will for engagement. The solution to overcome these difficulties is introduction of e-education. It can be adjusted to any specific course or group of students. Being more engaged with modern tools used in e-education enhances students' involvement and awareness. But increasing students' presence is just the first step in teaching improvement. The factors that lead to one's success are learning how to work in team, solve problems and find creative solutions for problems in a dynamic environment. By putting students in situations where they can learn these skills, their motivation will grow and with it their success in studies and the rest of career.

Project-based learning (PBL) is a learning approach that revolves around students, making them engage in real-world problems. It evokes students to develop knowledge and skills in a particular subject and makes them more involved in teaching. Buck Institute for Education, a leading organization in the field of project-based learning, defines PBL as "a teaching method in which students gain knowledge and skills by working for an extended period to investigate and respond to an authentic, engaging, and complex question, problem, or challenge" [1].

Integrating technology into teaching methodology serves to enhance student engagement. With technology tools like Mattermost, students promote critical thinking and problem-solving skills. E-education has the potential to transform higher education by providing personalized and flexible learning experiences [2].

This paper aims to provide an analysis of the benefits and drawbacks of using PBL with Mattermost. The analysis will explore how effective PBL is in improving students' practical skills as well as some people skills for working in the industry and its overall influence on students' motivation and involvement in class. Additionally, potential drawbacks or limitations will be identified, such as challenges to manage group projects and dynamics and if there is some need for guidance and support.

II. PROJECT-BASED LEARNING

PBL revolves around the assumption that it will lead to better outcomes for students, whether it is to pass the exam more efficiently or to find a job with more ease. Research has shown that PBL significantly improved students' programming, critical thinking, and problem-solving skills compared to traditional learning based on lectures and instructions. Students who were exposed to this learning method were more likely to be engaged and motivated. In the field of teaching information technologies, PBL can be an effective approach that can assist students to develop all necessary competencies required in the field of computer science [3].

Besides having an impact on providing a realistic experience of working in a project organization, PBL might not have a significant influence on improving students' theoretical knowledge [4]. The choice of the project has a significant role in both gaining theoretical knowledge and maintaining motivation. When students had felt motivation, they were more engaged in projects and showed more interest, commitment, and satisfaction. When, on other hand, students lack motivation, their performance on projects is negative [5].

An important aspect of project-based learning is taking ownership of a project. By giving students autonomy to choose projects they want to work on, the level of responsibility for the outcome grows. Using Mattermost to support PBL, students can facilitate communication and follow the progress of their projects. It helps to engage students more and with them being active during classes and after them, their success level increases [6].

Using Mattermost can improve students' satisfaction and learning outcomes in PBL. This comes from the fact that students have learned how to work with a new tool and put their theoretical knowledge to practical use. However, a need for training on how to use the tool effectively and the potential for distractions due to the constant availability of communication is something that needs to be tackled. Implementing project-based learning with Mattermost requires careful planning and consideration. Students' learning outcomes are dependent on several factors, including the quality of the platform, the level of instructor involvement, and student motivation [7].

Utilizing online platforms like Mattermost can address some PBL associated challenges. Mattermost is a communication and collaboration platform designed for teams. It gives students the ability to experience teamwork and share ideas with various features such as direct messaging, group messaging, file sharing, and integrations with other tools commonly used in project-based learning [8]. Online platforms that allow students to discuss are a way to enhance student engagement and learning. This is specifically the case in PBL where communication among team members is crucial [9]. The collaborative learning model based on Mattermost promotes active learning and encourages student participation.

III. APPLICATION OF PROJECT-BASED LEARNING WITH MATTERMOST

In this chapter, the implementation of Mattermost in higher education will be described. The way to configure the system and set up this tool will have a role in how the teams will function and if it will have benefits for students in an educational or professional sense.

A. Features of Mattermost tool

Mattermost is open-source software. This means that all users have access to the entire source code of the platform and that it is possible to change, modify and improve it according to needs. The source code of the platform is written in Go and JavaScript languages [10].

Mattermost offers two options for connecting to the server: connecting to the Mattermost server or the users' own. Connecting to their server provides users with unlimited data control, privacy, and compliance with legal regulations.

At the outset, a secure local installation of Mattermost in the customer's data center is provided, with layered security options such as SSL, VPN, and DMZ. Mattermost provides the ability to encrypt data in motion and at rest. Encryption is not necessary for the platform to be compliant with the GDPR (General Data Protection Regulation), but it represents additional protection against the misuse of data [11].

B. Installation and configuration of Mattermost

Once the system is installed, it offers the possibility of personalization at the level the user needs. In addition to the fact that it is a free software, which is open source, it provides the possibility of wide use in environments where the budget is limited, and the staff is competent to implement it and is familiar with some of the systems or databases that are supported.

In Mattermost, there are six types of user roles with different levels of permission:

- system administrator - the first user added to a newly installed system of this tool, usually a member of the IT staff, is assigned the role of system administrator;
- team administrator - when a team is first created, the person who set it up becomes the team administrator. It's a team-specific role, meaning someone can be a team admin for one team, but only a member of another team;
- channel administrator - the person who creates the channel assumes the role of channel administrator for that channel;
- members - this is the initial role given to users when they join a team;
- guests - this is a role with limited permissions, which allows organizations to collaborate with users outside their organization, so-called external users, and to control which channels they are on and with whom they can collaborate
- inactive accounts.

When the first user is created, they will not be added to any team, because there are no teams yet and it is required to create some team.

The main features of Mattermost are having teams, channels, messages, notifications, and search. During the search, the results are searched in all channels that the user is a part of. Notifications are used to inform the user that there are unread messages and mentions. Further elaboration will be provided on other features.

C. Teams

The team at Mattermost is a digital workspace where collaboration between members is possible. One person can be a member of one or more teams depending on the settings in the organization using Mattermost. If the system administrator has enabled the user to create teams, the user who creates a team will automatically be assigned the role of administrator of that team. Single-team deployment is currently recommended for the following reasons:

- single team applications improve communication throughout the organization. When more teams are added, groups can become isolated;
- cross-team or channel search is not supported yet, which may affect the team-user experience;
- integrations are persistent only in single-team applications.

However, some Mattermost users prefer multiple team deployments for the following reasons:

- teams are useful when there is a purpose for each team. For example, one team is used for staff members, i.e. internal users of the organization, and another team for external users;
- performance is better when users are spread across multiple teams instead of all in the same one. With multiple teams, there is less content to load per team and database queries are faster as it is also partially based;
- creating a shared team for all users and using advanced permissions to control who can create channels and add members to a shared team improves multi-team collaboration when using multiple teams.

D. Channels

Channels are used to organize conversations on different topics. he channels in the system can be categorized into three types: public channels, private channels, and direct messages.

All team members have access to public channels. When new team members are added, they are automatically added to public communication channels.

Private channels are used to discuss sensitive topics and are only visible to specific team members who have been added to them. All members of a private channel can add new members to it. A team member can leave a channel at any time, but cannot kick out other channel members; only the team admin has that option.

Direct messages refer to direct communication between two people. There are also group messages, which are direct messages between three to seven people. Both types of messages are only visible to people who are involved in the conversation. If users want to communicate in a group of more than seven people, it is necessary to create a private channel on which to do so.

Channels and teams can have an unlimited number of members, which is possible because it is possible to modify the source code and the base used.

E. Messaging

Good and active team communication is necessary for productive teamwork, which is made possible by sending and receiving messages. It is possible to modify or delete each sent message, as well as refer to it.

IV. MATTERMOST TOOL IN TEACHING

Department for e-business in the Faculty of organizational sciences implemented Mattermost to enhance students' learning experience. In this model of project-based learning, students from three courses were given different roles within a team and each team chose one project to work on (development or analysis of various applications). During these courses, students had the opportunity to gain theoretical and practical knowledge about both PBL and scrum methodology. During the courses, it was obligatory for team members to record all necessary information within channels where they were members. Those were messages to other team members or facilitators to inform them on the progress of their part of work. To track progress more visually, Mattermost Boards feature was used. It is a tool for recording and assigning tickets to team members, setting deadlines, and prioritizing them [12].

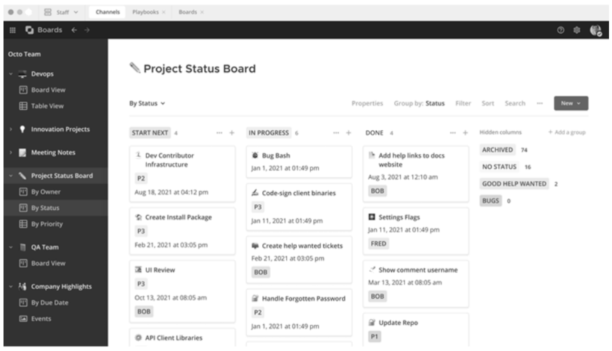

Fig 1: Mattermost Board

If Mattermost is implemented and used by various student teams, the next step would be to analyze statistics, e.g. number of students on the platform, number of messages, time of activity, and others. The system administrator role is the only role with access to System Console. There, the team size can be modified, notification settings can be set as well as many other configurations regarding security, day-to-day use, and overall functioning of the system.

In the reporting section of the system console, the system administrator can track the number of users and their activity. Administrators can see which users were most recently active and who posted the most in the team. In terms of teaching, this means that professors will be able to regularly monitor students' work and adapt their lessons to the state of the report.

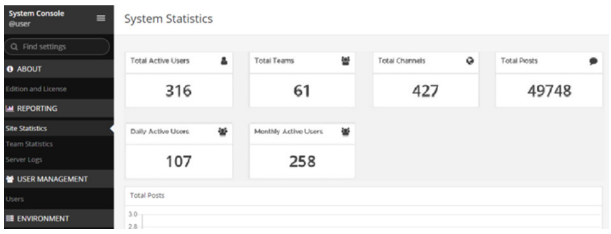

Fig 2: Statistics from the system

Another way to get usage data is via Mattermost API. The Mattermost REST API is a web service that employs JSON to enable communication between servers and third-party applications, as well as Mattermost clients. The server is currently on API version 4.. All API access is via HTTP(S) requests to your-mattermost-url.com/api/v4. Mattermost offers approximately forty API groups, each with multiple different APIs. The ability to call any method depends on the user's role. JavaScript and Golang drivers are available to connect to the APIs. Device drivers are different for each operating system and depend on the hardware.

To extract data from the system using APIs, it is needed to create an app that calls them and saves results. A couple of APIs that will be implemented are: get teams, get user's sessions, get channel's pinned posts, and many others.

Extracted data will be analyzed using VOSviewer – a software tool for constructing and visualizing bibliometric networks. These networks may, for example, include journals, researchers, or individual publications, and may be constructed based on citations, bibliographic linkages, co-citations, or co-authorship relationships. In addition, VOSviewer provides capabilities for text mining, allowing for the creation and visualization of co-occurrence networks that highlight significant terms extracted from scientific literature [13].

An application that calls Mattermost APIs must allow the user to view a selection of fields that call different APIs via the computer. Clicking on the field triggers the call. Some APIs need to send some parameter: user, team, or channel ID. All methods are GET and the goal of the application is to save the obtained data from Mattermost in corresponding JSON documents (responseTeamMembers.json responseTeams.json, etc.).

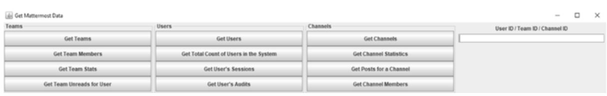

Fig 3: Java application for data extraction

VOSviewer is storing configuration for visualizing the network and the JSON files imported in it must be in a specific format. For example, attributes network, config and info of type object are mandatory and each of them contains list of mandatory and non-mandatory attributes [14]. JSON files retrieved by using Mattermost API have predefined structures and the response format cannot be modified during API call, i.e. there are no parameters that can influence the outcome. Since these response files do not contain all attributes required by VOSviewer, they need to be transformed into desired format.

ETL (Extract, Transform, Load) is a data integration process that involves the data being extracted of data from diverse sources, transformed to suit a specific target format, and then loaded into a target database or data warehouse [15]. The diagram bellow displays how is ETL process applied to get data from Mattermost in adequate VOSviewer format.

