EBT CONFERENCE

PROCEEDINGS

2022 International conference
E-business technologies

23-24. JUNE 2022.
BELGRADE, SERBIA

Editors:

Marijana Despotović-Zrakić
Zorica Bogdanović
Aleksandra Labus
Dušan Barać
Božidar Radenković

Conference supported by
Ministry of Education, Science, and Technological Development, Republic of Serbia

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2022 INTERNATIONAL CONFERENCE

E-BUSINESS TECHNOLOGIES

23-24 June 2022
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Proceedings

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Publisher:

Faculty of Organizational Sciences, University of Belgrade

Jove Ilića 154, 11000 Belgrade, Serbia

Printing:

New Press, Smederevo

Momčila Tepavice 2, Novi Sad, Serbia

Year: 2022

Conference organizer:

Department of E-business, Faculty of Organizational Sciences, University of Belgrade

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

005:004(048)
005.6(048)
005.8(048)
658:004(048)
004.738.5:658(048)

INTERNATIONAL Conference E-Business Technologies, (2 ; 2022 ; Beograd)

Proceedings / 2022 International Conference E-Business Technologies, 23-24 June 2022 Belgrade, Serbia ; editors Marijana Despotović-Zrakić... [et al.] ; [Conference organizer: Department of E-business, Faculty of Organizational Sciences, University of Belgrade]. - Belgrade : Faculty of organizational sciences, 2022 (Smederevo : New Press). - XII, 191 str. : ilustr. ; 30 cm

Tiraž 70. - Str. VII: Foreword to the EBT 2022 conference / Marijana Despotović-Zrakić, Zorica Bogdanović, Aleksandra Labus, Dušan Barać, Božidar Radenković. - Bibliografija uz svaki apstrakt.

ISBN 978-86-7680-414-6

а) Бизнис -- Информациона технологија -- Апстракти
б) Електронско пословање -- Апстракти
в) Пројектни менаџмент -- Апстракти
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COBISS.SR-ID 68903689

Printing of this book was supported by Ministry of Education, Science and Technological Development, Republic of Serbia.

2022 INTERNATIONAL CONFERENCE
E-BUSINESS TECHNOLOGIES

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Foreword to the EBT 2022 conference

Dear colleagues, dear friends,

We are glad to welcome you to the second 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 2021 accepted 31 regular papers from 7 countries. In addition to a large number of researchers and experts from Serbia, the conference will include researchers from abroad: Turkey, Russia, Iran, India, Libya and Eritrea. Keynote lectures will be given by three eminent experts: prof.dr Vladan Devedžić, Professor of Computer Science and Software Engineering at the University of Belgrade Faculty of Organizational Sciences and the Corresponding member of Serbian Academy of Sciences and Arts, prof.dr Marko Suvajdžić, Associate professor of Digital arts & sciences, University of Florida, USA, and prof.dr Dejan Milojičić, Distinguished technologist at Hewlett Packard Labs and IEEE Computer Society President 2014, Hewlett Packard Labs, Palo Alto, CA, USA.

Further, the conference includes many 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 2022 in Belgrade

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Prof. dr Vladan Devedžić
Professor of Computer Science and Software Engineering at University of Belgrade Faculty of Organizational Sciences, Serbia

Prof.dr Marko Suvajdžić
Associate professor of Digital arts & sciences, University of Florida, USA

Prof.dr Dejan Milojičić
Distinguished technologist at Hewlett Packard Labs, Palo Alto, CA, USA
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KEYNOTE LECTURE

AI: Living is Easy with Eyes Closed

Vladan Devedžić

Professor of Computer Science and Software Engineering
Corresponding member of Serbian Academy of Sciences and Arts

University of Belgrade Faculty of Organizational Sciences
Belgrade, Serbia
vladan.devedzic@fon.bg.ac.rs

Abstract: Everybody's talking about Artificial Intelligence (AI). The hype is evident, and there is virtually no AI-free area any more – business, technology, military, agriculture, medicine, industry, law, arts, media, education, even sports and politics, all seem to be labeled 'AI', one way or another. However, does everyone who's talking about AI really understand what it is and what underlies it? Have they ever read any textbook on AI? Can they explain why they label products, actions, events and jobs 'AI'? What does a job in the area of AI look like? What does a job in another area look like if they say the job requires AI skills? Are the systems labeled 'AI' solid, robust, autonomous? If they are intelligent, how intelligent are they? How does one measure the intelligence of AI systems? What are the criteria to declare a system intelligent and not to discard it as dumb? Can AI go wrong, or rogue? Do clear trends in the development of AI as a field emerge or not? This talk touches upon questions like these, but it doesn't take sides; it rather indicates a variety of different views.

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KEYNOTE LECTURE

Blockchain protocol and its mechanics: What is Blockchain, its recent history, and its uses

Marko Suvajdžić

Associate professor of Digital arts & sciences

University of Florida
USA
marko@digitalworlds.ufl.edu

Abstract: The lecture will present foundations and functions of blockchain technologies, with the main focus on their integration into business systems. We will present the various blockchain protocols, discuss their expected development, and give recommendations on how to choose the protocol that best suits business needs. Further, we will discuss the possible applications of blockchain technologies in various domains that rely on the integration with AI and virtual reality, such as arts and creative industries, gaming, metaverse and healthcare. Finally, we will present the main results of projects conducted at the Blockchain Lab, University of Florida.

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KEYNOTE LECTURE

Digital strategy: Igniting digital transformation

Dejan Milojičić

Distinguished technologist at Hewlett Packard Labs
IEEE Computer Society President 2014

Hewlett Packard Labs, Palo Alto, CA
USA
dejanm@ieee.org

Abstract: IEEE Computer Society (IEEE CS) has unveiled its annual Technology Predictions, addressing the long-lasting influence of the pandemic on tech advancements, new technology fundamentals, and anticipated trends shaping the industry for 2022 and beyond. No one can say with 100% certainty what path the future of technology will take, but IEEE CS experts in the field offer useful insights and predictions into some of the most influential possibilities. The top three tech trends that are anticipated to dominate in 2022 are datacentric AI, remote medicine, and health, safety, and wearable biomedical technologies.

Converging technologies increasingly play crucial roles in disruption and are becoming essential for our survival. Predicting technologies helps address pandemic impacts and concerns; it goes well beyond hypothetical exercise. The 2022 Technology Predictions provides a deep dive into each prediction with analysis of specific problems and current demands; the opportunities for the technology; the impact the technology will have on the public, products, services, and related technologies; and the sustainable solutions and business opportunities that it could potentially inhibit and/or enable.

EBT 2022

Do we need e-Business management or not? A Critical Literature Review

Yüksel Akay Ünvan

Ankara Yildirim Beyazit University
Business School
Ankara, Turkey
aunvan@ybu.edu.tr
https://orcid.org/0000-0002-0983-1455

Ahmet Şükrü Pampal

Ankara Yildirim Beyazit University
Business School
Ankara, Turkey
aspampal@ybu.edu.tr
https://orcid.org/0000-0003-0334-8195

Abstract—Tue to technological developments and Covid-19 pandemic, a highly competitive business environment was established. It becomes more important for organizations to know their customers and partners in this environment. As known during Covid-19 pandemic all potential customers of companies stayed at home. These circumstances bring up how adaptation of electronic business technologies are essential for firms. Setting up new high technologies creates new concept e-business management. This concept proves that if companies cannot manage the adaptation process systematically, it will be waste of resources and time for that company. As a result, most of the organizations produce researches and contribute to the literature to adapt to e-business technologies. The main purpose of this article is to review the existed e-business management literature and to make a critical examination of research based on the last five year.

Keywords: E-Business Management, COVID-19, Systematic Review

I. INTRODUCTION

In the previous five years, the usage of e-business is increased rapidly and the quantity of research papers examine mostly the relationship between e-business and information technologies (Ghobakhloo & Tang, 2011). In the recent years, the COVID-19 have forced companies to adapt digital transformation to sustain their business. Firms that adopted the traditional way of doing business could not operate during the COVID-19 measures. To be successful in an uncertain and competitive business environment, organizations should devise strategies to innovate their technologies to facilitate internal knowledge transfer and adapt their e-business management to integrate internationally based systems into their operations (Kim & Ramkaran, 2004; Zhu & Kraemer, 2002; Martin et al, 2011).

The importance of e-business technologies for institutions has increased rapidly. Previously many traditional and family-owned companies reject to use new technologies (Huang, Kaigang, Kumar, Praveena, 2018). Moreover, companies did not see the importance of e-business management over time. After technological breakthrough and Covid-19, the communication between organizations and customers are lost. They seek new ways to commerce their product or service and to strength the relationship between partners and customers. E-business management concept is adapted by company owners and top level executives. They realized that e-business technologies are must for organization success (Chaffey and Smith, 2008).

With the implementation of e-business technologies, many companies aim to integrate high technology into all business processes. Companies from various countries understand the importance of the term and are used by these organizations. At the same time, researchers realized the importance of e-commerce in the 1960s. However, the concept was not clearly defined and understood by the readers. The development of the Internet has a serious impact on the definition of the new concept of e-business management.

In the last five years it is clearly seen that many firms, non-governmental organizations, non-profit organizations and researchers clearly understand the importance of e-business management to survive in a highly dynamic business environment and to increase the business performance in internal and external work of the company (Sruamsiri et al. 2017; Lisa & Burke, 2018; Alshurideh, 2019; AL-Mansour & AL-Ajmi, 2020; Olayinka and Wynn, 2021; Attila, 2022).

A CRITICAL LITERATURE REVIEW: E-BUSINESS MANAGEMENT

Researchers realized the term ‘’e-business’’ in the beginning of 1960s via development in information technologies (Zwass, 1996; Wigang, 1997). After the advancement on internet, e-business has increased its importance for organizations (Melao, 2009). Electronic business technologies have become inevitable for organizations to increase their performance. E-business technologies has increased confinity in every business operation in an organization. Biggs (2000) supports the idea that the e-business technologies are a breakthrough development for organizations created by the evolution of internet.

Chaffey and Smith (2008) define e-business technologies as usage of internet and electronic networks are key for

business success. This technology includes e-commerce which is providing services to customers and purchasing and selling goods via technological advancements (Turban et al., 2006). Electronic business technologies provide proper web-based platform for companies to establish collaboration with suppliers, agents, customers etc., and easiness of the communication between business partners to create competitive advantage over their rivals (Currie and Parikh, 2006). On the other hand, firms use the fruitful information in online platforms to identify their competitors, improve their product quality and invest in research and development in their goods and services (Singh, 2002).

The current technological development pushes businesses to be self-service businesses based on current technology (Dabhokar et al. 2003). Usage of e-business technologies support companies to explore new markets, to forge new alliances and improve their customer relationship and it rapidly increase burst velocity of using e-business in business environment (Deise et al., 2000). In other words, e-business technologies establish clear communication inside whole organization among suppliers, workers, clients, stakeholders regardless of the physical business environment (Rodgers et al., 2002). Building effective digital communication among partners help companies to reach focused customers and to find right business partners (Strauss and Frost, 2001, p:6). Follit (2000) supports that adaptation of e-business technologies increase interaction between customers and organization and improves relationship lead to loyalty in the relationship then result in gaining competitive advantage over rivals and to increase organization profits.