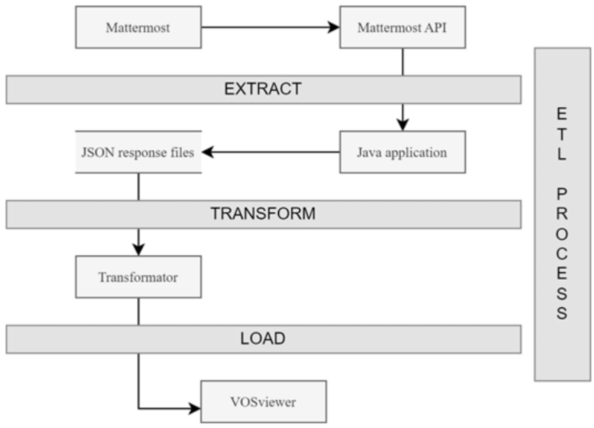

Fig 4: Mattermost-VOSviewer workflow

With this data, combined with student success and satisfaction scores, success of the implementation of project-based learning can be displayed.

Two years after the Department for e-business implemented Mattermost at Faculty of Organizational Sciences, around 40 projects were completed, with over 100 students involved. It was used as a channel for communication within the projects and between students and teaching staff. It was also used for official announcements by professors [16].

An important integration that was put in place was an integration of BigBlueButton with Mattermost. BigBlueButton is an open-source system that enables video conferencing, screen sharing, whiteboarding and recording. It is designed specifically for online learning. It is shown that this system increases flexibility for students to follow lectures and encourages interactive learning followed with discussion and collaboration [17].

With integration of these two tools, it was ensured that communication on project is transparent and available to all interested students.

The use of agile project management tools facilitated better communication and coordination among team members, ensuring that everyone was working towards the same goals and objectives. Project-based learning provided students with the opportuinity to develop important soft skills such as collaboration and time-management [4].

Students of Faculty of Organizational Sciences have demonstrated high adaptivity skills to this new tool that became part of their education. The innovative method in teaching was recognized and very well received.

All students were successful in regards to completing all activities for the subjects and passing the exams. As the greatest benefit of this method of learning, students singled out the opportunity to experience real teamwork and management, and the opportunity to get an insight into what their future work on projects looks like. What increased students' motivation the most was the interest to participate in practical exams and projects [18].

V. CONCLUSION

Project-based learning is an innovative approach to teaching. It carries many benefits for students, such as increasing motivation, awakening curiosity, and the will to follow the lessons. Project organizations are the majority of IT companies nowadays and gaining experience in such an environment can be crucial in the early stages of career-making. Students in this method are working in a team, follow a specific timeline, and are responsible for delivering their product.

On the other hand, the implementation of PBL can face many challenges. Adjusting from classical theoretical knowledge transfer to more hands-on lessons, especially in a virtual environment, leaves space for professors and departments to be creative to overcome that.

Mattermost as a collaboration tool has been demonstrated to be a platform that is easy to accommodate. It is user-friendly and resembles in looks and features many applications that are in everyday use by students. By providing space for teams to collaborate and members to open as many discussions on however many channels and groups, Mattermost offers versatility for students and professors to their projects and needs.

Implementation of Mattermost, as in installation and configuration, can be a challenge itself. So far, Mattermost has become a popular tool in the IT industry and with its popularity, documentation, and instructions on installation and use are available online.

Implementation of project-based learning with Mattermost has shown that with dedicated department members and students who are willing to explore new teaching methods, it is possible to improve students' success. By following metrics and analysis of data from Mattermost usage, professors can adjust some parameters or give students additional training or directions.

The goal of future work is to introduce functions that fully automate the ETL process. This implementation should considerably ease the job of teachers in data analysis and enable them to concentrate on the decision-making process based on the analysis results. The planned features should support the automatic collection, cleansing, and conversion of data into desired formats, with the integration of different data sources.

As education continues to evolve, the hope is that in the future more departments and faculties will implement tools like Mattermost to support project-based learning. In doing so, it is crucial to listen to students and analyze their progress in every step of the project.

REFERENCES

[1] Buck Institute for Education. What is PBL? Retrieved on 14th of April 2023, from https://www.bie.org/about/what_pbl

[2] Denić, N. (2020). Possibilities of Application E-Education in the Function of Improving the Quality of Higher Education. Journal of Educational and Social Research, 10(5), 33.

[3] Akkuzu, N., & Kurtoğlu, N. (2021). The effect of project-based learning on learning outcomes in computer programming courses. Education and Information Technologies, 26(1), 401-417.

[4] Baranović, M., & Stojanović, I. (2018). The effectiveness of the project-based learning approach in the education of computer science students. Tehnički vjesnik, 25(1), 224-230.

[5] Chen, Y., Chen, N.-S., & Kinshuk. (2016). Exploring the effects of different pedagogical designs on project-based learning. Journal of Educational Technology & Society, 19(3), 33-43.

[6] Tomašević, I., & Branković, V. (2019). The Role of Mattermost in Project-Based Learning: An Exploratory Study. International Journal of Emerging Technologies in Learning (iJET), 14(3), 84-95.

[7] Nikolić, S., & Živković, M. (2020). Project-Based Learning with Mattermost: An Evaluation of Student Satisfaction and Learning Outcomes. Journal of Educational and Social Research, 10(5), 93-104.

[8] Kalaivani, T., & Rajkumar, P. (2019). Mattermost for Collaboration in Educational Institutions. International Journal of Emerging Technologies in Learning, 14(13), 191-196.

[9] Hrastinski, S., & Keller, C. (2007). Online discussions and social media for learning: A comparative analysis of two e-learning environments. Proceedings of the 40th Hawaii International Conference on System Sciences, 1-10.

[10] Perić, M., & Popović, M. (2019). Upotreba Mattermost platforme u e-učenju. Naučno-stručni časopis, 4(1), 101-116.

[11] Mattermost, Retrieved on 18th of April 2023, from https://mattermost.com/security/

[12] Odalović, B., & Mihajlović-Milićević, J (2022). Managing students' projects in e-learning. E-business technologies, 122-126.

[13] VOSviewer, Retrieved on 23rd of April 2023, from https://www.vosviewer.com/

[14] VOSviewer JSON files, Retrieved on 23rd of April 2023, from https://app.vosviewer.com/docs/file-types/json-file-type/

[15] Kimball, R., & Ross, M. (2013). The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling (3rd ed.). John Wiley & Sons.

[16] Radenković, M., Popović, S., & Mitrović, S. (2022). Project based learning for DevOps: School of Computing experiences. E-business technologies, 127-131.

[17] Kljajevic, D., & Stojanovic, I. (2020). E-learning in the age of coronavirus: analyzing the usage of BigBlueButton at the University of Kragujevac. Teme, 44(2), 825-840.

[18] Odalović, B., & Mihajlović-Milićević, J (2022). Managing students' projects in e-learning. E-business technologies, 122-126.

Statistical Techniques for Project-based Learning

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Abstract—Although present for a long time, project-based learning is still the very focus of researchers because of its potential to improve the learning process. New technologies provide opportunities for a better understanding of the data generated by the learning process. This literature review searches for statistical techniques used in the field of project-based learning and classifies them in line with common classifications found in the field of statistics. The goal is to identify the most common statistical techniques used in the field and explain the way they are applied in the research. The results show that the most often statistical techniques are descriptive statistics and inferential statistics, followed by factor analysis, regression analysis, correlation, and social network analysis. This result arises from the type of research design, which is in most cases quasi-experimental, where researchers try to measure the influence of project-based learning on different dimensions of learning outcomes. This kind of research design usually employs descriptive statistics as a preliminary step, followed by statistical tests.

Keywords - statistical analysis, inferential statistics, quasi-experimental research design

I. INTRODUCTION

Project-based learning is a form of learning by doing in which the student is at the center of the learning process acquiring deeper knowledge through active exploration of real-world challenges [1]. This approach helps motivate students as they play an active role, collaborating with other students and instructors in producing artifacts [2]. Various forms of computer software and other cognitive tools can significantly amplify and extend what students can learn [1].

Although the beginnings of the scientific field date to the early 20th century, project-based learning is still the focus of researchers because of its potential to improve the learning process. The modern approach includes quasi-experiments where the outcomes from the project-based learning process are measured against the classical or some other approach. These outcomes can be classified as [3]:

- cognitive outcomes which include knowledge and strategies,
- affective outcomes like student's perception of benefits and experiences with project-based learning,
- behavioral outcomes which relate to various kinds of skills and student engagement in the learning process and
- artifact performance, i.e., measurable characteristics of physical objects, documents, and multimedia created as a result of the learning process.

Different types of instruments can be used for the measurement of these outcomes. The most frequently used are self-reported questionaries, rubrics, tests, interviews, observation, self-reflection journals, and artifacts. Especially useful sources of data are software logs where computer technologies are used as a scaffolding tool. Software logs contain data about the contents, timing, and frequency of students' activities and enable the discovery of patterns in students' behavior. This additional information can help teachers and researchers improve curricula in the next iteration by better understanding students' strategies, interests, and engagement [3].

Data obtained from the learning process can be qualitative and quantitative. Which type will prevail in the research depends a lot on the goals and the design of the research. Combining both types can sometimes reveal more information about the learning process. When computer software is included as a tool in the learning process, a huge amount of quantitative data can be generated, which can require complex and computationally demanding techniques for their processing. The development of statistical techniques and machine learning, backed with rising computing power provide tools for this processing.

The focus of this literature review is on quantitative techniques used to analyze the data originating from the project-based learning field. The goal is to find out the quantitative statistical techniques most frequently used in project-based learning and describe the typical way they are applied. With this goal in mind, two research questions are formulated:

Q1: Which quantitative statistical techniques are the most often used in the field of project-based learning?

Q2: In what way are the statistical techniques applied in the field of project-based learning?

The remainder of the paper is structured as follows: The methodology section outlines the methodological approach in this literature review. Chapter Results and Implications briefly describe the quantitative statistical techniques found in the literature and the context in which they are applied. Finally, the chapters Discussion and Conclusion give an overview of the results of the research, point out the main findings and limitations of the research, and propose the future direction of the research.

II. METHODOLOGY

Concerning the goal and the type of data collected, this literature review is descriptive and qualitative. The literature reviewed is collected from the Web of Science and Google Scholar databases of academic articles. Included are peer-reviewed articles published in scientific journals, and papers published in conference proceedings in the period 2018 through 2022 without restrictions on the research design. Literature reviews are excluded from the review. Only the papers that relate to project-based learning which include quantitative statistical processing of data are considered relevant. Papers whose entire text was not available were excluded from the review.

The initial search was made on April 10th, 2023, in English. Both databases were searched for the exact phrase "project-based learning". Since the search returned a large number of hits, results are sorted by relevance, and the first 30 hits from each database are taken to the second round of elimination. The papers were selected based on the abstract. In the next step, the full text of articles that were found relevant was carefully analyzed from the viewpoint of the statistical methods used for data processing, and the final list was made. It is comprised of 43 articles on project-based learning that use quantitative statistical techniques. They make the foundation for the discussion and conclusion.

III. RESULTS AND IMPLICATIONS

Table 1 shows the frequencies of quantitative statistical techniques found in the sample. Techniques are grouped by common classifications found in the field of statistics.

Table I. Statistical techniques in the sample

Statistical technique	***Number of articles***
Descriptive statistics	34
Inferential statistics	29
Factor analysis	7
Correlation	6
Regression	6
Social network analysis	1

In the following subsections, each technique and its usage are briefly described. Where appropriate, the examples from the literature are briefed in the context of the research.

A. Descriptive statistics

A set of techniques designed to describe and sum the data is called descriptive statistics [4]. It is a common term that includes the measures of central tendencies, measures of dispersion, and the shape of the distribution. It merely reports measured data, without producing a prediction or conclusion about the population [5].

Descriptive statistics is one of the major techniques used for monitoring and analyzing learning data. Usually, the researcher starts with some kind of descriptive statistics technique to get a better understanding of the data. For that reason, it is included in almost every quantitative research, regardless of its design.

Applications of descriptive statistics in the field of project-based learning include monitoring students' activity and engagement over time, inspecting online behavior, and providing feedback [6]. It enables the identification of the extreme values in the data which can help identify students at risk [7].