During Covid-19, e-business management become a widely needed concept for various institutions such as educational and public institutions and so on. Electronic websites are established to teach tutors and students how to adapt new technologies while learning how to be successful in their projects (Lisa & Burke, 2018). According to Falae (2018) e-business technologies support online learning in business via some courses aimed to teach students from different ages and countries. E-business technologies enable people to get their education anywhere and anytime (Huang et al., 2018). In public institutions governments transform their traditional public work into electronic environment such as Turkish government (Yildirim and Bostanci. 2022). As lockdowns became the new normal during Covid-19, businesses and consumers increasingly "went digital", providing and purchasing more goods and services online, raising e-commerce's share of global retail trade from 14% in 2019 to about 17% in 2020 (UNCTAD, 2021).

E-business is using newly emerging technologies in order to establish clear communication and manage relation between customers and business partners to improve companies' services and products (Lin & Lin, 2008; Palacios et al., 2014; Alshurideh et al., 2015; Oliveira et al., 2016; Alshurideh, 2016; Alshurideh, 2019; Alzoubi et al., 2020). Ash and Bur (2003) supported the term e-business management as organizing internal and external processes of firms and those processes based on internet (Hinton and Barnes, 2005). Urbaczewski (2002) divides e-business in two key elements: online (network, computer based information tech etc.) processes and exchanging values (goods, services, money, information time etc) of firm. Companies adapt new technologies to integrate and manage interorganizational activities (Bolat et al., 2016) and aim to develop business models to maximize profit and improve business value (Lin, 2008).

Business Management comprehend all activities happened in internet such as online money exchange, e-commerce and e-trade transactions, digital marketing and so on (Sruamsiri et al. 2017). The common e-business management tools are listed in Figure 1 below.

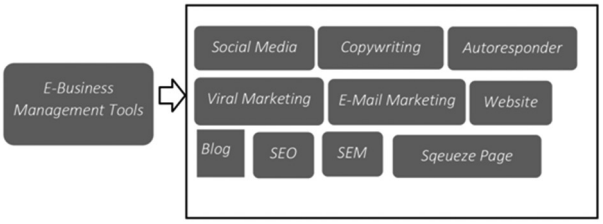

Figure 1: E-Business Management Tools (Zebari, R. R., Zeebaree, S. R., Jacksi, K., & Shukur, H. M. 2019)

Adapting e-business technologies hand over priority to companies a competitive advantage in developing countries (Olayinka and Wynn, 2021). Olayinka and Wynn (2021) suggested that organizations must prepare different strategies among partners, customers and internal units. Otherwise, adapting new technologies are going to be resulted as waste of resources and decayed business performance. On the other hand, e business management must be seen as a holistic way to clarify benefits of e-business on performance (Chen, Rutkar, Carrillo, 2013). It will help organizations to consider predicted benefits and implementation of new management roles (Chaffey, 2013).

Covid-19 fastens the digital transformation process of companies and evolves the e-business management to create value added products and services (Aherinia, Shariatnej, Saedi, Moshtaghi, 2021). The world is constantly changing day by day and digital marketing tools are comprehend everywhere, which brings out the concept of e-business management (Treiblmaier & Sillaber, 2021) . During COVID-19, organizations realized that this pandemic cause lots of unemployment (Zhang et al., 2020; Kuijpers, 2020). On the other hand, it brings out some opportunities with it (AL-Mansour & AL-Ajmi, 2020).

Today's economic environment and competitive climate require innovative products and processes to survive in these business conditions. In order to gain a competitive advantage in the market, companies should focus on their customers and aim to develop e-business technologies in their work (Youniss, 2022). E Business technologies become beneficial and essential while managing customer

relationship (Siby & George, 2022). The Figure 2 shows the general framework for e-business management in a competitive environment.

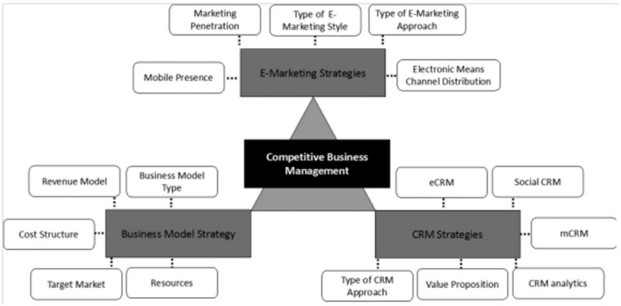

Figure 2 Framework for E-Business Management in competitive environment (Isaías, P., Carvalho, L. C., Junior, N. C., & Cassundé, F. R. 2019)

In the last twenty years, e-business management have rapidly growth its importance and many researches are completed in e-business technologies and management of those technologies (Ghobakhloo & Tang, 2011). During COVID-19, companies realized that they must adapt digital transformation and continuous update and innovation of their technologies in order to integrate all organization activities successfully (Attila, 2022; Kim & Ramkaran, 2004) and use e-business management methods to establish long term relationship among business units to sustain competitive advantage in environmental uncertainties (Zhu & Kraemer, 2002; Martin et al, 2011). Thereupon, e-business management supports companies in digital transformation while integrating relations among departments, units, customers and help firms to manage their activities effectively then create value added products or services (Attila, 2022).

III. METHODOLOGY

In this paper, a systematic review technique is applied while collecting and analyzing existing studies. In this context, it is essential to understand how e-business management is developed during last five years. Using systematic review is overviewing main studies in the literature (Greenhalgh, 1997; Rêgo et al., 2021). In this technique, firstly the related studies are read and the existing problem is summarized and then it is aimed to identify the gap in the current literature. In summary, this paper presents a systematic review over the literature of e-business management.

In the scope of this study, the systematic review was done in three steps. Firstly, the research was done on the basis of the Web of Science database. Moreover, some filters such as "last five years, only English, articles" were applied while searching. In addition, e-business management term was added to filter in order to find the related articles. In the second step, only articles from business and management journals were searched. Finally, totally 32 articles have reviewed at the end of the study. The Figure 3 below summarizes the research details.

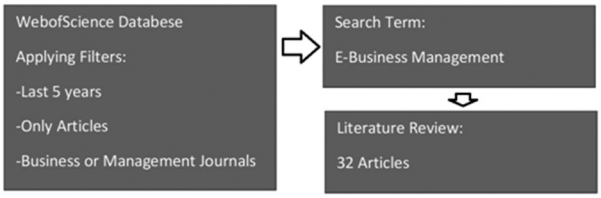

Figure 3 Systematic Review Process

IV. CONCLUSION

As a result, e-business management sustains its importance for companies. At the same time, following new coming technologies and adapting them to business procedures become inevitable during COVID-19. That is, e-business management technologies are adapted and used by companies (Attila, 2022; Kim & Ramkaran, 2004) and those companies reach their strategic goals and become successful in an uncertain business environment (Ghobakhloo & Tang, 2011).

Moreover, companies need to adapt to e-business technologies in order to survive the COVID-19 period with the least cost. Reaching more customers, easiness of communication with business partners and technological advancement in business processes support companies to reach upcoming opportunities in the market (AL-Mansour & AL-Ajmi, 2020). The adaptation of e-business technologies helps companies to have competitive advantage.

The implementation of systemic review of this study demonstrates that e-business management shows its importance in last twenty years period. However, the essentiality of the topic is increased in the last five years. Especially, in the last two years, that is in the COVID-19 period, the needs of e-business technologies boost the usage by firms. Currently, it becomes a hot topic for researchers to contribute the literature of e-business and COVID-19.

Finally, this literature review article aims to contribute current e-business management literature. The main input which this article provide to literature is applying a systematic review in e-business management literature. With this, there are also some limitations in this research. For example, in the recent ten years, apart from the attention of the topic, there are few researches about the subject. Moreover, it is understood that there are mostly articles from the last five years on the subject in the literature. However, this topic needs more than five years of systematic review in e-business management. In further research, researchers can extend the time and write a more comprehensive literature review on e-business management. As a result, the answer to the question, which is the title of this study, is that although traditional methods still maintain their position to a certain extent, e-business management has taken its place as an inevitable necessity to exist in the sector, as a fact confirmed by the Covid-19 process.

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The methodological approach to introducing a new fashion brand to the digital market

Milica Simić

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
milica.simic@elab.rs

Vukašin Despotović

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
despotovicvule@gmail.com

Marija Jović

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
marija.jovic@fon.bg.ac.rs,
0000-0002-9971-0971

Aleksandra Labus

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
aleksandra@elab.rs,
0000-0002-7716-5845

Marijana Despotović-Zrakić

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
maja@elab.rs,
0000-0002-6458-1575

Abstract—This paper presents a methodological approach to introducing a new fashion brand to the digital market. According to the developed methodological approach, the readiness for the introduction of a new fashion brand to the digital market was determined, and the obtained results were analyzed. For the appearance of a new fashion brand on the Internet, it is necessary to develop an internet marketing plan that includes an Internet business plan and digital marketing strategies. According to the proposed methodological approach in this research, the implementation of the Internet marketing plan of a new fashion brand is presented. The proposed method can be adapted and used for introducing any new brand or other products to the digital market.

Keywords - Internet Marketing Plan, Internet Business Plan, Digital Marketing, Fashion Brand

I. INTRODUCTION

The development of modern information technologies has initiated the inevitable digital transformation in all industries, including fashion [1][2]. The digitalization of the fashion industry aims to create a completely new experience for the end-users enabling e-commerce services, and real-time support during the purchase process [1]. The process of digitalization has affected all business processes in the fashion industry: from the production of fashion brands to marketing promotions and selling to the end customers, creating in this way new e-supply chains [1][3][4].

The concept of digitalization is applied all over the world and many fashion houses have their appearance on the Internet and use digital marketing strategies for promotion, omnichannel communication, and monitoring of customers' needs [5]. The existence of websites, mobile applications and social networks business profiles is important for the appearance of fashion brands on the Internet, which increases the visual identity and credibility of and improves the relationship with customers and stakeholders. Through the website, as one of the most used channels of digital marketing, business and shopping possibilities are expanding. Online shopping aims to bring the brand closer to the customers, create a sense of security and provide assistance when shopping. By purchasing through the site or mobile applications, customers are provided with real-time information through online channels and this way of shopping allows them to save time during the purchase [6].

The digital world has affected the customers' habits and behavior when shopping [6][7]. It is very important for fashion brands to find their place in the digital world and to bring their products closer to customers in a creative and modern way [8]. An important role in positioning a fashion brand on the digital market is played by the plan of its appearance on the Internet and marketing promotion, which will encourage customers to make a purchase. New information technologies make it possible to easily identify the needs of customers by collecting and analyzing data from websites, mobile applications, and social networks [6][9].

The main aim of this paper is proposing a methodological approach to introducing a new fashion brand to the digital market. Using the proposed method, the readiness for the introduction of a new fashion brand to the digital market is analyzed and the implementation of the Internet marketing plan is presented.