In the sample of analyzed articles, mean and standard deviation are the most often reported measures, followed by a table of frequencies, percentages and percentile ranks, range, minimum and maximum. Where the mean is not an appropriate measure because of the data type used in an analysis, the median is used instead. Major descriptives can also be presented as boxplots, as in [8]. In [9] and [10] authors used skewness and kurtosis for the description of the shape of the distribution. Cronbach's Alpha, CR (composite reliability), and AVE (average variance extracted) are often classified under descriptive statistics. They are used to measure some characteristics of the construct, like the reliability of an instrument used for data collection or its discriminant validity. These measures are often reported when research includes questionary [10], [11], [12], [13], [14] [15], [16], [17], [18].

B. Inferential statistics

Inferential statistics is a set of mathematical techniques based on a probability theory and the logic of hypothesis testing that enable researchers to test hypotheses, quantify covariances between variables, or identify causal relations based on the analysis of a sample [4]. This kind of analysis aims to provide valid conclusions about the population characteristics from which the sample was drawn. Inferential statistics should provide an answer to the question if the sample comes from a known population, or the two or more samples come from the same population. In addition to the estimate of parameters, valid inferential statistical procedures must provide information about the precision of this estimate [19].

The choice of an appropriate statistical test depends on the goals of the analysis, the type of data, the number of groups that are compared, and the relationship between the groups [5]. The basic classification is parametric and non-parametric, based on the type of data distribution. Tests based on the normal distribution are called parametric, while others are considered non-parametric. Depending on the goals of the analysis, the researcher can test for the differences or the correlation between the groups. In the remainder of this section, different tests of difference will be explained, while tests of correlation will be presented in the subsequent sections.

The most often test used in the sample of articles is the t-test. It is used when the means of two groups are compared to establish if they come from the same population. T-tests can exist in two forms: t-test for independent samples and paired t-test. When the appearance of a student in one sample excludes the possibility of their appearance in other samples, a t-test for independent samples is used [9], [14], [20], [21], [22], [23], [24], [25]. This is the situation where, for example, students in the experimental group are compared to students in the control group. On the contrary, if both samples are consisted of the same persons, then paired t-test is used [12], [13], [16], [20], [21], [22], [25], [26], [27], [28], [29], [30], [31]. This is the case where there are repeated measures of the same group of students, i.e., when pre-test and post-test are done. Where data does not comply with the requirements of the t-test, the Mann-Whitney test is used for independent samples [8], [18], [32] and Wilcoxon's test [33] is used for paired samples as non-parametric alternatives to the t-test. When more than two groups are compared, one-way [14], [34], [35] or two-way [36] ANOVA (analysis of variance) is used, depending on the number of variables observed. If the samples are paired, then ANOVA for paired samples is the appropriate statistical technique [11], [37]. Non-parametric alternative to ANOVA is Kurskal-Wallis test [18]. To provide information about the main and interaction effects controlling for the effects of other variables which co-variate with the dependent variable, ANCOVA (analysis of covariance) is used in [12], [38], [39]. These statistical tests rely on statistical significance. Since statistical significance doesn't imply practical significance, some researchers report the effect size in addition [13], [18], [27], [31], [34].

C. Correlation

Correlation analysis is conducted to get the answer to the question if there is a relationship between two variables, in which direction the relation goes, and how strong it is. Relation in this context describes the tendency of two variables to vary consistently [5]. The most popular measure of the correlation is the correlation coefficient [13], [40]. Where there are multiple variables whose relations are examined in pairs, correlation coefficients are usually presented in the form of a matrix [16], [17], [41].

Another way to examine and present the existence of a correlation between two variables is a scatter plot [8]. A scatter plot can be very useful in finding out the relationships which are not linear. Usually, it complements the correlation coefficient.

D. Regression

Regression is a set of statistical procedures built around the concept of correlation which permit the researcher to use information about one or more variables to predict the value of one or more other variables. By enabling the inspection of the relationship between multiple variables at the same time, regression analysis overcomes the shortcomings of the correlation coefficient [42].

Regression analysis allows researchers to make models of different complexity, depending on the research goals. Multiple linear regression is used to predict the value of a dependent variable using multiple independent variables which presumably are in a relationship with the dependent variable in [11], [43], [44]. Hierarchical regression applied in [16] and [17] is the type of regression where independent variables are entered in steps based on a theoretical framework. Multilevel linear regression allows grouping the observations in multiple levels and is applied in [45].

E. Factor analysis

In this section, the use of PCA (principal component analysis), EFA (exploratory factor analysis), and SEM (structural equations modeling) are presented. Although they significantly differ in many aspects, common for all these statistical techniques is that they allow for exploring the underlying structure of data.

PCA is aimed to extract information from the variance-covariance matrix in such a way that a group of random variables is reduced to a smaller group of random variables that reflect the original structure [42]. It is used in [37] and [44] to reduce the number of variables before the main analysis.

EFA uses PCA to discover the hidden structures laying in the background of covariances between variables. A set of related variables is transformed into a set of unrelated variables called factors or components, to get a relatively small number of variables that explain a significant portion of the original variance. The researcher must consider the theoretical framework when defining underlying factors [42]. In [13] and [45] authors applied exploratory factor analysis and then used the obtained factors in the regression and correlation analysis that follows.

SEM is a family of statistical techniques used for modeling complex relations between measured and latent variables. They include elements of regression and factor analysis providing more freedom for researchers to explore complex models. Within SEM family, path analysis was applied in [46] and [15], while PLS (partial least square) was applied in [10].

F. Social Network Analysis

SNA (social network analysis) is a tool for exploring relations between individuals or organizations. A social network is looked at as a graph made of a series of nodes each representing the actor and relations between them. To understand network structure and the patterns of the actor's behavior, a set of characteristics is examined. The most important are the degree of centrality, closeness and betweenness of nodes, density, and connectivity of the network [6].

Using SNA researchers can gain insight into the broader picture of interactions and dynamics of the participants in the project. On the group level, it is possible to discover the patterns of interaction between students and teachers, while on the individual level, it makes it possible to quantify the role of each participant in the network [47]. In [48] authors used SNA to investigate how it can lead to improvements in the learning process. On the individual level, they monitored three SNA constructs for each participant: the level of interactivity, role and position in the information exchange, and the role in collaboration. On the group level, they monitored interactivity and group cohesion.

IV. DISCUSSION

Based on a literature review, statistical techniques used in project-based learning are identified and grouped in a way common in the field of statistics. Every technique has its peculiarities and assumptions for usage which emphasize the importance of using the appropriate technique for the goal and design of research.

One statistical technique alone rarely can answer the research questions and hence they are usually combined. Descriptive statistics is usually the first step in every analysis because it gives the basic information about the data which can direct further research. It is usually coupled with data visualization, which makes complex patterns easier to grasp.

The most common research design in the sample is quasi-experimental design. Students are separated into two or more groups. Those who belong to the experimental group get treatment in the form of project-based learning, while others work in a classical way. Measurements are usually done at the beginning of the project and after the project is finished. This way it is possible to measure the advancement in the outcome independently of the treatment, as well as compare experimental and control groups to test the effect of the treatment. Such a design greatly defines the statistical techniques used. In typical research, inferential statistics are used. It is recommended to report the effect size as well as the result of the statistical test [4].

When searching for differences between groups of students and only two groups are examined researchers apply t-test for independent samples and paired t-test. If there are more than two groups, then depending on the number of variables and their relationship one-way, two-way ANOVA or ANCOVA are used.

When the goal of the research is to find the level of influence that a variable exerts on the outcome of the learning, then correlation or regression analysis is applied. In addition, these techniques provide information for predicting outcomes and performing statistical tests at the same time. Regression analysis provides a way to put in relation more than two variables, while path analysis is used if a research design is even more complex.

In both cases, PCA and EFA are used to reduce the number of variables. SNA is useful for researching the structure and dynamics of the group.

Systematization of statistical methods made in this paper should provide easier comprehension of the methods for studying the effects of project-based learning on learning outcomes. A short description of statistical techniques in the language of applied statistics should give the researcher better insight into the "technical" part of the research and facilitate the understanding of non-technical researchers.

Although they are very useful in the exploration of the characteristics of the phenomenon under examination, quantitative statistical methods are not almighty. Quantitative methods can point out trends, correlations, groups, and structures in the data, but it is usually useful to complement them with qualitative methods which provide additional information and can help find out the causes of such results. [6].

V. CONCLUSION

The literature review presented in this paper grouped numerous statistical methods and techniques used in research of project-based learning into six groups. Based on the presented, the answers to the research questions follows:

Q1: Which quantitative statistical techniques are the most often used in the field of project-based learning?

The most often used statistical techniques in the field of project-based learning are descriptive statistics, inferential statistics, factorial analysis, regression, correlation, and social network analysis.

Q2: In what way are the statistical techniques applied in the field of project-based learning?

Descriptive statistics describe the data and are used as a preliminary step that provides an overview of data. The research design determines the techniques used. Since most researchers use a quasi-experimental design aiming to identify the effect of the treatment, the technique of choice falls to the inferential statistics group of techniques. Within this group, the most common are t-tests and analysis of variance. Exploratory factor analysis is usually used to reduce the number of variables. Where the research design is more complex, SEM is used, while SNA is used for discovering group structure and dynamics.

The limitation of this literature review relates to the relatively small sample of papers that are analyzed, which can lead to overemphasizing some techniques to the detriment of others. In the future, a more comprehensive review can include a larger sample. Also, future research can provide more details by focusing on a particular area of statistical techniques used with the most frequent research design.

REFERENCES

[1] Z. Xing and Z. Chen, "A Project-Based Approach for Learning Blockchain Technology," Procedia Comput. Sci., vol. 214, no. C, pp. 581–589, 2022, doi: 10.1016/j.procs.2022.11.215.

[2] A. Saad and S. Zainudin, "A review of Project-Based Learning (PBL) and Computational Thinking (CT) in teaching and learning," Learn. Motiv., vol. 78, no. March 2022, doi: 10.1016/j.lmot.2022.101802.

[3] N. C. B. Tuyen, N. T. Nga, and N. T. X. Mai, "Applying Project-Based-Learning to improve English speaking skills of remote learners at tertiary education," Ho Chi Minh City Open Univ. J. Sci. - Soc. Sci., vol. 12, no. 2, pp. 85–103, 2022, doi: 10.46223/hcmcoujs.soci.en.12.2.2292.2022.

[4] K. P. Nesselroade and L. G. Grimm, Statistical Applications for the Behavioral and Social Sciences, Second edi. John Wiley & Sons, Inc., 2019. doi: 10.1002/9781119531708.

[5] L. Cohen, L. Manion, and K. Morrison, Research Methods in Education, Sixth edit. New York: Routledge, 2017. doi: 10.4324/9781315456539.

[6] M. A. Chatti, A. L. Dyckhoff, U. Schroeder, and H. Thüs, "A reference model for learning analytics," Int. J. Technol. Enhanc. Learn., vol. 4, no. 5–6, pp. 318–331, 2012, doi: 10.1504/IJTEL.2012.051815.

[7] K. S. Ray and M. Saeed, "Applications of educational data mining and learning analytics tools in handling big data in higher education: trends, issues, and challenges," Appl. Big Data Anal. Trends, Issues, Challenges, no. July, pp. 1–214, 2018, doi: 10.1007/978-3-319-76472-6.

[8] E. Cifrian, A. Andrés, B. Galán, and J. R. Viguri, "Integration of different assessment approaches: application to a project-based learning engineering course," Educ. Chem. Eng., vol. 31, pp. 62–75, 2020, doi: 10.1016/j.ece.2020.04.006.

[9] H. J. Yazici, "Project-Based Learning for Teaching Business Analytics in the Undergraduate Curriculum," Decis. Sci. J. Innov. Educ., vol. 18, no. 4, pp. 1–23, 2020.

[10] J. Zang, Y. Kim, and J. Dong, "New evidence on technological acceptance model in preschool education: Linking project-based learning (PBL), mental health, and semi-immersive virtual reality with learning performance," Front. Public Heal., vol. 10, 2022, doi: 10.3389/fpubh.2022.964320.

[11] B. Blandin et al., "Distance project-based learning during lockdown and learner's motivation," Interdiscip. J. Probl. Learn., vol. 16, no. 1, 2022, doi: 10.14434/ijpbl.v16i1.32580.

[12] C. T. Hsin and H. K. Wu, "Implementing a Project-Based Learning Module in Urban and Indigenous Areas to Promote Young Children's Scientific Practices," Res. Sci. Educ., vol. 53, no. 1, pp. 37–57, 2023, doi: 10.1007/s11165-022-10043-z.

[13] H. E. Vidergor, "Effects of Innovative Project-Based Learning Model on Students' Knowledge Acquisition, Cognitive Abilities, and Personal Competences," Interdiscip. J. Probl. Learn., vol. 16, no. 1, 2022, doi: 10.14434/ijpbl.v16i1.31183.

[14] J. Peng, B. Yuan, M. Sun, M. Jiang, and M. Wang, "Computer-Based Scaffolding for Sustainable Project-Based Learning: Impact on High- and Low-Achieving Students," Sustain., vol. 14, no. 19, pp. 1–25, 2022, doi: 10.3390/su141912907.

[15] M. A. Almulla, "The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning," SAGE Open, vol. 10, no. 3, 2020, doi: 10.1177/2158244020938702.

[16] M. E. Beier, M. H. Kim, A. Saterbak, V. Leautaud, S. Bishnoi, and J. M. Gilberto, "The effect of authentic project-based learning on attitudes and career aspirations in STEM," Journal of Research in Science Teaching, vol. 56, no. 1. pp. 3–23, 2019. doi: 10.1002/tea.21465.

[17] P. He, I.-C. Chen, I. Touritou, K. Bartz, B. Schneider, and J. Krajcik, "Predicting student science achievement using post-unit assessment performances in a coherent high school chemistry project-based learning system," JRST, 2022, doi: 10.1002/tea.21815.

[18] Y. Viñuela and A. M. de Caso Fuertes, "Improving motivation in pre-school education through the use of project-based learning and cooperative learning," Front. Educ., vol. 7, no. January, 2023, doi: 10.3389/feduc.2022.1094004.

[19] C. Heumann, Shalabh, and M. Schomaker, Introduction to Statistics and Data Analysis With Exercises, Solutions and Applications in R, vol. 44, no. 1. Springer International Publishing Switzerland, 2016. doi: 10.1007/978-3-319-46162-5.

[20] K. J. Kim, "Response to medical students' perspective: project-based learning approach to increase medical student empathy," Med. Educ. Online, vol. 26, no. 1, 2021, doi: 10.1080/10872981.2021.1877100.

[21] S. Asli, R. Abu-Alhiga, S. Algmal, and M. Hugerat, "Teaching and Learning about Bee Extinction through Project-Based Learning (PBL): Its Impact on the Classroom Climate (CL) among Eighth Grader Students," Sustain., vol. 14, no. 12, 2022, doi: 10.3390/su14127477.

[22] T. Makkonen, K. Tirri, and J. Lavonen, "Engagement in Learning Physics Through Project-Based Learning: A Case Study of Gifted Finnish Upper-Secondary-Level Students," J. Adv. Acad., vol. 32, no. 4, pp. 501–532, 2021, doi: 10.1177/1932202X211018644.

[23] T. T. Wu and Y. T. Wu, "Applying project-based learning and SCAMPER teaching strategies in engineering education to explore the influence of creativity on cognition, personal motivation, and personality traits," Think. Ski. Creat., vol. 35, no. January, 2020, doi: 10.1016/j.tsc.2020.100631.

[24] Witarsa and S. Muhammad, "Critical thinking as a necessity for social science students capacity development: How it can be strengthened through project based learning at university," Front. Educ., vol. 7, 2023, doi: 10.3389/feduc.2022.983292.

[25] Y. H. Wang, "Integrating games, e-books and AR techniques to support project-based science learning," Educ. Technol. Soc., vol. 23, no. 3, pp. 53–67, 2020.

[26] A. M. H. Bani-Hamad and A. H. Abdullah, "The Effect of Project-Based Learning to Improve the 21st Century Skills among Emirati Secondary Students," Int. J. Acad. Res. Bus. Soc. Sci., vol. 9, no. 12, pp. 560–573, 2014, doi: 10.6007/IJARBSS/v9-i12/6749.

[27] D. A. Fauziah, E. E. Susiyawati, and M. Budiyanto, "Implementation of Project-Based Learning Models to Improve Science Literacy of Junior High School Students," J.Pijar MIPA, vol. 18, no. 2, pp. 176–182, 2023, doi: 10.29303/jpm.v18i2.4795.

[28] D. Paľová and M. Vejačka, "Project-based Learning in the University Course and its Effectiveness," TEM J., vol. 11, no. 4, pp. 477–1484, 2022, doi: 10.18421/TEM114-07.

[29] D. S. Ibrahim and A. M. Rashid, "Effect of Project-Based Learning Towards Collaboration among Students in the Design and

Technology Subject," World J. Educ., vol. 12, no. 3, p. 1, 2022, doi: 10.5430/wje.v12n3p1.

[30] E. Karan and L. Brown, "Enhancing Student's Problem -solving Skills through Project-based Learning," vol. 10, no. 1, pp. 74–87, 2022.

[31] R. E. Larasati, L. Yuliati, and P. Suwasono, "The effect of project-based distance learning on mastery of work and energy concepts," J. Ris. dan Kaji. Pendidik. Fis., vol. 9, no. 2, pp. 41–54, 2022, doi: 10.12928/jrkpf.v9i2.34.

[32] R. Listia, "Technology-Assisted Project-Based Language Learning on Wetland Concern," LET Linguist. , Lit. English Teach. J., vol. 12, no. 2, pp. 327–351, 2022.

[33] P. Parrado-Martínez and S. Sánchez-Andújar, "Development of competences in postgraduate studies of finance: A project-based learning (PBL) case study," Int. Rev. Econ. Educ., vol. 35, no. March, 2020, doi: 10.1016/j.iree.2020.100192.

[34] P. Crespí, J. M. García-Ramos, and M. Queiruga-Dios, "Project-Based Learning (PBL) and Its Impact on the Development of Interpersonal Competences in Higher Education," J. New Approaches Educ. Res., vol. 11, no. 2, pp. 259–276, 2022, doi: 10.7821/naer.2022.7.993.

[35] Z. Zen, Reflianto, Syamsuar, and F. Ariani, "Academic achievement: the effect of project-based online learning method and student engagement," Heliyon, vol. 8, no. 11, 2022, doi: 10.1016/j.heliyon.2022.e11509.

[36] R. Mursid, A. H. Saragih, and R. Hartono, "The Effect of the Blended Project-based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes," Int. J. Educ. Math. Sci. Technol., vol. 10, no. 1, pp. 218–235, 2022, doi: 10.46328/ijemst.2244.

[37] A. Lozano, R. López, F. J. Pereira, and C. Blanco Fontao, "Impact of Cooperative Learning and Project-Based Learning through Emotional Intelligence: A Comparison of Methodologies for Implementing SDGs," Int. J. Environ. Res. Public Health, vol. 19, no. 24, 2022, doi: 10.3390/ijerph192416977.

[38] S. Suwarno, W. Wahidin, and S. H. Nur, "Project-based learning model assisted by worksheet: It's effect on students' creativity and learning outcomes," JPBI (Jurnal Pendidik. Biol. Indones., vol. 6, no. 1, pp. 113–122, 2020, doi: 10.22219/jpbi.v6i1.10619.

[39] Syahril, Purwantono, R. E. Wulansari, R. A. Nabawi, D. Safitri, and T. T. Kiong, "The Effectiveness of Project-Based Learning On 4Cs Skills of Vocational Students in Higher Education," J. Tech. Educ. Train., vol. 14, no. 3, pp. 29–37, 2022, doi: 10.30880/jtet.2022.14.03.003.

[40] W. Zhang, A. C. H. Yang, L. Huang, D. Y. H. Leung, and N. Lau, "Correlation between the composition of personalities and project success in project-based learning among design students," Int. J. Technol. Des. Educ., vol. 32, no. 5, pp. 2873–2895, 2022, doi: 10.1007/s10798-021-09716-z.

[41] M. Rodríguez-Peñarroja, "Integrating Project-Based Learning, Taskbased Language Teaching Approach and Youtube in the Esp Class: a Study on Students' Motivation," Teach. English with Technol., vol. 22, no. 1, pp. 62–81, 2022.

[42] D. Daniel, Applied Univariate, Bivariate, and Multivariate Statistics, vol. 72, no. Book Review 2. New Jersey: John Wiley & Sons, Inc., 2016. doi: 10.18637/jss.v072.b02.

[43] J. Choi, J. H. Lee, and B. Kim, "How does learner-centered education affect teacher self-efficacy?The case of project-based learning in Korea," Teach. Teach. Educ., vol. 85, pp. 45–57, 2019, doi: 10.1016/j.tate.2019.05.005.

[44] M. A. Amaral Féris, K. Goffin, O. Zwikael, and D. Fan, "Enhancing software development through project-based learning and the quality of planning," R D Manag., vol. 51, no. 5, pp. 447–467, 2021, doi: 10.1111/radm.12435.

[45] J. Hanham, J. McCormick, and A. Hendry, "Project-based learning groups of friends and acquaintances: The role of efficacy beliefs," J. Educ. Res., vol. 113, no. 2, pp. 133–144, 2020, doi: 10.1080/00220671.2020.1756729.

[46] A. R. Saavedra et al., "The Impact of Project-Based Learning on AP Exam Performance," Educ. Eval. Policy Anal., vol. 44, no. 4, pp. 638–666, 2022, doi: 10.3102/01623737221084355.

[47] M. Saqr and A. Alamro, "The role of social network analysis as a learning analytics tool in online problem based learning," BMC Med. Educ., vol. 19, no. 1, pp. 1–11, 2019, doi: 10.1186/s12909-019-1599-6.

[48] M. Saqr, U. Fors, M. Tedre, and J. Nouri, "How social network analysis can be used to monitor online collaborative learning and guide an informed intervention," pp. 1–23, 2018

IoT Game-based Learning Model in Education

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Abstract—The subject of this paper is the development of a game-based learning model based on the Internet of Things (IoT). The main problem discussed in the paper is to investigate the possibility of implementing a game-based learning model in an interactive educational environment that will increase student interest and enhance learning outcomes. The developed model will be based on ubiquitous computing technologies and integrate IoT, mobile, and augmented reality technologies. The proposed model integrates with existing components of the educational infrastructure. As part of the model evaluation, testing and measurement of relevant parameters that affect the effectiveness of the proposed model was carried out.

Keywords - edutainment, Internet of Things, mobile technologies, augmented reality, smart learning environments

I. INTRODUCTION

The development of the Internet of Things (IoT), mobile technologies, and augmented reality has contributed to innovations and new methodologies in education, such as developing smart educational environments, focusing on ubiquitous and active learning, and adapting learning to individuals [1].

The mobile age has made digital content part of everyday life and brought even more changes to the learning context, such as a focus on blended learning and the introduction of augmented reality and the Internet of Smart Devices as part of the teaching process [2]. Modern education requires learning on the go, anywhere and anytime, in physical or virtual environments. [3].

Augmented reality combines different computer technologies and provides the user with a unified worldview. Studies have shown that using augmented reality in education improves learning outcomes [4], [5].

Introducing educational games into smart classrooms creates an activity-filled learning environment where students can learn through play without the constraints of an actual classroom [6]. Students will be more interested in learning by presenting knowledge in a game format [8]. In order to implement smart educational environments into existing learning methods, it is necessary to base them on core values such as ethics and transparency [8].

The paper's research subject is developing a game-based learning model based on the Internet of Things (IoT). The research aims to develop a learning model through play in an interactive educational environment that will increase students' interest and improve learning outcomes. The developed model is based on ubiquitous computing technologies and the integration of IoT, mobile, and augmented reality technologies.

The primary research objective in this paper is the development of a game-based learning model based on the Internet of Things. Different models and implementation approaches for IoT-based game-based learning systems are defined. The paper proposed a new methodological procedure for learning through play based on the application of the Internet of Things.

II. BACKGROUND

Smart environments can be adapted to specific needs. Smart environments adapted to education are equipped to enhance the learning process from a technological perspective [9]. Smart learning environments enable the safe use of current technologies in the transfer of knowledge [10]. "Smart learning environments refer to a ubiquitous, personalized and intelligent system that is context-aware, capable of providing high levels of motivation, engagement and intelligent feedback for a better learning experience" [11]. By enabling communication between devices, smart educational environments offer quick and easy access to classroom distance learning material [12].

Koper, 2014 outlines the requirements for creating smart play environments [13]:

- digital devices are added to physical learning locations;
- digital devices detect the location and context of students;
- digital devices improve the physical learning environment with additional digital learning functions;
- digital devices monitor students' progress.