II. DIGITAL FASHION INDUSTRY

Fashion is a cultural phenomenon that reflects the appearance and status of an individual through clothing and other fashion accessories [10][11]. It is related to social epochs and habits of society and as such represents the social image of society in certain periods of time [6]. These

original perceptions of fashion as a social giant have not changed since its inception, but what has changed is the way of communication and selling products to customers. The advent of e-business has led to the replacement of one-way communication with more interactive and dynamic strategies in the business world [6][12][13].

Many studies have shown that a very large number of customers enjoy the benefits of online shopping from their homes, which has caused an increasing presence of fashion brands on the Internet [10][14][15]. In order for a fashion brand to be competitive in the online market, it is very important that it achieves and maintains the recognition of its brand.

The digital fashion industry can be defined as a network that includes a number of different online channels that are put in support of fashion brands [10][16]. It encompasses the sum of the characteristics of a product, services, or fashion brand as an organization that, in a specified way, is a particular perception or experience of users and other stakeholders [10][16].

There are three disruptors that affect the digital fashion industry [17]:

- Digital start-ups. As a consequence of the rapid development of the Internet and digital platforms, a large number of fashion brands run only e-business. Sales are made only online, through websites, mobile applications or social networks, which leads to reduced costs and more affordable prices for the customers themselves. In this case, physical stores and traditional sales and communication channels do not exist in the business [17].
- AI-enabled demand forecasting and product design. Artificial intelligence is the science of intelligent computer programs and machines that behave and act in imitation of a certain level of human intelligence. The fashion industry market is rapidly changing and requires timely anticipation of customer needs and requirements. Traditional fashion houses end the production process much earlier before the sale, which can lead to a significant discrepancy between planned and actual demand. As a result, artificial intelligence has found a place in the fashion industry as a way to anticipate customer needs and product design, thereby minimizing inventory and missed sales opportunities [18].
- Collaborative consumption. It is defined as "traditional sharing, bartering, lending, trading, renting, gifting, and swapping" via a digital medium [17]. It has appeared in many industries, including fashion, where it is constantly growing. There are two ways of using collaborative consumption in the fashion industry: the first involves platforms through which it is possible to rent clothes for a short period of time, while the second refers to peer-to-peer platforms through which it is possible to donate and buy second-hand clothes [19].

The application of modern information and communication technologies has enabled a great transformation in the business of fashion brands and created an opportunity for sales through online channels. Web 2.0 has created a need for new communication strategies as customers have ceased to be passive participants in the communication chain who only receive information through traditional channels [6]. In online environments, fashion brands display a set of features of their products using various formats such as text, images, or video, which gives to customers additional information and contributes to better visualization of the brand [20].

The challenge of a new fashion brand lies in finding the right e-business techniques and tools and consequently the right strategy by which the fashion brand will find its place in the digital market [6][21]. A key goal of the e-business of a fashion brand is enabling an easy way of shopping using services that would help customers to decide what to buy (for example, enabling virtual trying of clothes) [22].

III. THE METHODOLOGICAL APPROACH TO INTRODUCING A NEW FASHION BRAND TO THE ONLINE MARKET

The methodological approach to introducing a new fashion brand to the digitl market is presented in Figure 1.

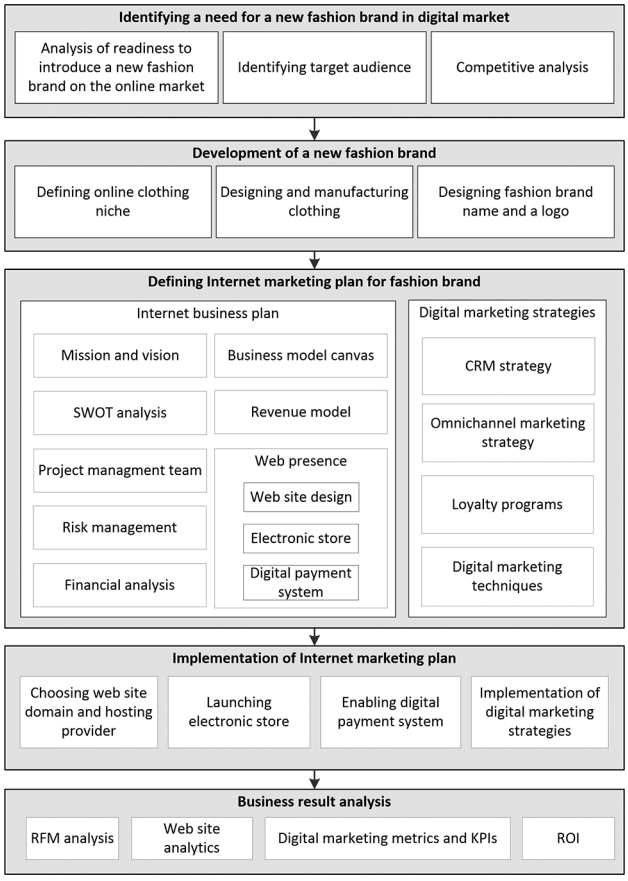

Fig. 1. The methodological approach to introducing a new fashion brand to the digital market

Proposed methodological approach encompasses following:

1. Identifying a need for a new fashion brand in digital market. To develop a new fashion brand and present it to customers, it is necessary to examine the readiness to introduce a new fashion brand on the online market. In

this way, the target audience can be identified and their needs for specific fashion apparel. It is also important to analyze the digital market and the competitors' advantages and disadvantages of e-business.

2. Development of a new fashion brand. After identifying customers' needs, follows defining online clothing niche and fashion designers can approach designing new fashion brand. This step also implies designing a fashion brand name and suitable logo.
3. Defining Internet marketing plan for fashion brand. This step implies defining an internet business plan and digital marketing strategies. Internet business plan contains missions and vision of a new fashion brand, Business Model Canvas, revenue model, SWOT analysis, designing a web presence, cost planning, and risk management. Digital marketing strategies for new fashion brand include defining CRM, omnichannel marketing strategies, loyalty programs, and digital marketing techniques (e-mail marketing, affiliate programs, social media marketing, etc.). The project management team is responsible for defining these elements of the internet marketing plan and can gather a team of fashion designers and stylists, IT designers and programmers, marketing managers, project managers, and financial managers.
4. Implementation of Internet marketing plan. This step includes the implementation of all elements related to web site development and appliances of digital marketing strategies.
5. Business result analysis. After implementing an internet marketing plan, it is necessary to monitor and analyze achieved business results in order to improve future offers and fashion brand development.

IV. ANALYSIS OF READINESS TO INTRODUCE A NEW FASHION BRAND ON THE DIGITAL MARKET

In order to examine the readiness of consumers to introduce a new fashion brand, as well as to determine their preferences, attitudes and expectations, an exploratory quantitative research was conducted. For the purposes of this research, a survey was created, which included two groups of questions. The first group of questions included those aimed at identifying demographic data, such as age, level of education, employment and material status, etc. In addition to demographic questions, the first group also included questions related to the level of digital literacy of respondents, the degree of use of social networks and habits when buying clothes. Another group of questions referred to questions that examined respondents' preferences and attitudes about online wardrobe shopping. This includes issues ranging from the frequency of online wardrobe shopping, through the different specifics of shopping, to possible negative experiences in such activities.

A total of 144 respondents participated in the research, of which 13 responses of male respondents were excluded from the further research process because they do not belong to the target group of the research, ie adult females. Average age of respondents M = 26.82; SD = 7.38. Regarding the educational structure of the sample, 47.3% were persons with completed secondary school, 32.1% were persons with a university degree or higher, and 20.6% were persons with completed postgraduate studies. The majority of respondents (56.5%) rated their material status as average, ie similar to people from their environment, while 11.5% of those with slightly worse and 32% of those with above-average or far better material status.

Respondents generally (87%) rated their digital literacy as excellent, choosing the option to successfully use a computer or smartphone for various activities. Only 9.9% of respondents stated that they use a computer or smartphone only for basic activities, while 3.1% of them use assistance in using these devices. Figure 2 shows the extent to which respondents use different social media.

When it comes to the type of wardrobe they buy, respondents prefer a ready-made wardrobe, rather than tailoring (Fig.3).

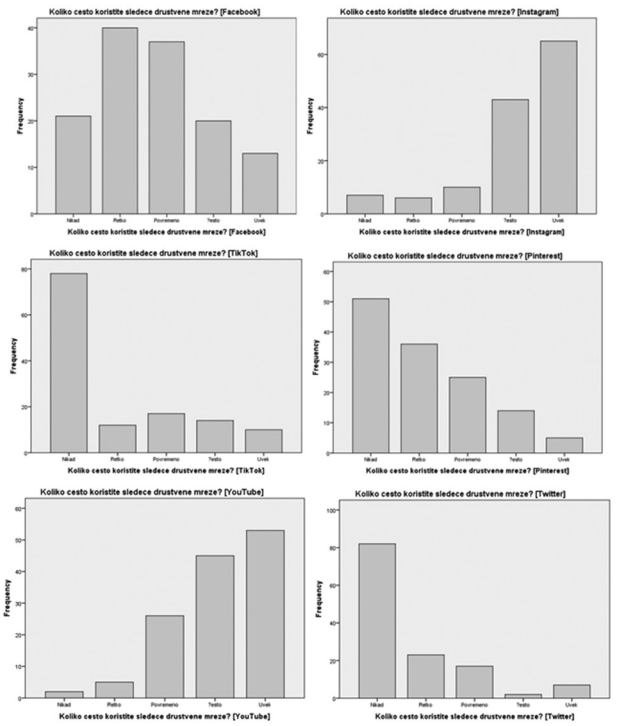

Fig. 2. The degree to which respondents use different social media

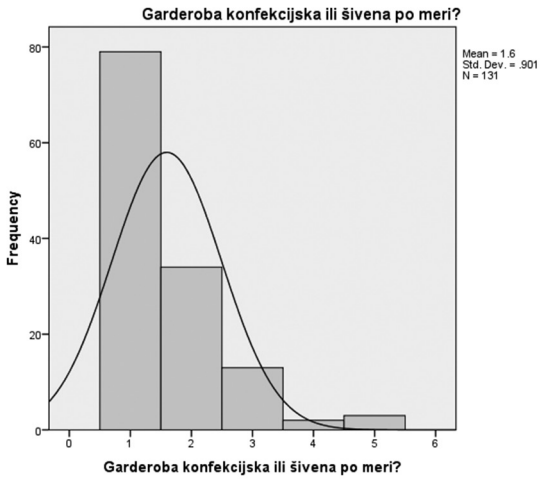

Fig. 3. The type of wardrobe respondents buy

It is similar with the way of shopping, ie the respondents largely prefer to buy clothes in traditional stores compared to online stores (Fig.4).

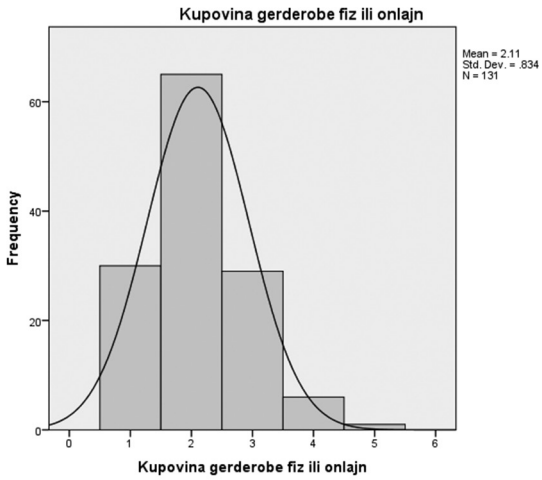

Fig. 4. Place of buying clothes

Table 1 presents the frequency of wardrobe purchases via the website and social media.