Learning through play is a learning method realized by applying games in the teaching process that improves attitudes and approaches to learning and allows students to have fun during the learning process [14]. Many studies have shown that digital game-based learning positively impacts motivation, attitude, student engagement, and performance [15]. Learning through play facilitates students to learn by using games as a medium, activating motor and cognitive sensors [16].

Educational games are games that contribute to the education of the player [17]. Educational games include not only those created as such but also those that only secondarily expand the knowledge and abilities of the contestants. [18]. It can be said that any game that helps players develop is actually educational [19]. Games help improve competitors' abilities, primarily cognitive and the ability to react and make quick decisions. However, at a higher level, educational games help to master certain areas, complex concepts, or other teaching elements within which they are implemented [20].

The combination of the IoT ecosystem with educational games is called Smart Educational Games. Smart educational games are tools that can solve real-world problems in any domain where game technology can help [21], [22]. In an interconnected IoT ecosystem, educational games could collect and analyze data from players' physical environments and present it to the user to provide better insight into player behavior. Using player behavior data allows game developers to improve the game, provides more robust conclusions about game-related research, and helps the industry tailor in-game content to match player satisfaction, among other things [23]. Research into the application of sensor technologies has highlighted gamification as an area of high potential. It allows sensor-based data to make recommendations to users, creating a smart solution [24].

The Internet of Things can be used to enhance learning through play. The physical aspects of the Internet of Things contribute to students' interaction and hands-on experience. Maintaining games within the IoT system makes it possible to simulate real situations and measure the players' adaptation to the environment [25].

Technologies such as augmented reality and their application in digital educational games have the potential to motivate students [26]. Augmented reality provides the user with a unique view of the world created as a combination of physical and virtual. The combination is created by combining the real world in which the user is located and computer-generated virtual scenes. It is an interactive environment where reality is enhanced with real-time virtual objects [27]. By analyzing the literature, it was observed that using educational games with augmented reality elements in teaching activities leads to an increase in learning efficiency. Other benefits include increasing student motivation and interest, improving communication and interaction between participants, and a higher degree of satisfaction after learning. [28].

Learning through play using technology in a smart learning environment enables students to acquire knowledge and develop cognitive and social skills [29]. The benefits and needs of serious games require implementing advanced technologies in smart environments to improve the learning process. Games in smart environments are interactive and capable of automatically tracking and collecting data on student activities [30]. Learning through play provides students with a fun, interactive, and challenging learning experience. In addition to the transfer of knowledge, students can practice the practical application of acquired knowledge, test themselves, and measure their progress [31]. This type of learning provides students with a contextualized and personalized learning environment that meets the individual needs of different students [32].

Modern educational games are created using advanced technologies, and their implementation requires appropriate technical conditions. The technical characteristics of smart educational environments serve as the initial infrastructure for implementing educational games. Some of the benefits of smart environments are access to the Internet and intranet; various sensors that can help play the game, and interfaces that facilitate the implementation process itself. If it is about smart classrooms, there is an additional advantage, integration with existing learning systems. The advantages of applying learning games in smart environments can be divided into the following categories [33]:

- Collecting data about students and the game process;
- Adapting the game to students;
- Overview of achieved results and competitions;
- Interaction with the game system.

III. MODELING

Modeling a smart educational environment for learning through play is a way to connect the services of the Internet of Things, mobile technology, and educational games into a unique system that improves the learning process in higher education. The proposed model of education in smart educational environments includes the following components: the framework of the learning system through the game, the architecture of the smart environment, the software infrastructure of the smart environment, testing knowledge through games, the integration of the components of the

Internet of Things with the e-learning system.

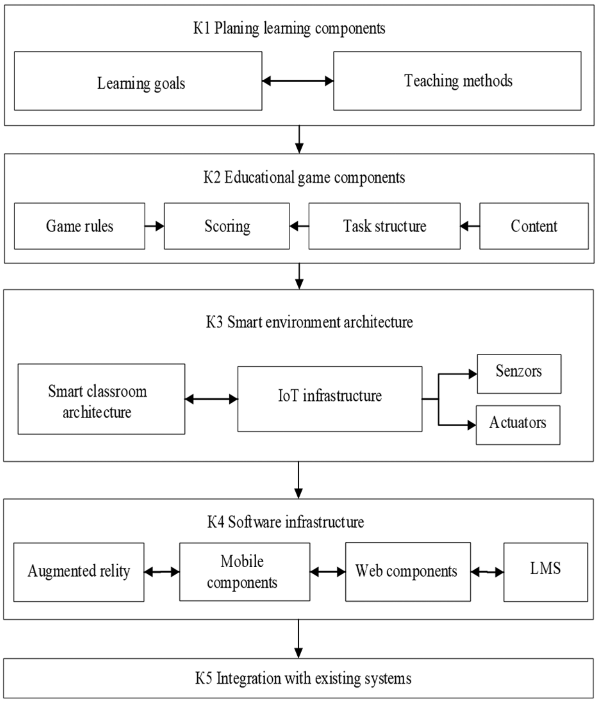

Figure 1 Model structure

The first step in planning the model is defining learning goals and outcomes. The success of the learning model is measured based on the efficiency and effectiveness of the knowledge transfer process, maintaining student motivation and achieving learning outcomes [34]. Smart educational environments, IoT, and augmented reality have a wide range of potential effects on student motivation and learning outcomes.

Here is a summarized, but not exhaustive, list of possible goals related to students and learning:

- greater interest in the field of study;
- higher level of motivation during learning;
- higher level of communication and cooperation with other students and professors;
- better learning outcomes.

When creating a teaching plan that would meet the mentioned goals and enable the achievement of the required learning outcomes, it is necessary to follow the revised Bloom's Taxonomy [35]. Before the lesson, it is necessary to make a lesson plan. The lesson plan should include the content that will be taught during the lesson. The content includes professor's lectures (presentation of knowledge), practical teaching (application of knowledge), and testing. In addition to classic lectures, it is necessary to prepare learning material that is always available to students through systems integrated into a smart environment. After planning and preparing the materials, designing games for application and testing is necessary. At this stage, it is necessary to consider the environment's current technical and technological capabilities. Based on the present IoT devices and implemented software, planning each task individually and combining them into one game is necessary. The tasks depend on the application technologies, and it is necessary to create standardized tasks for easier classification and implementation. The components used in the tasks must be designed according to the principle of mutual communication and communication with other system elements.

The initial hypothesis of the application of educational games in education is the influence on student motivation [36]. A higher level of engagement and commitment is achieved by implementing solutions that require user interaction. If the medium of knowledge transfer is also fun for the user, better results were observed during knowledge testing compared to the control group. [37].

Depending on the goal of the game and the area of the teaching material, it is necessary to choose the type of game to be created. According to the type of game and the objectives of the test, it is necessary to define the rules of the game. The number of players that will make up one team should be defined if it is a team game. The game should test students' knowledge, so it is necessary to define whether the testing is time-limited for one attempt to solve, the method of scoring tasks, the flow of tasks that can be random or sequential, and the way of interaction between tasks, participants and the learning system.

According to the type of study material and technical limitations, it is necessary to choose the type of game that will be used. After choosing the type of game and creating the framework, it is necessary to divide the game into meaningful parts that will be separately designed and implemented, so-called tasks. The task tests one domain of knowledge from the subject of study. It is necessary to define the necessary teaching material, technical equipment, and, if the task is solved by physical presence in the environment, the execution location. Each task must have the characteristics of communication with the system and with users and must meet the criteria of fun character and valid transfer and testing of knowledge.

Students learn how to solve complex problems in an ideal educational game environment. The game's problems usually start easy and become progressively more difficult as the player's skill develops. Students are motivated to learn because learning occurs through the process of theorizing, examining, thinking, and drawing conclusions about the simulated situation depicted in the game. Objectives are clear, and information is made available to players to achieve each objective [38].

When researching learning through play, two types of outcomes were observed, changes in learning outcomes and changes in interest and motivation. In addition to measuring the success of knowledge transfer, it is also important to check players' satisfaction with a given game. For games to be interesting and accessible to users, it is necessary to define a user experience model. Factors affecting the experience are grouped into the following categories [39]:

- Engagement,
- Purpose of the game,
- Interaction and
- Possibility of learning.

IV. RESULTS

The designed system was evaluated in the Internet of Things course of graduate studies in the Information Systems and Technologies department of the Department of Electronic Business at the Faculty of Organizational Sciences, University of Belgrade. In the course, students learn the basics of internet technologies of intelligent devices. The course was implemented in the form of mixed learning using the Moodle system.

The research was conducted at ELAB during the spring semester of the 2017/2018 school year. Year, on a sample of 24 undergraduate students who attended the Internet intelligent devices and Mobile business courses. All respondents were between 20 and 25 years old; 29.2% were men, and 70.8% were women.

All students who attended the course consented to participate in the research. During the 3-month course, students have exercises in which they discover new elements and participate in group projects that require weekly evaluation. The game was presented during one of the lectures during the semester. The purpose of the research and instructions for using the software were explained in the presentation. The first step was filling out the questionnaire. After filling out the questionnaire, two tests followed. The first was a written test, and all students did it simultaneously. The second test was realized through the presented software and hardware. Due to technical limitations, the second test was done in groups. Both tests had the same tasks. In the game, the tasks are given in a random order. Students did not have an insight into the accuracy of the solutions to the tasks until both tests were completed. In this way, the influence of the first test on the second was avoided. After the two tests, students were asked to complete a second questionnaire.

The results show that the time needed to solve the game is significantly longer than the time to solve the written test ($t = 29.37$, $p < .05$). Students achieved better results in the game compared to the results of the written test, which leads to the conclusion that this type of game-based learning and assessment can be incorporated into regular activities. A positive observation is that more students passed the IoT test. A possible explanation is that some students struggle when taking written tests, and using active learning methods is easier. Detailed results were published in [40].

V. CONCLUSION

This paper aimed to develop a game-based learning model based on the Internet of Things. Using a mobile educational game based on ubiquitous computing and the Moodle learning system, it is proposed to expand the formal learning process by abandoning the concept of traditional classrooms and moving to learn through interaction with the environment. The main contribution of the research is a defined approach to learning through play in smart learning environments based on the Internet of Things to increase students' interest. The presented approach can be used both as a learning activity and a tool for testing students' knowledge.

REFERENCES

[1] X. Wei, Q. Gu, Y. Luo, and G. Chen, “The reform of computer experiment teaching based on O2O model,” Comput. Appl. Eng. Educ., vol. 27, no. 1, pp. 102–111, 2019.

[2] Z. Bogdanović, D. Barać, B. Jovanić, S. Popović, and B. Radenković, “Evaluation of mobile assessment in a learning management system,” Br. J. Educ. Technol., vol. 45, no. 2, pp. 231–244, Mar. 2014.

[3] P. Sharma, “Blended learning.,” ELT J. English Lang. Teach. J., 2010.

[4] Y. Wang, S. K. Ong, and A. Y. C. Nee, “Enhancing mechanisms education through interaction with augmented reality simulation,” Comput. Appl. Eng. Educ., vol. 26, no. 5, pp. 1552–1564, 2018.

[5] J. Ristic, D. Barac, Z. Bojovic, Z. Bogdanovic, and B. Radenkovic, “Designing augmented reality application for interaction with smart environment,” in Proceedings of the 10th International Conference on Virtual Learning, 2015, pp. 273–278.

[6] J. P. Gerval and Y. Le Ru, “Smart Classroom,” in Smart Innovation, Systems and Technologies, 2016, pp. 415–422.

[7] A. Labus, M. Despotović-Zrakić, B. Radenković, Z. Bogdanović, and M. Radenković, “Enhancing formal e-learning with edutainment on social networks,” J. Comput. Assist. Learn., vol. 31, no. 6, pp. 592–605, Dec. 2015.

[8] D. Stojanović, Z. Bogdanović, L. Petrović, S. Mitrović, and A. Labus, “Empowering learning process in secondary education using pervasive technologies,” Interact. Learn. Environ., pp. 1–14, 2020.

[9] K. Nagao and K. Nagao, “Smart Learning Environments,” in Artificial Intelligence Accelerates Human Learning, 2019, pp. 105–134.

[10] R. Zhuang, H. Fang, Y. Zhang, A. Lu, and R. Huang, “Smart learning environments for a smart city: from the perspective of lifelong and lifewide learning,” Smart Learn. Environ., vol. 4, no. 1, p. 6, 2017.

[11] F. J. Agbo, S. S. Oyelere, J. Suhonen, and M. Tukiainen, “Scientific production and thematic breakthroughs in smart learning environments: a bibliometric analysis,” Smart Learn. Environ., vol. 8, no. 1, 2021.

[12] A. Alelaiwi, A. Alghamdi, M. Shorfuzzaman, M. Rawashdeh, M. S. Hossain, and G. Muhammad, “Enhanced engineering education using smart class environment,” Comput. Human Behav., vol. 51, pp. 852–856, Oct. 2015.

[13] R. Koper, “Conditions for effective smart learning environments,” Smart Learn. Environ., vol. 1, no. 1, p. 5, Dec. 2014.

[14] A. K. Yadav and S. S. Oyelere, “Contextualized mobile game-based learning application for computing education,” Educ. Inf. Technol., vol. 26, no. 3, pp. 2539–2562, May 2021.

[15] D. Tigelaar and P. Sins, “Effects of formative assessment programmes on teachers’ knowledge about supporting students’ reflection,” J. Vocat. Educ. Train., vol. 73, no. 3, pp. 413–435,

2021.

[16] J. Piaget, Play, dreams and imitation in childhood. 2013.

[17] M. Ortiz-Rojas, K. Chiluiza, and M. Valcke, “Gamification through leaderboards: An empirical study in engineering education,” Comput. Appl. Eng. Educ., vol. 27, no. 4, pp. 777–788, 2019.

[18] I. Garcia, C. Pacheco, A. León, and J. A. Calvo-Manzano, “Experiences of using a game for improving learning in software requirements elicitation,” Comput. Appl. Eng. Educ., vol. 27, no. 4, pp. 249–265, 2019.

[19] M. A. Khenissi, F. Essalmi, M. Jemni, and Kinshuk, “Learner Modeling Using Educational Games: A Review of the Literature,” Smart Learn. Environ., vol. 2, pp. 1–6, 2015.

[20] M. D. Griffiths, “The educational benefits of videogames,” Educ. Heal., vol. 20, no. 3, pp. 47–51, 2002.

[21] M. Fominykh, A. Smorkalov, M. Morozov, and E. Prasolova-Førland, Fusion of Smart, Multimedia and Computer Gaming Technologies, vol. 84. Cham: Springer International Publishing, 2015.

[22] L. Petrović, D. Stojanović, A. Labus, Z. Bogdanović, and M. Despotović-Zrakić, “Harnessing Edutainment in Higher Education: an Example of an IoT Based Game,” in In The 12th International conference on virtual learning, Sibiu, Romania-Europe, 2017, pp. 318–324.

[23] J. Henry, S. Tang, S. Mukhopadhyay, and M. H. Yap, “A randomised control trial for measuring student engagement through the Internet of Things and serious games,” Internet of Things (Netherlands), vol. 13, Mar. 2021.

[24] M. Swan, “Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0,” Journal of Sensor and Actuator Networks, vol. 1, no. 3. MDPI AG, pp. 217–253, Dec-2012.

[25] L. Petrović, I. Jezdović, D. Stojanović, Z. Bogdanović, and M. Despotović-Zrakić, “Development of an educational game based on IoT,” Int. J. Electr. Eng. Comput., vol. 1, no. 1, pp. 36–45, 2017.

[26] L. E. Bruno, “Get Gamified: Promoting Augmented Reality and Digital Game Technology in Education,” in Augmented Reality Games I, 2019.

[27] M. Kesim and Y. Ozarslan, “Augmented Reality in Education: Current Technologies and the Potential for Education,” Procedia - Soc. Behav. Sci., vol. 47, pp. 297–302, Jan. 2012.

[28] T.Ređep and G. Hajdin, “Use of Augmented Reality with Game Elements in Education – Literature Review,” J. Inf. Organ. Sci., vol. 45, no. 2, pp. 473–494, Dec. 2021.

[29] A. Carruana Martín, C. Alario-Hoyos, and C. Delgado Kloos, “Smart Groups: A Tool for Group Orchestration in Synchronous Hybrid Learning Environments,” in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2021, vol. 12884 LNCS.

[30] A. Husnanda and J. Ikhsan, “Developing Science Education Game Based on Internet of Things (IoT): Materials and Methods Overview,” in Proceedings of the 6th International Seminar on Science Education (ISSE 2020), 2021, vol. 541.

[31] C. H. Chen, J. H. Liu, and W. C. Shou, “How competition in a game-based science learning environment influences students’ learning achievement, flow experience, and learning behavioral patterns,” Educ. Technol. Soc., vol. 21, no. 2, pp. 164–176, 2018.

[32] J. M. Sykes and S. Dubreil, “Pragmatics Learning in Digital Games and Virtual Environments,” in The Routledge Handbook of Second Language Acquisition and Pragmatics, Routledge, 2019, pp. 387–399.

[33] M. Zhang and X. Li, “Design of Smart Classroom System Based on Internet of Things Technology and Smart Classroom,” Mob. Inf. Syst., vol. 2021, 2021.

[34] P. Tungkunanan, “Learning model of undergraduate students: Confirmatory factor analysis,” Int. J. Instr., vol. 13, no. 3, pp. 665–678, Jul. 2020.

[35] L. W. Anderson, D. R. Krathwohl, and B. S. Bloom, A taxonomy for Learning Teaching and Assessing. 2001.

[36] J. Krath, L. Schürmann, and H. F. O. von Korflesch, “Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning,” Comput. Human Behav., vol. 125, Dec. 2021.

[37] Z. Yu, M. Gao, and L. Wang, “The Effect of Educational Games on Learning Outcomes, Student Motivation, Engagement and Satisfaction,” J. Educ. Comput. Res., vol. 59, no. 3, pp. 522–546, Jun. 2021.

[38] J. Hamari, D. J. Shernoff, E. Rowe, B. Coller, J. Asbell-Clarke, and T. Edwards, “Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning,” Comput. Human Behav., vol. 54, pp. 170–179, Aug. 2016.

[39] V. Nagalingam, R. Ibrahim, and R. C. M. Yusoff, “EDUGXQ: User experience instrument for educational games’ evaluation,” Int. J. Adv. Comput. Sci. Appl., vol. 11, no. 1, pp. 562–569, 2020.

[40] L. Petrović, D. Stojanović, S. Mitrović, D. Barać, and Z. Bogdanović, “Designing an extended smart classroom: An approach to game-based learning for IoT,” Computer Applications in Engineering Education, vol. 30, no. 1. pp. 117–132, 2022.

Digital Project-Based Learning for Kids: A Case Study of Start-up Kids Campus

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Abstract—This paper proposes a conceptual model for implementation of Digital Project-based Learning (D-PBL) for kids in the age range of 7 to 17 years old to teach them 21st century skills using project-based learning methodology in a digital environment. The model is applied to a practical initiative called Start-up Kids Campus which focuses on fostering start-up and entrepreneurship skills, creative economy, and development of soft skills. Kids living in different regions, but who have the same country origin are brought together in a D-PBL platform to collaboratively participate in impactful projects. The paper discusses the conceptual model and shares the experiences gained from the initial work and the digital tools and resources used for the implementation of D-PBL in the context of Start-up Kids Campus. Future works include integration of kid friendly project management tools, expanding the access to multi-national teams, and integration with generative AI solutions.

Keywords - digital project-based learning, start-up kids, soft skills, knowledge economy, creative economy

I. INTRODUCTION

Project-Based Learning (PBL) is an educational approach that emphasizes the acquisition of knowledge through the solving of real-world problems and participation in projects [1]. PBL is a constructivist theory-based learning model that involves students in problem-solving activities and gives them the chance to work in teams autonomously to construct their own learning in accordance with the demands of the curriculum. PBL is an innovative learning model that involves students in problem-solving activities and gives them the chance to work in teams autonomously to construct their own learning in accordance with the demands of the curriculum [2]. It is a student-centered learning approach that offers educators the opportunity to engage learners in solving complex real-world problems [3]. PBL has also been found to improve students' performance and achievement and has been used in various fields of education, including STEM education [4][5], vocational education [6], and engineering education [7]. The implementation and assessment methods of PBL makes it a bit challenging [8][9]. In general, PBL involves working in groups, developing technical and communication skills, excelling in creative and critical thinking, which can be enhanced by digital educational technologies.

Digital Project-based Learning (D-PBL) is an innovative approach to education that incorporates digital technologies and tools to facilitate learning and enhance the quality of education [10]. D-PBL extends the traditional approach to PBL by incorporating digital technologies and tools to facilitate learning and has been shown to improve the learning outcomes of students and enhance the quality of education and developing variety of skills [11].

This paper proposes a conceptual model for D-PBL for kids, which is inspired by the play-based Finish educational framework in primary education and the Erasmus+'s D-PBL project in higher education [12]. The Finnish education system is known for its play-based educational framework, which emphasizes the importance of learning through play and exploration [13]. The Finnish curriculum is designed to promote creativity, critical thinking, and problem-solving skills. The benefits of the Finnish curriculum include high academic achievement, low levels of stress and anxiety among students, and a focus on equity and equality in education [14]. On the other hand, the Erasmus+ program has been involved in several projects related to project-based learning and digital technologies which demonstrate the potential benefits of project-based learning and digital technologies in various fields and learning contexts [15][16][17]. The recent Erasmus+ D-PBL project, however, aims to provide learners with technical skills in a real-world context, develop digital competencies that are useful in business, and involve students in multinational teams. In a similar approach, the model D-PBL for Kids is applied to a practical initiative called Start-up Kids Campus, which aims to teach kids in the age range of 7 to 17 years old various 21st century skills, including start-up and business skills, knowledge and creative economy, soft skills, and emotional intelligence by engaging young students in project-based extracurricular courses and special events empowered by digital learning environment. The initiative fosters cross-regional collaboration among kids in different parts of the world, but who have the same country origin. The kids supported by their parents and remote mentors work together in a digital learning environment and participate in projects to solve real-world problems affecting their community. The paper discusses the theoretical foundations of the conceptual model, the design principles, the learning outcomes, and how D-PBL is being implemented in the Start-up Kids Campus initiative. The findings of this paper have implications for the education of kids, particularly in the digital age, and offer insights for future research directions.

In theory, D-PBL, which follows student-centered learning approach brings an immense opportunity to enhance formal education by engaging learners in solving complex real-world problems using digital tools and resources in various fields of education, including STEM education, vocational education, and engineering education. However, its applicability and implementation can be challenging due to the need for a shift in pedagogical approaches and the lack of resources and support from trained teachers [18][19]. Most tools, settings, environments, and resources for project-based learning are designed to support the interaction of small groups rather than entire classes, making them particularly unusable in classroom settings [20]. However, well curated digital technologies and teachers with digital competencies can provide opportunities to overcome these challenges in an extracurricular setting at a satisfactory scale. Digital tools such as video production resources, editing software, 3D design platforms, coding, e-book writing, and role-play resources can be used to enhance student engagement and provide a more authentic learning experience [21]. Additionally, the use of flipped teaching, active learning, and collaborative active learning digital spaces can be used to facilitate multidisciplinary and multinational project-based learning [22].

In the case of Start-up Kids Campus, D-PBL model was implemented based on basic and generic learning competences and project-based courses were designed to advance learners start-up and business skills and these courses were offered via integrated digital learning environment. Unlike the highly hyped self-paced learning [23], which offers limited or no opportunity for collaboration and is prone to procrastination, cohort-based traditional learning is a better option for implementation of the PBL methodology. This paper discusses a conceptual model that facilitates a project-based digital learning approach to teach kids start-up and business skills. Courses are offered at clearly specified schedules and in addition to pre-recoded online learning materials, live sessions are arranged at regular time intervals.

The rest of the paper is organized as follows: section II discusses literature review, section III discusses the D-PBL for Kids conceptual model, section IV highlights the implementation of D-PBL in Start-up Kids Campus, section V presents some experiences and lessons learned, and section VI concludes with summary of findings and future directions.