Frequency	Shopping via website	Shopping via social media
Once every few years	9%	32%
Several times a year	67%	54%
Several times a month	20%	11%
Several times a week	3%	2%
Almost every day	1%	1%

Table 1. Frequency of wardrobe purchases via website and social media

In terms of the type of clothing they buy online, dresses (M = 3.29; SD = 1.2) and T-shirts (M = 3.01; SD = 1.03) stand out, while shirts and blouses are somewhat rarer (M = 2, 62; SD 1.28), trousers (M = 2.44; SD 1.37) as well as skirts (M = 2.38; SD = 1.21). The respondents are less likely to buy jackets, shorts, overalls and bodysuits online.

The preferences of the respondents' style of dress are presented in Table 2.

Dress style	M	SD
Casual style	4,19	0,809
Sports style	3,49	1.016
Elegant style	3,48	1.073
Classy style	3,13	1.016
Business style	3,06	1.018
Chic style	2,58	1.243
Street style	2,52	1.230
Vintage style	2,17	1.068
Sexy style	1,95	1.437

Table 2. The preferences of the respondents' style

Respondents point out cash on delivery as the preferred method of payment, followed by card payments and, to a very small extent, payments to the account and PayPal (Figure 5).

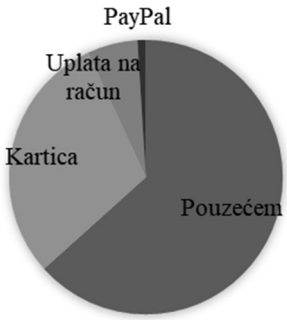

Fig. 5. Preferred payment method

The importance of various factors when buying clothes online is presented in Figure 6.

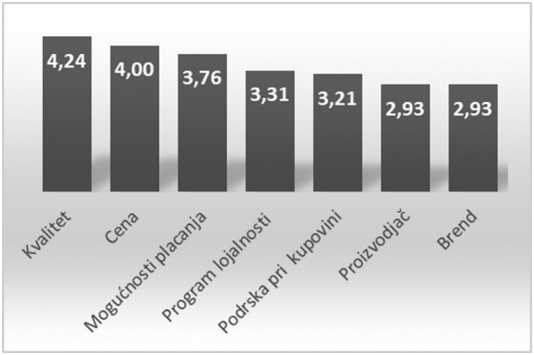

Fig. 6 The importance of various factors when buying clothes online

V. AN EXAMPLE OF THE IMPLEMENTATION OF A NEW FASHION BRAND IN THE ONLINE MARKET

A. Business Model Canvas

The digital transformation has led to the emergence of new e-business models. For e-business and appearance on the Internet, it is necessary to define an internet marketing plan and an Internet business plan. Within the Internet business plan, the key elements are the canvas business model and the revenue model. The business model canvas is an instrument of strategic management and a framework for developing new and documenting existing business models [22][23]. It consists of nine segments that need to be defined:

- Key partners. Partners who help run business activities.
- Key activities. Activities that represent the core of the company's business system.
- Key resources. Resources used by the company in creating value for customers.
- Value propositions. Products and services that the company offers to meet the needs of its customers.
- Customer relationships. There are different relationships with customers such as personal assistance, self-service, automated services, etc.
- Customer segments. Description of the characteristics of all user groups (stakeholders) and their role in the system.
- Channels. The basis for building relationships and long-term trust between users and the business system.
- Cost structure. The set of costs that only the business requires to perform its activities.
- Revenue streams. The way a company generates revenue from each market segment.

Defining the canvas business model enables faster adaptation to constant changes in the market and gaining a competitive advantage. For the newly created fashion brand, it is very important to precisely define all segments of this model in order to strengthen the network of potential customers, and later create a network of loyal customers.

At Business Model Canvas of a new fashion brand, the focus is on developing a website and online store (Fig. 7). The key partners are suppliers who would deliver preagreed goods, a courier service that would deliver the ordered products, media partners through which marketing promotions would be realized and payment gateway companies through which transactions would be securely enabled. Key activities would be the development of a website and e-store through which loyal customers would have certain benefits and the implementation of digital marketing strategies. All these activities would be implemented using the key resources (partners, development team, physical resources). All this would be done in order to successfully achieve the proposed values of the fashion brand- to create an open market that facilitates communication between buyer and seller, a wide range of products, flexible payment methods, fast delivery, customization and innovation, cheaper and more efficient shopping. The idea is to achieve the best possible relationship with customers by providing them with a loyalty program, as well as safe purchasing of products. The channels through which business would be conducted would be the main channels of digital marketing: website, mobile application, social networks, as well as sites of other companies. The market is divided into segments depending on the age of the women. Online sales of products would generate the highest revenue, while costs would relate to marketing, development and maintenance of e-business and operating costs.

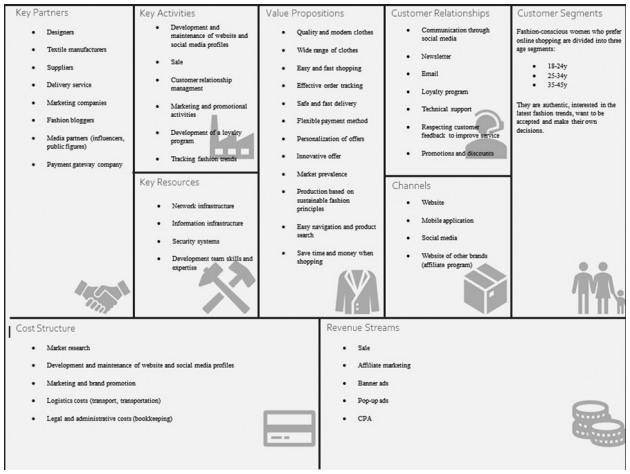

Fig. 7. Business Model Canvas of a new fashion brand

B. Revenue Model

A revenue model is a way for a company to generate revenue, generate profit, and return invested capital. [24] The proposed revenue model for a new fashion brand consists of 5 submodels (Fig. 8): advertising model, subscription model, transaction commission model, sales model and affilation model.

Revenue model				
Advertising model	**Subscription model**	**Transaction commission model**	**Sales model**	**Affiliation model**
The company offers advertising space and generates revenue from its publication.	The company offers content or services and charges a subscription to access some or all of the offer.	The company generates commission income to enable the transaction to be conducted.	The company generates revenue by selling products, services or content.	The company directs the consumer to a third party and gets a percentage of sales.
Include other brands in your offer	Loyalty program	Internet shop	The clothes	Affiliate and Fashion Blogger program

Fig. 8. Revenue Model

The main source of income would be the online sale of clothing, which is represented through the sales model. Partnerships with brands and their presentation on the website of the fashion brand are planned as well. This is an advertising model and affiliate model. Cooperation with various influencers on social networks and fashion blogs also presents using an affiliate model. In this case, promoters who redirect consumers to a fashion brand's website get

a percentage of sales, ie. if the customer buys the product based on their recommendation, promoters receive a fee in return. Since the fashion brand would only have an online store, another source of income is the commissions that are obtained by enabling the transactions. This is a model of transaction fees. For the subscription model, the fashion brand company would develop a loyalty program. Applying for this program brings various benefits to members. Applying for the program, as well as membership in the club is completely free, however, every time you purchase something your exclusivity as a member of the loyalty club increases. So, customers here are actually conditioned to buy as much as possible, and in return receive increasing benefits from the company (discounts, invitations to exclusive events, pop-up stores, etc.).

C. Web site appearance

Many options are available within the web application, from the home screen to the e-shop. Various search filters have been created for easier navigation and product search. Each product is described in detail, and buyers for all doubts can ask a question within the formed chatbot or directly by contacting the seller through various social media that are connected to the application itself. A loyalty program has also been developed, which contributes to a greater connection with the brand, and includes collecting certain points when buying and ranking in relation to their total number. Personalization is enabled by creating an avatar with the personal characteristics of the customer. Some of the options are shown in Fig. 9.

VI. CONLUSION

The scientific contribution of this paper is the development of the methodological approach to introducing a new fashion brand to the digital market. The development and implementation of key models of the Internet marketing plan are presented, and future directions of research will be related to further method implementation and evaluation.

ACKNOWLEDGMENT

This research was funded by the Ministry of Education, Science, and Technological Development of the Republic of Serbia, grant number 11143.

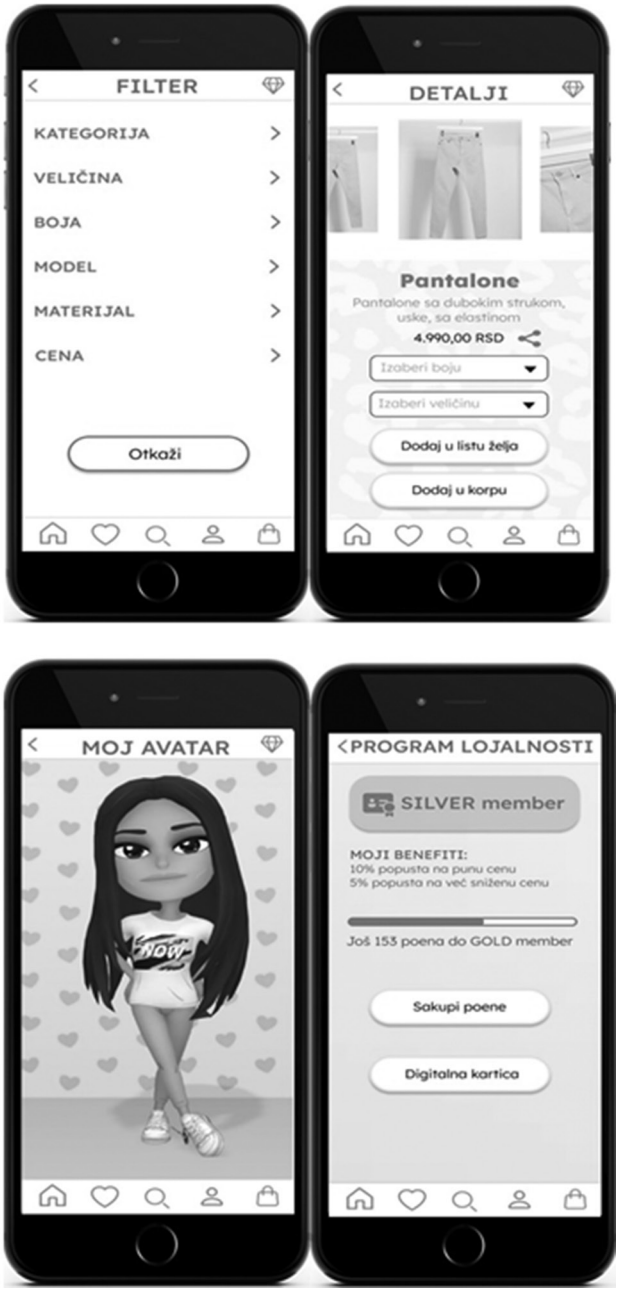

Fig. 9. Fashion brand responsive web application

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Innovations in museum financing: Potential of Civic Crowdfunding

Miloš Milosavljević

Faculty of organizational sciences
University of Belgrade
Belgrade, Serbia
milos.milosavljevic@fon.bg.ac.rs
https://orcid.org/0000-0002-4965-4676

Željko Spasenić

Faculty of organizational sciences
University of Belgrade
Belgrade, Serbia
zeljko.spasenic@fon.bg.ac.rs
https://orcid.org/0000-0001-5219-6461

Nemanja Milanović

Faculty of organizational sciences
University of Belgrade
Belgrade, Serbia
nemanja.milanovic@fon.bg.ac.rs
https://orcid.org/0000-0002-4965-4676

Slađana Benković

Faculty of organizational sciences,
University of Belgrade
Belgrade, Serbia
sladjana.benkovic@fon.bg.ac.rs
https://orcid.org/0000-0002-8798-916X

Abstract— Recently, museums have been experiencing sharp decline in public funding worldwide. Innovative classes of financing are required to fulfill the gaps in museums' budgets. This paper examines a particular technology-enabled class of financing – civic crowdfunding – as a potential mechanism for the attraction of sponsorships and donations for the museum operations. A specific questionnaire was designed to collect primary data on the potentials of civic crowdfunding of a specific project – the renovation of the Memorial Museum of Nadežda and Rastko Petrović. As indicated by the respondents (N=284), civic crowdfunding can be additional mechanism and viable alternative to the classical forms of public financing.

Keywords - innovative financing, civic crowdfunding, museum management

I. INTRODUCTION

Museum management has been recently developing as an important field of scholarly interest [1]. A number of external and internal factors have affected the age-old industry of museums, thus changing the paradigm of conservativism in the museum management. For instance, museums as public institutions generally suffer from low managerial efficiency of museum managers [2]. The new role of museum directors requires a change from museum being 'predominantly custodial institutions to becoming increasingly focused on audience attraction' [3].

Additionally, museums worldwide face cutbacks in their budgets and governmental financial support. Some studies report on the immense budgetary constraints of museums in the last few years [4]. The other studies, nonetheless, report on a progressive decline in the governmental funding of museums in the last few decades [5].

Finally, museums are faced with the development of novel technologies. For instance, blockchain technologies are used for tracking system for the loan of cultural objects, thus facilitating the circulation of cultural items and artefacts [6]. Even from a grand scheme of things, the paradigm of digitalization has touched upon museums [7].

Overall laggard management of public institutions, coupled with budgetary constraints that museums nowadays face, create a need for additional sources and ways of financing. Technology advancement, however, enable new mechanisms for donations and sponsorships. A particularly suitable solution might be civic crowdfunding.

Civic crowdfunding is a specific sub-genre of crowdfunding [8]. Civic crowdfunding is an alternative public financing instrument [9], used to finance quasi-public assets and projects [10]. In the context of this paper, 'quasi-public assets' refers to the cultural heritage.

As in other forms of crowdfunding, participation of small-scale investors is crucial for the success of the project posted on a crowdfunding platform such as Kickstarter or IndiGoGo. Unlike other crowdfunding projects, civic crowdfunding is used for fundraising for public assets or projects. The success of a civic crowdfunding project is usually attributable to the participation of citizens as investors.

The concurrent body of knowledge has already delineated a possible direction of the greater citizen participation in financing public cultural institutions [11]. Also, direct financial participation of citizens in financing public goods and services has a long tradition in Serbia [12]. The use of technology-driven methods of financing public goods, such as civic crowdfunding, on the other side, has not been vastly implemented in Serbia [13].

The aim of this paper is to examine the potential of civic crowdfunding as an alternative financing instrument for the museums. More precisely, this study is focused on

the examination of the main drivers (antecedents) of the investors' decision to invest either time or money in civic crowdfunding projects.

This study is focused on a single business case study of required renovation and refurbishment of the Memorial Museum of Nadežda and Rastko Petrović in Belgrade. Using a specifically developed questionnaire to address this aim, we collected responses from 284 respondents. The data were used to test the main factors that could affect either time- or monetary-related investments in the above-mentioned civic crowdfunding project.

The remainder of this paper is organized as follows. Section 2 briefly explains the business case for the civic crowdfunding project of the Memorial Museum of Nadežda and Rastko Petrović, which is part of the National Museum of Serbia). Section 3 delineates the methodology (research instrument, variables, measures, sampling procedure and data processing). Section 4 explains the results. Section 5 contextualizes the findings in the form of discussion and conclusions.

II. A BUSINESS CASE FOR THE MEMORIAL MUSEUM OF NADEŽDA AND RASTKO PETROVIĆ

The cultural institution Museum - Legacy of Nadežda and Rastko Petrović is a lasting memory of the greats of our culture and art. It was opened thanks to the noble gift of their sister Ljubica Luković. In 1967, she bequeathed all her immovable and movable property to the National Museum of Serbia, on the condition that this important legacy be permanently exhibited in her house [14].

The museum has a collection of the famous Serbian painter – Nadežda Petrović – a symbol of feminism and important artist and a nurse of WWI [15]. In addition to the collection of paintings by Nadežda Petrović, the donor bequeathed to the Museum the works of other Bulgarian and foreign artists from the collection of Rastko Petrović (such as I. Meštrović, P. Picasso, O. Rodin, A. Modigliani, E. Degas, J. Cocteau, etc.). A valuable segment of the legacy is also represented by the manuscripts of Rasta Petrović, his African and Mexican collection, travel films, gramophone records, his drawings and especially his large and rich library. This precious gesture of giving was the best way to permanently preserve an extremely valuable collection of paintings and other art objects, personal belongings and memories from the lives of great artists, which also complements our understanding and interpretation of various aspects of their personality and creativity [16][17].

This institution is of great importance for the general cultural heritage of Serbia. At the moment, the Museum-Legacy requires intense investment in renovation and refurbishment.

III. METHODOLOGY

A. Research model

For the purpose of this paper, we examined three variables that might affect the success of the civic crowdfunding project: 1) project difficulty (rewarded from [18]), 2) managerial experience (developed following [18]), and 3) emotional aspects (inspired by 3). These independent variables were developed following [19].

As for the dependent variables, we investigated possible investment of time or money towards the civic crowdfunding project following the scale developed by [20]. Investment in time means a consumption of a person's time to recommend, comment or in any other mean unforcefully communicate the idea of the project [21].

The set of hypotheses is graphically displayed in Fig. 1.

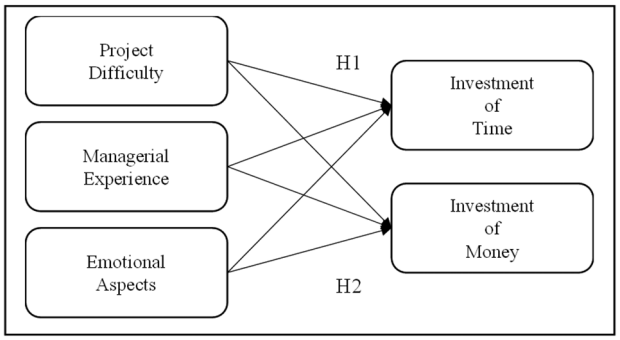

Fig. 1. The hypothesized model

B. Research instrument, variables and measures

We based our study on primary data collected via a specifically developed questionnaire. The questionnaire had six parts. The first part aimed at collecting demographic characteristics of the respondents. Parts 2-4 aimed at collecting data on independent variables (Project Difficulty, Managerial Experience, and Project Plan). Each independent variable was multi-itemed and measured at a Likert-type scale. Individual items of the independent variables are given in Table 1.

Table 1. Variables and measures (independent variables)

Item	Code	Inquiry
Project Difficulty (PD)	PD1	It is difficult for management to realize the plan
	PD2	It is difficult for management to complete project on-time
	PD3	Overall, the project is difficult to implement

Managerial Experience (MD)	MD1	Managerial team is experienced in carrying out this project
	MD2	Managerial team has competence to complete this project
	MD3	Managerial team has corresponding knowledge to implement this project
Emotional Aspects (EA)	EA1	Visiting this museum would be beneficial for learning
	EA2	Visiting this museum would be beneficial for amazement and surprise
	EA3	Visiting this museum would be beneficial for involvement
	EA4	Visiting this museum would be beneficial for identification with the historical period
	EA5	Visiting this museum would be beneficial for identification with the artists
	EA6	Visiting this museum would be beneficial for entertainment

Parts 4-5 of the questionnaire aimed at collecting data on the dependent variables (Investment of time and Investment of Money). The dependent variables were also multi-itemed and operationalized as: 1) probability, 2) readiness and 3) likelihood for the investment t of time and/or money. Once again, the Likert-type scale was used.

C. Sampling procedure

In total we sent the questionnaire in the e-form to more than 1.200 email addresses. The snowball sampling technique was used, following the recommendations given in [22]. The total of 295 were returned and 284 marked as valid.

D. Data processing

Data were entered in the Statistical Package for Social Science. The descriptive statistics were used for the pre-analysis. Cronbach Alpha was used for the internal reliability of the multi-itemed constructs. Pearson moment two tailed correlation was used for the interdependence among the observed variables. Finally, two regression models were used to validate the hypotheses.

IV. RESULTS

A. Sample features

The sample was gender-disbalanced, since 60.3% of respondents were female. Most of the respondents were educated (16.7% holding college, 64.1% holding bachelor or master, and 2.8% holding doctoral degrees). Only about 5% of respondents have not visited any museums in last five years, whereas 17.1% have visited 1-2 times, 43.6% have visited 3-5 times, and 34.5% have visited more than five times in the last five years.

B. Pre-analysis

Prior to testing hypotheses, we conducted pre-analysis, including means and standard deviations, internal reliability analysis and correlation analysis (Table 2).

Table 2. Means, standard deviations, internal reliability and correlation matrix

Variable	Mean	STD	CA	2	3	4	5
PD	4.23	1.74	.94	.83**	.79**	.79**	.75**
ME	3.86	1.84	.95		.92**	.80**	.76**
EA	3.59	1.73	.93			.84**	.79**
Inv-Time	4.16	1.94	.98				.85**
InvMon	4.12	1.62	.87				

** p <0.01

As shown in Table 1, the respondents were relatively moderately interested into investing in the crowdfunding project either time (Mean=4.16, STD=1.94) or money (Mean=4.12, STD=1.62). All the multi-itemed constructs were scaled to analyze internal reliability using the Cronbach Alpha. All the values were highly above the traditional threshold of CA>0.70. Finally, we found a number of statistically significant correlations both between and among the independent and dependent variables. Moreover, all the correlation coefficients were strong (r>0.70).

C. Hypotheses testing

As we learned about the statistical significance and the strength of the relationship between and among the observed variables, we proceeded to hypotheses testing. The first regression model used Investment of Time (InvTime) as a dependent variable, and three independent variables (Project Difficulty – PD, Managerial Experience – ME, and Emotional Aspects – EA).