II. LITERATURE REVIEW

Project-Based Learning (PBL) is an educational approach that emphasizes the acquisition of knowledge through the solving of real-world problems and participation in projects [2]. PBL is a constructivist theory-based learning model that involves students in problem-solving activities and gives them the chance to work in teams autonomously to construct their own learning in accordance with the demands of the curriculum [24]. It is an innovative learning model that involves students in problem-solving activities and gives them the chance to work in teams autonomously to construct their own learning in accordance with the demands of the curriculum. Implementation of PBL can be made for different purposes and at different success rates. This section briefly discusses implementation experiences of both PBL and D-PBL and some of the related challenges [8].

A project-based learning in the classroom was studied by [17], in which 114 fist-year high school students participated with the objective to analyze the experience of the students who participated and understand their satisfaction. A very positive assessment was made by the students, related to teamwork and the use of digital tools as explained by the results obtained. However, there were complications regarding the time devoted and the orientation during the project work. The authors have analysed groups using inferential analysis and have revealed significant differences between the work groups.

In another study [25], the authors investigated the effects of D-PBL on students' academic achievement and technological skills. It was found that a significant difference exists between students' academic achievement who were taught under the D-PBL with satisfactory results and students who were taught under non-PBL courses which didn't meet expectations in their results.

A research study conducted by [12], in the higher education sector aimed to explore how students cope with a digital project-based learning environment and how the findings can be utilized to enhance future digital or blended-learning situations. The evaluation of a higher education course involved students conducting an independent empirical study through self-directed project planning, execution, and critical reflection. The study focused on the evaluation results of a digital project-based course in higher education. The research findings centered on the students' perspectives, behaviours, and inclinations towards digital project-based learning.

Researches similar to our approach were done at different capacities. For instance, [26], reviewed the pedagogical structure and the impact on skill development of live marketing related courses designed using project-based methodology, but at a university setting. The courses that were conducted in real-time aimed to assist students in acquiring technical skills related to digital marketing, as well as essential meta-skills such as creativity, critical thinking, collaboration, and communication. The assessment process, which included both direct and indirect methods, was used to evaluate the effectiveness of the projects. The results indicate that live project-based learning can aid in the development of technical and meta-skills that are crucial for students to adapt to uncertain and ambiguous situations, and to be well-prepared for the workforce.

Sampurna, et al. [27], explored learners' and teacher's participation in online non-formal project-based language learning. Tinapple, et al. [28], outlined a project-based digital arts curriculum through which novice middle and high school students are intrinsically motivated to learn and apply STEM skills and computational thinking. In another study, Hana and colleagues [29], examined the potentials of digital and physical modeling as tools for project-based learning. Marry Rose, et al. [30], suggested that crafting digitized modules in the context of project-based learning can be an effective tool in improving learners' scientific competency skills. To empower children and young people with creative and critical digital skills [31], a knowledge and skill set base was developed and learning was suggested to be offered through playful solutions. In another study [32], the use of digital storytelling for early childhood creativity was explored. Johnston, K. in [33], discussed how digital technology can support children and educators as co-learners.

The study papers discussed in the literature offered theory and practice-based guidelines for practitioners who wish to empower children to make and shape digital technology in the context of non-formal learning and fab labs. These studies and related resources demonstrate the potential of D-PBL to empower skills and talent development in kids at variety of age ranges. However, these studies do not offer a clear conceptual model that can be replicated for a selected age ranges and for specific competency areas. Building on these studies, the Start-up Kids Campus initiative designs a conceptual model for implementing D-PBL for kids with the objective to teach kids start-up and business skills along with technical skills, soft skills and emotional intelligence as a form of extracurricular cohort-based courses, events and projects.

III. DIGITAL PROJECT-BASED LEARNING FOR KIDS CONCEPTUAL MODEL

The conceptual model for implementing D-PBL for Kids in the case of Start-up Kids Campus revolves around these three complementary phases:

- *Basic and generic competences*: indentifying and documenting basic and generic competencies desired to be mastered by kids of age ranging from 7 to 17 years old.
- *D-PBL Courses:* Designing and categorizing digital courses that teaches kids start-up and business skills, technical skills, soft skills and emotional intelligence coupled with the competences identified in a project-based learning setup
- *Educational digital technologies*: selection, design, development, integration and utilization of digital technologies used to disseminate the D-PBL courses, which in turn embed the desired competences.

A. Basic And Generic Competences

The competences that are used in this project are categorized into two categories and their brief descriptions are included wherever possible:

1. *Basic competences:* These competences include
   a. *Literacy;*
   b. *Numeracy;*
   c. *Information and Communication Technology;*
   d. *Citizenship, Language, Culture, and Nationality,;*
   e. *Entrepreneurship and Start-up skills;*
   f. *Science and Technology;*
   g. *Communication in an International language.*
2. *Generic competences for PBL*: These competences include
   a. *Critical thinking and problem-solving*: Project-based learning motivates children to scrutinize intricate problems, exercise critical thinking, and devise inventive solutions. They acquire the ability to recognize obstacles, generate ideas, and assess various methods to tackle problems [34].
   b. *Communication and collaboration*: Engaging in project-based learning cultivates effective communication and collaboration skills in children. They acquire the skills to articulate their thoughts, actively listen to others, negotiate, and work collaboratively as a team. They also develop the ability to delegate tasks, collaborate, and make valuable contributions to group projects.
   c. *Creativity and innovation*: project-based learning provides children with the freedom to explore ideas, experiment with solutions, and think creatively, which stimulates innovation. They learn to embrace diverse perspectives, take risks, and develop original solutions [35].
   d. *Digital literacy and technology skills:* Participating in digital project-based learning provides children with crucial digital literacy skills. They acquire the ability to navigate digital tools and platforms, utilize technology for research and communication, and develop expertise in using software and online resources that are pertinent to their projects [36].
   e. *Time management, productivity and organization:* Project-based learning teaches kids valuable skills in time management, organization, and prioritization. They learn to set deadlines, create schedules, and manage their time effectively to complete tasks within given timeframes.
   f. *Self-directed learning and autonomy*: Project-based learning enables children to take charge of their learning process [37]. They acquire self-directed learning skills, become more independent in their decision-making, and assume accountability for setting objectives, strategizing, and tracking their advancement.

B. D-PBL Courses

Some of the courses designed for the purpose of implementing D-PBL for Kids for start-up and buisness skills include:

- Entrepreneurship for Kids
- Start-up and Business Development
- Nationality, Language and Culture
- Coding for Kids
- 3D Design and Printing for kids
- ICT Literacy
- Math Mastery and
- Environment and Sustainability

All these courses are offered in an online environment, enrolment per class is in small number from five to seven students. The courses are time bound and scheduled with interval live sessions.

C. Educational digital technologies

There are a range of digital technologies compatible with teaching programs for kids. However, in the case of Start-up Kids project, the technology resources are highly curated and well-integrated. Some of the tools are:

a. Smart LMS: a freely available and open-source leanring management system customized into Smart LMS, which is the core system for the Start-up Kids virtual campus platform.

b. Video conferencing tool: Well-integrated with the Smart LMS, the online meeting and video conferencing tool is used to organize cohort-based online live session with students.

c. Media content creation: Digital tools to create, edit, and publish digital content.

d. 3D design and Coding tools: For prepating 3D printed educational and useful to the day-to-day life of students.

e. Project Management and Calendar tools: These tools and resources are crucial to the project-based learning methodology.

f. Virtual/Augmented Reality (VR) resources: Used to simulate and experince digital worlds.

g. Productivity and Communication tools: used to inpire kids to start working in a productive manner.

D. The D-PBL Conceptual Model

The following figure illustrates the conceptual model of the D-PBL for kids project implementation in Start-up Kids Campus:

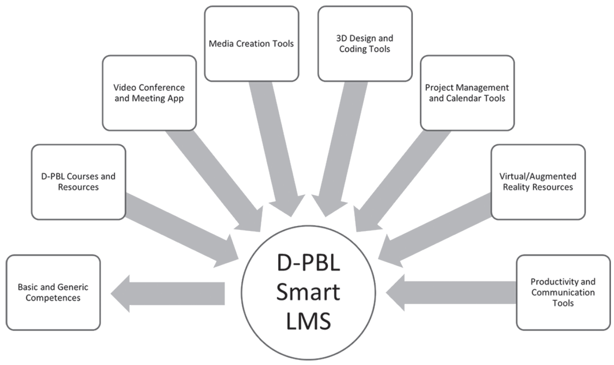

Fig. 1. D-PBL for Kids Conceptual Model

All the tools and resources around the D-PBL Smart LMS contribute to the development of the basic and generic competences. At the center of the simple conceptual model is the core digital technology for integrating with other supplimentary tools and resources. The use of digital technologies has a significant effect on project-based learning for children, resulting in various advantages, including:

- *Access to information and resources*: Children can benefit from digital tools and technologies as they provide them with access to a wide range of information resources, including online libraries, educational websites, and research materials. This enables them to explore different perspectives, gather information, and enhance their comprehension of project subjects.
- *Collaboration and communication*: With the aid of digital platforms, children can collaborate and communicate with ease, irrespective of their location. They can connect, exchange ideas, work together on projects, and receive immediate feedback from both peers and mentors.
- *Multimedia and interactive learning*: The use of digital technologies provides children with multimedia resources, such as interactive simulations, videos, and virtual reality experiences. These resources increase engagement, offer practical learning opportunities, and simplify complex concepts, making them more enjoyable and accessible for kids.
- *Project management and organization*: Children can utilize digital project management tools to effectively organize their tasks, set deadlines, track progress, and collaborate with team members. These tools offer intuitive platforms that enable them to visualize their project workflow, allocate resources, and manage their work efficiently.

Taking into account the aforementioned factors, a conceptual model for introducing project-based learning in a digital learning setting to teach children start-up and business skills, technical skills, soft skills, and emotional intelligence may comprise the subsequent elements:

1. *Project Selection and Planning*: Children, under the guidance of teachers or mentors, select project subjects that align with their interests, learning objectives, and desired competencies. They strategize the project's scope, goals, and outcomes, taking into account the incorporation of start-up and business skills, technical

skills, soft skills, and emotional intelligence.

2. *Digital Resource Exploration*: Children employ digital resources and tools to conduct research, collect information, and investigate pertinent content. They utilize online libraries, multimedia resources, educational websites, and interactive platforms to attain comprehensive and captivating learning experiences.
3. *Collaboration and Communication*: Digital platforms enable virtual collaboration and communication among children, peers, and mentors. They participate in online discussions, brainstorming sessions, and peer feedback to promote efficient teamwork, communication abilities, and cross-cultural comprehension.
4. *Skill Development Activities*: Children take part in diverse activities that aim to enhance particular skills. They involve themselves in online courses, interactive tutorials, virtual workshops, and practical projects that concentrate on developing start-up and business skills, technical skills, soft skills, and emotional intelligence.
5. *Project Implementation and Reflection*: Children utilize their gained knowledge and skills to strategize, implement, and finalize their projects. They make use of digital project management tools to arrange tasks, establish deadlines, monitor progress, and cooperate with team members.
6. *Assessment and Feedback*: To assess children's project outcomes and their progress in achieving targeted competencies, evaluation techniques such as rubrics, peer evaluations, and self-reflection are employed. Teachers and mentors offer constructive feedback to facilitate continuous improvement and learning.
7. *Reflection and Presentation*: Children contemplate on their project experiences, acquired knowledge, encountered obstacles, and individual development. They exhibit their project results through presentations, digital portfolios, or multimedia artifacts to showcase their accomplishments and improve their communication abilities.
8. *Continuous Learning and Iteration*: The model highlights the significance of continuous learning and iteration, enabling children to participate in several project cycles to improve their skills, knowledge, and competencies. Feedback obtained from assessments and reflections is utilized to inform subsequent projects, fostering a progressive and iterative learning process.

The implementation of this model enables digital project-based learning to offer a well-organized and captivating approach for children to enhance their start-up and business skills, technical skills, soft skills, and emotional intelligence in a digital learning setting. The model encourages active learning, collaboration, critical thinking, and creativity, empowering children with the competencies required for success in the 21st century.

IV. IMPLEMENTATION OF D-PBL FOR START-UP KIDS CAMPUS

The D-PBL for Kids concept model was implemented partially in the Start-up Kids Campus initiative. The initiative is founded in Kigali, Rwanda, but targets kids of Eritrean communities living all over the world with the mission to bring together kids having different cultural, educational, and life exposures, yet who have the same country origin. As of this writing, the initiative so far attracted 68 students age ranging from 7 to 17 years old who are living in Africa, Europe, UK, and US. Out of which 37 students are able to participate in the core digital project-based learning platform – the Smart LMS. While all of the students are active participants of one or more digital tools, especially the online video conferencing tool is very popular.

To implement the project, first the desired basic and generic competences were identified. Following, D-PBL courses were developed and/or adopted and customized from popular public resources. Finally, the relevant digital educational technologies were selected, customized and deployed. Discussed below is the details for the implementation of the D-PBL technical platform followed by PBL course delivery and translating learning into the basic and generic competencies identified in section III.

A. Implementation of Smart LMS

On of the key components for the implementation of the D-PBL conceptual model for the Start-up Kids Campus initiative is the digital learning platform called as Smart LMS. The purpose of Smart LMS is to deliver project-based learning courses and manage student teams and related projects. Smart LMS is developed based on an open-source content management system – WordPress, customized and rebranded as Smart LMS. Here are the main components of the LMS in support of D-PBL:

- *Smart Lessons and Quizzes* – this component enables teachers and mentors to prepare time-bound, pre-scheduled learning and assessment materials.
- *Smart Teams* – adds the ability to create teams of size from five to seven members. Members discuss about the course they are taking, project they are working on and share knowledge with other students in the platform.
- *Cohort-based learning* – instead of leaning at their own pace, students participate in PBL courses within a pre-defined time range, encouraging them to submit assignments, project milestones in a given time period.
- *Content Drip* – this is more of a feature than a component. Series of learning contents are delivered at specific dates of the week and are made available once the previous lesson is completed.
- *Multi teachers/ Mentors* – a single project-based course is facilitated by multiple teachers/ mentors who specializes in different professions that are related to the particular project-based courses.
- *Video conference integration* – students are able to participate course-related pre-scheduled online classes which run in the form of workshops. This is made possible by integrating video conference tools like Google meet and Zoom meeting.

- *Basic project and time management* – students are able to access platform wide calendar with a view of all project and course-related upcoming and past events. In the future, kid-friendly project management tools will be introduced

B. Course Deisgn and Delivery

Project-based courses are designed and delivered via the Smart LMS platform. Courses are meant to teach young students start-up and business skills in an engaging and participatory way. Some of the courses already applied are:

- Start-up and Entrepreneurship for kids
- Communication, Language, and Culture
- Basic Finance for kids
- 3D Design and Printing
- Coding and Game Development
- Technology, Toys and Kids
- Creative Economy
- Soft skills for Kids

C. Ocassional Events, Workshops and Hackathons

As part of the Start-up Kids Campus initiative, teachers and mentors organize competitive events, workshops and hackathons for young students while educating them start-up skills and business concepts.

V. EXPERIENCES AND LESSONS LEARNED

Although the implementation of D-PBL for Kids for the Start-up Kids Campus initiative is at its initial stage, the following lessons were learned from the experience:

- Project-based learning is becoming more attractive and engaging to young students as it is enhanced by digital technologies
- Interactive live sessions and gamified contents gets more attention by students
- Allocating students into teams and providing them with similar projects leads to competition and cooperation and students learn new concepts in their way
- Too much pre-recoded video, audio and text materials are a bit boarding to students and many students collect their attention when team members trigger each other
- Students learn better and achieve better if they are supported and guided by mentors
- As the age increases, the seriousness of the project selected and accomplished by students increase
- Start-up and business skills can be taught to children of as low as six to seven years old.
- Some parents have limited technological exposure, especially those living in Africa and new immigrants in Europe and become bottle neck for their children in using technology enhanced learning
- As technology gets advanced, especially with the introduction of generative AI, students will get the opportunity to utilize AI as mentors in the D-PBL settings.

VI. CONCLUSION THE FUTURE PLANS

To conclude, the implementation of digital project-based learning provides a promising approach for teaching children start-up and business skills, technical skills, soft skills, and emotional intelligence. The conceptual model presented above offers a framework to guide educators, mentors, and parents in promoting the holistic development of children in a digital learning environment.

Looking forward, there are exciting possibilities for enhancing the educational experience further by integrating generative AI technologies. By leveraging generative AI, D-PBL can be personalized and adapt learning materials to cater to the unique needs and interests of individual children. AI algorithms can analyze student performance data, identify areas for improvement, and suggest tailored resources, exercises, or challenges to optimize their learning journey.

Moreover, generative AI can facilitate the creation of interactive and immersive learning experiences. Virtual reality (VR) and augmented reality (AR) applications can simulate real-world scenarios, enhancing engagement and understanding. For instance, children can explore virtual start-up environments, participate in business simulations, or collaborate with AI-driven virtual agents as project partners or mentors.

Additionally, the use of generative AI can enable intelligent feedback and assessment systems, complementing the lack of enough mentors and lack of parents' attention to their children. Natural language processing algorithms can provide real-time feedback on written and verbal communication skills, helping children refine their abilities. AI-powered assessment tools can analyze project outputs, evaluating not only the final results but also the process, critical thinking, and problem-solving skills demonstrated throughout the project.

To ensure the ethical and responsible use of generative AI in teaching children, it is crucial to address privacy concerns, algorithmic biases, and maintain a human-centered approach. Ongoing research and collaboration between AI developers, educational experts, and child psychologists are essential for designing AI systems that align with pedagogical principles, promote inclusivity, and prioritize the well-being of children.

In the future, the integration of generative AI technologies within the framework of digital project-based learning has the potential to revolutionize how children acquire and apply essential skills. It will enable personalized, immersive, and intelligent learning experiences, empowering children to develop the competencies required for success in a rapidly evolving world.

By embracing these future development ideas and fostering a culture of innovation and collaboration, a dynamic and engaging learning environment can be created that nurtures the growth and potential of every child.

REFERENCES

[1] Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. Improving Schools, 2016 19(3), 267–277

[2] The Usage Effectivity of Project-Based Interactive E-Module in Improving Students' Achievement. Jurnal Pendidikan Teknologi dan Kejuruan, 2018, 2(24), 198-202.

[3] Promoting Systems Thinking Using Project- and Problem-Based Learning. J. Chem. Educ., 2019, 12(96), 2901-2909.

[4] The Usage Effectivity of Project-Based Interactive E-Module in Improving Students' Achievement. Jurnal Pendidikan Teknologi dan Kejuruan, 2018, 2(24), 198-202.

[5] Science, Mathematics, Engineering, and Mathematics (STEM) Education in Indonesia: a Literature Review. J. Phys.: Conf. Ser., 2021, 1(1776), 012028.

[6] The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students. IJIET, 2016, 9(6), 709-712.

[7] A Mixed-Methods Study of Cognitive and Affective Learning During a Sophomore Design Problem-based Service Learning Experience. IJSLE, 2014, 1-28.

[8] The implementation of project-based learning model and audio media Visual can increase students' activities. IJMMU, 2018, 4(5), 166.

[9] Exploring Issues and Challenges of Project-Based Learning for Teaching and Learning., 2018, 98-117.

[10] Verónica Basilotta Gómez-Pablos, Marta Martín del Pozo, Ana García-Valcárcel Muñoz-Repiso, Project-based learning (PBL) through the incorporation of digital technologies: An evaluation based on the experience of serving teachers, Computers in Human Behavior, Volume 68, 2017, Pages 501-512

[11] Jungerth, M., & Andersson, L. (2022). Developing Skills Through Digital Project-Based Learning: Dual case study of Linköping University and WSP Sweden AB.

[12] Knoblauch, C. (2022). Digital Project-Based Learning in the Higher Education Sector. In: Guralnick, D., Auer, M.E., Poce, A. (eds) Innovations in Learning and Technology for the Workplace and Higher Education. TLIC 2021. Lecture Notes in Networks and Systems, vol 349. Springer, Cham.

[13] Case Study: The Finnish National Curriculum 2016—A Co-created National Education Policy., 2018,397-422.

[14] Current Tendencies of Development of Primary Education in Finland in the Context of Education Modernization. Primary Education, 2019, 3(7), 37-42.

[15] Accessibility And Usability of The Learning Tools To Accelerate Innovation in The Field of Smart Materials Development. Texteh Proceedings, (2021), 328-333.

[16] Digitalization In Small Business for Women Entrepreneurs in Ukraine. SM3P, 2021, 2(4), 3-10.

[17] Basilotta Gómez-Pablos, V., Torrecilla Sánchez, E. M., García-Valcárcel Muñoz-Repiso, A., & Hernández Martín, A. (2020). Project-based learning in the classroom: a case study at High school level. Aula abierta, 49(4), 429-438.

[18] Reflective renovation: Insights from a collaborative and active learning space project evaluation. AJET, 2018, 6(34).

[19] Project Based Learning Pedagogical Design in STEAM Art Education. AJUE, 2020, 3(16), 102.

[20] Collective digital storytelling at school: a whole-class interaction. IJART, 2012, 2/3/4(5), 271.

[21] Spotlight on authentic learning: Student developed digital video projects. AJET, 2006, 2(22).

[22] Project Based Learning Pedagogical Design in STEAM Art Education. AJUE, 2020, 3(16), 102.

[23] A Self-Paced Regularization Framework for Multilabel Learning. IEEE Trans. Neural Netw. Learning Syst., 2018, 6(29), 2660-2666.

[24] Project-Based Learning to Promote Effective Learning in Biotechnology Courses. Education Research International, (2012), 1-8.

[25] De Los Reyes, M. A., & Orongan, M. J. Q. Digital project-based learning (PBL) on students' academic achievement and technological skills in grade 10 science.

[26] Rohm, A. J., Stefl, M., & Ward, N. (2021). Future Proof and Real-World Ready: The Role of Live Project-Based Learning in Students' Skill Development. Journal of Marketing Education, 43(2), 204–215. https://doi.org/10.1177/02734753211001409

[27] Sampurna, J., Kukulska-Hulme, A., & Stickler, U. (2018). Exploring learners' and teacher's participation in online non-formal project-based language learning. International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 8(3), 73-90.

[28] Tinapple, D., Sadauskas, J., & Olson, L. (2013, June). Digital culture creative classrooms (DC3) teaching 21st century proficiencies in high schools by engaging students in creative digital projects. In Proceedings of the 12th International Conference on Interaction Design and Children (pp. 380-383).

[29] Hana, M. A., Al-Hagla, K. S., & Elcherif, I. N. G. I. (2020). Probing potentials of digital and physical modelling in construction courses. WIT Trans. Built. Environ, 195, 43-55.

[30] Mary Rose P. Cleofe1, Julie Fe D. Panoy (2023). Project-Based Digitized Module in Enhancing Scientific Competencies among Distance Learning Students. APJAET, 2815 – 2468. https://doi.org/10.54476/apjaet/03734

[31] Jaccheri, L., Mishra, D., Houmb, S. H., Omerovic, A., & Papavlasopoulou, S. (2017). SikkerhetsLøypa-Knowledge Toward Sustainable and Secure Paths of Creative and Critical Digital Skills. In Entertainment Computing–ICEC 2017: 16th IFIP TC 14 International Conference, Tsukuba City, Japan, September 18-21, 2017, Proceedings 16 (pp. 157-168). Springer International Publishing.

[32] Wibawa, B. (2022). Digital Storytelling for Early Childhood Creativity: Diffusion of Innovation" 3-D Coloring Quiver Application Based on Augmented Reality Technology in Children's Creativity Development". International Journal of Online & Biomedical Engineering, 18(10).

[33] Johnston, K. (2019). Digital technology as a tool to support children and educators as co-learners. Global Studies of Childhood, 9(4), 306-317.

[34] Alptekin, S. E., DeTurris, D., Macy, D. J., & Ervin, J. E. (2005). Development of a flying eye: A project-based learning experience. Journal of Manufacturing Systems, 24(3), 226-236.

[35] Lou, S. J., Chou, Y. C., Shih, R. C., & Chung, C. C. (2017). A study of creativity in CaC2 steamship-derived STEM project-based learning. Eurasia Journal of Mathematics, Science and Technology Education, 13(6), 2387-2404.

[36] McCready, L. (2019). An examination of one-to-one technology applications and pedagogical strategies in a middle school music program (Doctoral dissertation, Indiana University).

[37] Sudjimat, D. A., & Permadi, L. C. (2021). Impact of work and project-based learning models on learning outcomes and motivation of vocational high school students. Educational Sciences: Theory & Practice, 21(2), 131-144.