Prior to that, we examined the possible existence of auto- and multi-collinearity. As shown in Table 3, the value for Durbin-Watson test (DW=2.03) was in between the traditional threshold (1.5<DW<2.5). Also, Variance Inflation Factor (VIF) was below the threshold of VIF<10.00 for each observed independent variable (3.23, 7.66, and 6.57 respectively).

Finally, we confirmed H1 (R^2=.75, p<.01). In particular, two out of three observed independent variables were found to be statistically significant predictors of time investment in this potential civic crowdfunding project – project difficulty (Beta=.36, sig.<.01), and emotional as-

pects (Beta=.65, sig.<.01).

Table 3. Regression analysis for model 1

Dep.var.:	**Unst.Coeff**		**St.Coeff.**			
InvTime	**B**	**SE**	**Beta**	**t**	**Sig.**	**VIF**
(Constant)	.27	.15		1.78	.08	
PD	.40	.06	.36	6.74	.00	3.23
ME	-.09	.08	-.09	-1.12	.26	7.66
EA	.72	.08	.65	6.401	.00	6.57
P value	**R**	.87	**Adj R^2**	.76	**DW**	2.03
<.001	**R^2**	.75	**SE**	.96	**F**	292.81

Afterwards, we tested H2 (Table 4). Once again, we pre-checked for a possible auto- and multi-collinearity. Both Durbin-Watson (DW=1.99) and VIF (the same values as in the previous model) were within the standards, and we concluded that no auto/ or multi-collinearity is present in the model. We confirmed H2 (R^2=.81, p<.01). Once again, two out of three variables were found to be statistically significant predictors of time investment in this potential civic crowdfunding project – project difficulty (Beta=.32, sig.<.01), and emotional aspects (Beta=.51, sig.<.01).

Table 4. Regression analysis for model 2

Dep.var.:	**Unst.Coeff**		**St.Coeff.**			
InvTime	**B**	**SE**	**Beta**	**t**	**Sig.**	**VIF**
(Constant)	1.05	.15		7.17	.08	
PD	.30	.06	.32	5.23	.00	3.23
ME	.18	.08	.02	.28	.82	7.66
EA	.48	.08	.51	5.81	.00	6.57
P value	**R**	.81	**Adj R^2**	.66	**DW**	1.99
<.001	**R^2**	.66	**SE**	.94	**F**	186.15

V. DISCUSSION AND CONCLUSIONS

A. Key findings

The aim of this paper was to examine the potential of civic crowdfunding as an alternative financing instrument for the museums. More precisely, the objective was to specify what the main drivers (antecedents) are of the investors' decision to invest either time or money in civic crowdfunding projects. Three variables were tested – project difficulty, managerial experience, and emotional aspects of investing. For this purpose, a specifically developed questionnaire was used to collect 284 responses.

We confirmed that all project difficulty and emotional aspects play pivotal role in the citizens' decision to invest in civic crowdfunding project of the renovation of the Memorial Museum of Nadežda and Rastko Petrović (a part of the National Museum of Serbia).

B. Contributions and Implications

This paper adds to the concurrent body of knowledge in the field of civic crowdfunding by explaining the possible factors that affect the decision to invest in a specific project. From a grand scheme of things, this field is known as directing the wisdom of the crowd [23]. Hitherto, drivers of success for civic crowdfunding projects have been examined in the areas such as higher education [24], local government projects [25], or social work [26]. Very little has been known about museum financing via civic crowdfunding.

The specific novelty of this paper is the examination of specific drivers of investment decision for museum crowdfunding projects. As expected, the results indicate that the emotional aspect is a key factor for investment. This finding is in line with other crowdfunding studies that find emotions to be a vital force for investors, such as [27].

As for the managerial implications, this study has isolated emotions as the main predictor of the success in potential civic crowdfunding projects. Accordingly, emotional messages could increase the probability of the success of the elaborated project. It should be underlined that positive affective and perceptual language could increase the emotional connection and the sense of ownership of the investment. However, extensive use of social messages reduces the likelihood of the project success [28].

C. Limitations and further recommendations

This study has a number of flaws that could seriously affect the generalizability of the findings. First, the study is based on a limited sample size. An avenue for further research is the extension of the sample to generate a nation-wide conclusion regarding the innovations in financing museums in Serbia.

Second, the study included only a paucity of possible antecedents of investment decisions in civic crowdfunding projects. Also, the examined variables could be considered as a 'low-tension' and relatively obvious predictors. Follow-up studies should concentrate on additional and more intriguing factors.

Finally, this study was focused on a single and potential project. Other studies should focus on general readiness of Serbian people to invest in civic projects over crowdfunding platforms, and some ongoing projects of a public importance.

D. Concluding remarks

Although the aim of this study was to examine and explore the main drivers for the potential civic crowdfunding project, this paper addresses a more profound societal issue. Namely, traditional government-backed sources of financing museums are becoming scanter and scant-

er. Nevertheless, the direct financing (such as admission charging) might utterly jeopardize the number and range of visitors. In the world of today, it seems that free access to the cultural heritage might be a paramount factor for the preservation of cultural heritage.

This paper tackles a more profound social interrogatives and issues related to the preservation of the Serbian cultural heritage. In specific, we elaborate on the possibility of the diversification of financing museums via the use of novel technologies.

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Agent-Based Modeling Financial Services in Social Networks

Igor Klioutchnikov

Department of Economics and Finance of Enterprises and Industries
«International Banking Institute named after Anatoliy Sobchak, Saint Petersburg»,
Saint Petersburg, Russia,
igorkl@list.ru

Maria Sigova

Rector
«International Banking Institute named after Anatoliy Sobchak, Saint Petersburg»,
Saint Petersburg, Russia
MIPT Business School
«Moscow Institute of Physics and Technology (National Research University)»
Moscow, Russia
sigovamv@ibispb.ru

Anna Klioutchnikova

Science Center
«International Banking Institute named after Anatoliy Sobchak, Saint Petersburg»,
Saint Petersburg, Russia;
anutkakl0002@gmail.com

Abstract— A promising direction for the transformation of social networks is the connection of commercial and financial communications to them. This solves a whole range of problems: monetizing social networks, retaining users in networks, and increasing network traffic; receipt of financial and commercial services by network users in the process of network communications; and expanding the client base of financial institutions. At the intersection of financial services and social media, a new phenomenon has emerged – access to financial services on online social media (FS OSN). The novelty and the first steps in the formation of financial inclusions require conceptual justification and determination of approaches to their study. It is equally important to analyze the effectiveness of incorporating FS OSN into the general system of knowledge, business processes and social communications. This analysis is carried out from an institutional point of view and agent-based modeling. The article proposes methods and models that allow analyzing the socio-economic behavior of consumers of financial services in social networks from the moment they start applying for financial services (e.g., clicking on ads) to making decisions, as well as providing financial services. both through social media channels and bypassing them but using them at different stages of subsequent maintenance. The agent-based approach to the design of financial inclusions in social networks allows us to identify the conditions for the stability of the system and the conditions for transition to other states, as well as to establish the relationship between the evolution of financial intermediation and the social network and the innovative mission of digital financial technologies and social networks. Specific nodes, links and their strengths and weaknesses are the main structures of analysis important for determining the behavior of financial intermediaries, social networks, and their participants, as well as building a model of interaction between nodes. These interactions are considered as a set of social and business contacts in the network.

Keywords - Online Social Networks, Financial Intermediation, Agent-Based Modeling

I. INTRODUCTION

Social networks are an example of spontaneous development [1] and represent a high level of self-organization [2]. They are constantly in motion – moving from one state to another. Recently, social networks offered an increasingly wide range of financial and commercial services. For this, various recommender-based applications have been developed [3]. They help network users make decisions in the face of information overload and help financial institutions and retailers promote their services and products [4] and retain customer [5]. As a result, there are changes in the information, commercial and financial space, in the organization and structure of intermediation, as well as in the forms and methods of providing financial services to end users. Social networks are also changing their functionality and commercialization are expanding. They are increasingly offering their users a wide range of financial services and goods [6], which allows network users to make transactions in a "one-stop shop" – receive services and buy goods when communicating on social networks. In addition, financial services are not tied to business hours and office/shop location but are tied to the location of the network user. Equally important is the personification of the offer of services and goods. At the same time, it becomes possible to individualize services and consider the interests of network users more fully. As a result, the previously dominant universality, mass character and homogeneity of financial services are giving way to personalized offers. However, the prospects for the penetration of e-finance and e-commerce into social networks are still unclear [7]. A powerful accelerator of the commercialization of social sites is the monetization of social media platforms, the scaling of financial services and commerce, and the desire to retain users and increase traffic. The commercial success of financial and commercial applications in social networks acts as a kind of guarantee for the further development of this process. Financial and business applications in mobile communications are especially rapidly gaining momentum [8].

Modern social media platforms are based on Web 2.0 technologies, which have opened a wide range of opportunities for companies to connect to social sites [9]. The transition to Web 3.0 [10], which combines machine and human intelligence to create new ideas and values, greatly expands these opportunities. This shift will greatly expand the boundaries of social online technologies. The transition to Web 4.0 implies the further development of

the mobile space (allows you to combine real and virtual objects and users to create new value). At the heart of Web 5.0 is a sensory-emotional space that will further expand the boundaries of social sites to include additional features [11], [12].

Financial intermediaries are moving to better platforms as they connect businesses with end-users. The interaction between a financial intermediary, a social network, and a user can be viewed as a multi-agent system [13]. Doing business on a social platform provides stakeholders with the information they need to achieve their goals. The introduction of the Internet and e-commerce has led to the automation of many of the tasks performed by financial intermediaries and merchants and has led to the emergence of new intermediaries and structures. In some cases, the importance of complementary intermediary relationships is increasing significantly, leading to a change in the role of traditional financial intermediaries and traders. However, the key is usability and the value that new links create. It is no coincidence that social networks have included financial services in their activities. There were appropriate prerequisites for this, among which the intermediary function stands out, which is the basis of both financial activity and social communications.

Intermediation refers to the ability of social networks, first, to provide various value-added services, following the example of traditional financial intermediaries; secondly, to compensate for the negative consequences of additional costs arising in the process of value creation due to the appearance of additional links in the intermediary chain [14]; thirdly, to unite the efforts of all participants in the value chain in the context of adding a new element and new functions to the function; fourthly, to transfer the function of trust from one person to another [15]. A general approach to intermediary value chain analysis has been proposed by Bakos (1998) [16]. The analysis of value-added intermediary services requires an integrated approach, including the analysis of the relationship between the buyer and the seller, the search for a pricing mechanism and price compromises, facilitation of transactions and the provision of appropriate infrastructure. Social media offered all these elements. The social media platform is fully suited for offering goods and financial services to online users [17].

Conceptualization of new knowledge and processes based on the introduction of financial and commercial services in social networks is possible and necessary with the accumulation of the necessary statistical data. However, a hypothetical review of changes is possible at an early stage. It allows you to assess the current situation and consider possible trends and options for changes in financial intermediation and social networks. Financial and commercial services are becoming a prominent trend in the development of social media, financial intermediation, and e-commerce [18]. Social sites do not have restrictions on the time and place of the provision of services, unlike real offices and shops. Mobility, combined with the flexibility afforded by modern recommender systems embedded in social networks, allows such services to capture the attention of online users [19]. Social distancing and lockdowns caused by the COVID-19 pandemic have accelerated the spread of financial services and social media commerce [20]. As a result, the phenomenon of inclusive financial and trading participation in social networks has emerged, which serves to provide financial services and trade through social networks.

Although financial and merchant services have become a prominent trend in the development of social networks on the Internet, some restrictions may affect their further development. Among them, the following financial restrictions stand out: firstly, in a number of countries there are state restrictions on the development of financial services through social networks - from direct prohibitions (for example, in China) to requirements for licensing financial activities; secondly, financial institutions are introducing direct communication with customers - blogs, managers, networks interacting with customers online; thirdly, digital platforms are emerging that organize direct links between money holders and borrowers, which excludes financial institutions from the process of lending and investing. The article addresses the following questions. How can microfinance and micro trade determine the macroeconomic structure, in particular the development of the financial sector, and contribute to the creation of a unified information and financial environment? Is it possible to analyze these processes using agent-based modeling? What new financial technologies make it possible to expand the functions of financial intermediation and combine them with information mediation? Is the advent of financial services on social media a milestone in the development of financial and social intermediation, or just one of many passing phenomena?

II. THE STRUCTURE OF THE STUDY AND ITS FORMAL BASIS

There is a wealth of academic and practical literature on social media and its commercial functions [21], as well as financial intermediation [22], [23]. However, it is extremely rare to find works explaining the inclusion of financial services in social networks [24], and the behavior of participants in financial interactions in social networks. In addition, there are no works on the conceptualization of the nature of financial intermediation in social networks and on agent-based modeling of systems of financial and commercial recommendations in social networks. The literature on both social networks [25] and recommender systems [26], as well as the microstructure of the financial market [27], including cash and investment retail [28] and e-commerce [29], is extensive and includes both academic and industry publications. It is difficult, if not impossible, to give even a superficial overview in a few pages of these two, until recently, completely unrelated areas. However, with the digitalization of finance and retail and the advent of recommender systems, financial and merchandise social media applications have been developed. As a result, fi-

nancial and commercial functions have been incorporated into social networks. At the same time, there was an institutionalization of financial and commercial services in social networks in the form of financial inclusions (FI) and commercial inclusions in social networks.

The novelty and the first steps in the development of FI require the conceptualization and definition of approaches to the study of this problem. No less important is the choice of practical approaches related to its effective inclusion in the overall system of knowledge, business processes and social communications. There is a wide field of activity here, as information, trade and financial flows merge into a single organizational form, which opens great prospects for business and social communications and can influence the behavior of markets and social users. The new engine emerged from financial and commercial applications integrated into social networks based on recommender systems. At the first stage, the initiators of their formation were trade and financial institutions. Later, key social networks began to develop this niche. In some cases, they used the services of trade and financial intermediaries; in others they included the functions of the latter within their scope. To this end, social networks have included licensed banking or settlement operators in their structure. A lot of work has been done in academia and business practice to develop the theory and economic use of social networks, recommender systems, e-finance, and e-commerce; the relationship between these areas is still unclear. This article presents an innovative idea that allows you to integrate these areas and move on to conceptualization based on building an agent model and analyzing the mechanism for optimizing the interaction of agents.

III. CONCEPTUAL FRAMEWORK AND HYPOTHESIS

FI Concepts: Financial Intermediation & Social Media → Financial and Social Information Systems → Financial Recommender Systems; User-Oriented Systems → Agent-Based Models → Agent Behavior → Recommender System → System Optimization.

The problem of financial recommendations in this article is formulated as follows: let U is a set of users, S is a set of financial services; Then g: U × S → R, where R is a fully ordered set, that is, a utility function such that g(u, s) measures the gain in the utility of a financial service s for user u.

The main function of the network is to convey information and values that "flow" through the connections between nodes [30]. The flow of information between network participants is affected by the distance between nodes, the position of nodes in the network and the integration of nodes into the network, that is, contacts and their strength. In this case, mediation was ignored. However, in essence, mediation was recognized because the network was seen as a channel for the transmission of information. The introduction of social media financial applications has demonstrated the importance of online intermediation and the role of new embedded nodes in spreading information and influencing other nodes. The article discusses the mechanism for including financial intermediation in the system of social mediation. Financial investments in social networks have a high information and social-interactive potential, which has yet to be studied in detail. Network connections are critical to the efficient behavior and operation of agents in an agent society. The division of the network into the center and the periphery allows us to evaluate the dynamics of the network and the integration of new arrivals. How can financial inclusion use information to integrate into a dynamic network that runs from the periphery to the center? The agent model allows you to analyze not only the behavior of participants, but also the movement of information between them [31]. The problem is solved in different ways: (i) if the nodes that determine the input of financial information into the system are taken as the center, and users are taken as the periphery, then information about intermediation is collected, (ii) if network users are considered as central nodes, then the emphasis is on efficiency meeting their needs.

The environment in which recommender technology is commonly used has changed markedly over the past few years in terms of the scale, variety, and complexity of data available. Modern recommender apps not only have a matrix of user and item ratings, but also complex user experience data, detailed item profiles, and large-scale (own, public, or third-party) resources of many different types. For their successful functioning, various optimizers are used. Agent-based modeling is used as a lens to understand the nature of competing processes in recommender systems and the logic behind recommender development. The agent-based model of group behavior is used to model the logic of collective decisions, determined by reaching the consensus threshold. The key parameter of the model is the corporatism of interaction between agents. The probability of collective decisions depends on individual preferences and the strength of cooperation between agents.

The development of modern recommender systems has been accompanied by significant progress in the development of efficient algorithms for optimizing data input into recommender systems and in understanding the role of recommender functionality in various application areas. The availability and convergence of technologies and resources in social systems—personal user data, user interaction records, user-generated content, social networks, rich databases, geospatial information, and so on—have changed the context in which recommendations are made. Extensive information increases the ability to offer better solutions. However, the amount of information complicates the decision-making process. To simplify it, you need to optimize your data. Therefore, optimization problems become decisive in the process of making decisions and preparing recommendations.

A. Limitations/implications of the study

This research is limited to agent-based modeling of agent behavior when developing recommendations. The emerging collective behavior with consistent and non-deterministic individual decision-making can be modeled within the agent-based approach with local interaction between agents who are inclined to cooperate, considering the optimization of decisions.

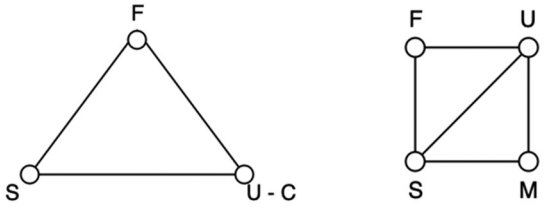
IV. AGENT-BASED MODELING

An important problem of economic theory is the modeling of the market, which is necessary to assess its state and predict its behavior in time and space (for example, to assess the prospects of markets in different countries). Rather conditionally, this task can be reduced to finding a certain law that allows, from the available information about the market at the initial moment of time , to determine its future state at any moment of time. Simulation allows (i) to understand the behavior of decentralized agents within financial and trade inclusions, (ii) to assess the behavior of such inclusions in social networks, (iii) to study the influence of individual behavior of agents, (iv) to assess the evolution of financial and trade inclusions, and (v) to optimize the interaction of financial and commercial agents with network users. At the same time, it becomes possible to assess the behavior of agents at the individual level - network users, financial institutions, shops, and social sites. A global vision of their behavior arises in the course of the activity of many agents, that is, as a result of modeling from the bottom up.

Agent-based modeling can be viewed as an alternative to DSGE models since in some cases they can better represent financial markets than standard models. Such modeling serves as a kind of background for the decision-making process.

A. Agent-based models

At the heart of the model construction of the proposal: each agent is interested in the realization of their own interests and, therefore, focuses on their own costs and benefits; private costs and benefits depend on other interests - financial and commercial agents in social networks; each agent promotes its interests and seeks to benefit from other agents. The state of agents has the following graphical structures: three-agent system - relations of a financial intermediary with social networks and network users (Fig. 1a) - FSU; four-agent system - relations of financial and commercial intermediaries with social networks and network users (Fig.1b) - USFM, where F is a financial intermediary, S is a social network in the network, U is a network user, M is a seller. In a four-agent system, the financial intermediary is the dependent variable - the actions of the financial intermediary depend on the buyer's choice of the purchase method, and the buyer is the independent variable - he determines the purchase from his own or borrowed funds.



Figures 1. (a) Three-agent– F-S-U and (b) four-agent system – U-S-F-M

The success of financial intermediaries and merchants largely depends on the number of online users. In turn, users also benefit from the number of network participants. First, financial, and commercial intermediaries grow their business through participation in social networks and benefit from their scale; secondly, costs decrease as the number of users of financial and commercial services increases; thirdly, the effectiveness of collective action increases with the increase in the scale of the network and financial and commercial activities. User groups with financial and commercial interests are defined as "inclusive" groups [32]. In contrast, "exclusive" groups attempt to promote targets for which the average benefit falls as group membership grows or is independent of group size. Therefore, financial and trade inclusions can be seen as a digital version of interactions that can be viewed in terms of the microeconomic structure of contracts and the theory of firms [33].

The sociometric approach to social and financial networks considers the location of nodes in the network [34]. Thus, network methods and graph theory allow us to proceed to the establishment of the centrality index [35]. It identifies the most important nodes in the network [36]. The centrality index characterizes both the uniqueness and the direction of the events and information on the site on a certain key topic (for example, financial and commercial). Centrality determines the position and state of financial and commercial services and their functions in social networks. The increase in the value of these functions is associated with their transition from peripheral to central. At the heart of this transition lies on the one hand, the digitalization of finance and its transfer to big data, and on the other hand, the transformations in social networks associated with the completion of their explosive growth and the transition to some slowdown [37].To stimulate development, social networks are moving from extensive mechanisms to search-intensive ones.

All this leads to an increase in networks and the number of network nodes, as well as to a change in the centers of influence of nodes in the network [38]. The rise of the typology of flow processes [39] determines the emergence of financial functions and their integration into the network mode [40] Centrality issues become the subject of research not only for commercial, but also for credit and investment networks when determining the relationship between interest rate, investment premium and risk [41]. Graphs of

financial investments in the network allow you to determine their connectivity, optimize paths between nodes and, thereby, determine the best recommendations, as well as improve the efficiency of connecting users to financial services and commercial transactions.

B. State and properties of agents

The graph denoted by G is represented by a set of nodes - a financial institution (F), a store (M), a social network (S), and a network user (U), connected by edges. In the model, the graph is denoted by G and is represented by a set of nodes - a financial institution (F), a store (M), a social network (S), and a network user (U), connected by edges. The number of ribs depends on the nodes in a particular group, in which financial activities, trade, communication services, and social, commercial, and financial needs are concentrated.

Financial services in social networks can be represented in the form of financial inclusions in which there is a series of end devices – a set of nodes (F, M, S, U) on a plane, labeled with integer coordinates (i, j), each of which can be in one of the states σ_(i,j):

$$\sigma\_(i,j)\ (t+1)= Ø(\sigma\_(k,l)\ (t)|(k,l)\ \epsilon\ N\ (i,j), \qquad (2)$$

where N (i, j) is some neighborhood of the point (i, j), which according to von Neumann is defined as N_N^1 (i,j)={(k,l)| |i-k|+|j-l|≤1}; according to Moore as N_N^1 (i,j)={(k,l)| |i-k|≤|j-l|≤1}. Various transition states arise, which are determined by the number of states σ and the number of other participants n: N_r=σ^(σ^n).

The evolution of participants leads to the emergence of sequences that obey certain rules. These rules can be attributed to local stable connections that affect the behavior of the entire system. First, in the process of interaction, local stable connections are formed. They are based on financial advice and contacts based on financial advice and services. Second, local changes in the initial conditions affect the parameters of the entire system and lead to its evolution.

The state of the system depends on the values that the participants bring to it. As part of a financial inclusions, the value depends on the sum of all values - an online user, a store, a social network, and a financial institution. Various specific values are possible both for each participant and for the entire system. The agent-based model makes it possible to identify patterns in the development of a collective solution for various interactions of agents, as well as to study the influence of changes and behavior of agents during the transition from an individual solution to a collective one, that is, in the process of coordinating a solution. The agent model makes it possible to model the logic of collective decisions determined by the achievement of a threshold value [43]. The key parameter of the model is the cooperativeness of agents, which places the group in a certain financial and cultural dimension of individualism / collectivism. There are many types of collective action. All of them cannot be reflected using the same formal model. Any model requires simplification of actions and situations, which allows considering the required circumstances [44].

The transition to financial services begins after two separate agents (a network user and a financial institution) or three separate agents (a network user, a merchant, and a financial institution) have prepared a common solution, that is, in the process of reaching a collective decision. The likelihood of moving to a collective decision depends on individual user preferences and financial guidance, as well as the strength of collaboration between agents. Collaboration allows the behavior of individual agents to be corrected. The recommendation system is designed to prepare cooperation. Each agent has complex behavior. They are based on simple local interactions between agents. Some of these interactions are used in local optimization. However, general optimization of financial and commercial interactions on social media has not yet been used for global optimization.

C. Agents' behavior

Thus, special systems appear on social networks – FSU and FSUM, which are associated with financial and commercial services for social users, which are defined as financial investments. These systems can generate various types of behavior, from asymptotically stable to chaotic and unstable [45]. The stability of the system is ensured by the constant formation of supply and demand for financial services and goods, as well as by algorithms for recommendations for applications in social networks [46]. FSU and FSUM are multi-agent systems. They have a special architecture and behavior determined by their agents [47].

Dividing the FSU system into simple interactions reveals simple rules of behavior for each agent, their groups (U-F, U-S and FS) – subsystems and the entire system as a whole [48]. The action of each agent depends on the environment, the state of the system, and other agents. The state of each system depends on other systems (for example, the financial system and social networking site) and the interaction of agents in the subsystem. Coordination in such subsystems depends on the actions of agents. The actions of agents are generally rational, but asynchronous and random. Other systems affect the state of the system. Variations in the behavior of individual agents can affect the state of the entire system of financial inclusions and lead to the expansion or reduction of the scale of its functioning.

This study does not consider agents such as the state and its regulators, which have a significant influence on the development of the entire system. The design of legal standards can stimulate, change, or suppress trends that lead to the formation of financial investments (e. g., by licensing the financial activities of social sites. An important condition for the development of this system is also a change in the behavior of agents [49] towards the forma-

tion of both cooperative and non-cooperative behavior. As a result, changes are possible in the ways and dynamics of collaboration between agents [50], as well as in the scaling and diffusion of financial services. The emergence of financial services will prompt a change in group behavior that can be described in terms of evolutionary game theory [51]. In this case, the actions of random netizens are assessed using simple adaptive rules of rational behavior, rather than a form of consistency of opinions and strategies [52]. Nash equilibrium means the correspondence between the behavior of a financial intermediary and a network user. As a result, equilibrium becomes a kind of reference point for a dynamic process at the level of netizens who have chosen financial services, rather than a form of coordination between beliefs and strategies. These interactions are not limited to the formation of a system of financial investments. They also change the status, properties, and place of agents in the network.

The development of financial services provided on social media is happening in stages. At the first stage, social media includes simpler forms of financial services such as payments for goods and services and international money transfers. There is a gradual shift towards more sophisticated financial services, including investment and equity advisory, equity trading, lending, and insurance. As financial services expand, the properties of the system change. In the development of social networks, the introduction of innovations, certain leaps are possible. For example, the behavior of Facebook and its users may change due to the introduction of digital currency. This jump is probably reflected in the change in the company name proposed at the end of 2021. As a result, a certain parameter of the system changes. Similar transitions were observed earlier in various areas. This happened in graph theory during the transition to the study of random graphs [53]. During these transitions, agents update their state and some properties based on new information. In many cases, information is extracted from random data and noise [54] by crossing certain thresholds. In digital systems, thresholds can be variable [55]. In such cases, the accumulated changes overcome the threshold barrier, which allows the system to move to a new state and offer the system participants new forms and conditions of behavior and service.

V. STATISTICAL AND GAME APPROACHES

The evolution of financial services on social media can be viewed from a statistical point of view as the evolution of a multi-agent system. It has an initial matrix and transitions during a Markov process. The state of such a system at each time step is represented by a random variable. This is a vector. It contains the probabilities of certain parameters that determine the actual state of financial investments (for example, the positions of agents, demand and supply of financial services and their characteristics). In this case, the system of financial integration into social networks can be considered stable [56], since the distribution of states converges to an equilibrium distribution, that is, to the following position: $P(X_n = j) \rightarrow \pi j$ when $n \rightarrow \infty$. In this case, the system of financial inclusions is stable, since, for large values of n, the probability distribution of the states of the system is provided regardless of the time step n [57].

An agent-based approach to the design of financial services in social networks allows us to identify different states, including the conditions for the stability of a multi-agent system [58]. Among them, two conditions are distinguished that are important for optimizing the behavior of agents - adaptability and learnability. According to Jennings (2000) [59], agents are: (i) able to solve problems using well-defined constraints and interfaces; (ii) located in an environment that serves as an entrance to the operation; (iii) set specific goals and outline ways to achieve them; (iv) flexible and adaptive to changes in the environment: (v) able to control their behavior in the course of achieving their goals; (vi) active - able to respond to changes and be guided by its goals.

The proposed interpretation of the state of the system cannot easily be applied to multi-agent interactions leading to the formation of financial inclusions. There are several explanations for this. First, the apparent output of the system is discrete (expressed in multiple states) but continuous. Significant volumes of data with a high level of noise are difficult to process. It is especially difficult to identify unknown parameters behind a time-delayed noise system. Various noise-corrected identification methods are used for identification [60]. Second, all financial interactions are deterministic. The slightest changes in the initial conditions change the overall picture. By statistically interpreting more behaviors, only approximate values for a specific configuration are generated. Nevertheless, the evolutionary game theory allows one to determine the strategies of agents and their effectiveness [61], and in combination with evolutionary methods can establish the conditions for the formation and phase transition from one stage to another stage, as well as the type and state of financial inclusions [62]. Third, there is a significant accumulation of various nonlinear effects, which makes it difficult to assess the transitions between different states of the system. Transitions occur spontaneously and do not depend on the decisions of one agent. They are based on the cumulative decisions of all agents. When a multi-agent system is denoted by a continuous Markov chain with discrete time with a potentially unknown distribution of the transition probability, the stability of the system becomes a set of effects [63].

Learning in a multi-agent environment is difficult due to nonstationary, which is based on changing the behavior of both the financial intermediary and the network user. There are two possible answers to nonstationary: adaptability to the behavior of another agent (financial intermediary or network user), proactive influence on the stabilization strategy of another agent, which can limit the nonstationary caused by another agent. Some modern recommender systems based on neural networks has such abilities. Wang et al. (2021) proposed to define an uncontrollable reward

for stability to teach a robotic system to deliberately influence another agent so that it stabilizes in the direction of a single strategy [64]. Stability refers to an advanced and relatively well-studied concept in physics in which it is viewed as the property of a system to continually return to a state of stable equilibrium after a minor disturbance. The mathematical definition of stability is not suitable for multi-agent financial systems with stochastic characteristics. The stability of multi-agent financial systems is achieved by preserving the basic properties of the system and returning it to its original state after various disturbances and changes in the values of the system parameters, for example, when new agents appear (for example, the creation of new financial institutions, the issue of securities or the elimination of the consequences of bankruptcy or takeover, merger). If a small initial disturbance becomes significant, the system becomes unstable.

A multi-agent financial system is in equilibrium provided that its statistical characteristics remain constant, including when external conditions change that may affect the system (for example, when government regulation changes) [65]. During violations in financial intermediation systems (for example, under the influence of digitalization of finance, implementation of financial recommendation systems, etc.) and in social media systems, the final states of systems change. Multi-agent systems formed in the form of financial inclusions can be represented as a set of agents participating in a multiplayer game. In-game theory, stability is the main property of balance. In this case, the problem of finding equilibrium is reduced to choosing the optimal strategy. Resilience can then be used to describe the characteristics of a set of strategies that are in equilibrium. If each player's strategy is the best response to the strategy of others, and no player has any incentive to deviate from the chosen strategy, then this state is the Nash equilibrium.

The stability of the financial services system in social networks is achieved through the actions performed by all agents of the system. Therefore, the equilibrium point is reached when each agent is in such a state that he does not need further work in the system, that is, the end-user either received the necessary financial service or refused it, which means that he left the system. In this case, the totality of agents' actions leads to stability - the termination of the system. Then each agent acts as if he is coordinating his actions with other agents. At the same time, the crowd effect allows predicting the behavior of agents [66]. The approach to the financial service system in social networks as a multi-agent system allows using the game method to study the behavior of agents and the entire system. In this case, the observed behaviors are considered, not the decisions made by the agents.

VI. CONCLUSIONS

The new "normal" caused by the COVID-19 pandemic has affected netizens and social media functionality. As a result, the transition of social networks to the provision of financial and commercial services to users has accelerated dramatically. For this, various applications have been developed and implemented that can respond to user requests and make recommendations to satisfy them. In turn, the financial sector faced a major challenge to respond to changes in customer behavior, which were largely related to the decline in their economic potential due to COVID-19. All these processes were combined with increased autonomy and isolation of customers, which led to a decrease in the number of customer calls to offices and the transition to online solutions. At the same time, pressure has increased on social media and digital payment, settlement, credit, and trading systems.

Financial and commercial applications were formed through the development of financial and commercial recommender systems in social networks, which was accompanied by an increase in the efficiency and effectiveness of interaction between all participants. As recommender systems become more complex and more in line with the requirements of consumers and financial intermediaries, as well as the conditions provided by social systems, the conditions have been prepared for their integration and institutionalization in social networks. As a result, financial applications continued structural and organizational consolidation and institutionalization within social networks.

In the process of incorporating financial services into social networks, several organizational principles stand out. Among them, the following are especially noticeable: the institutionalization of processes, the absence of time limits, the transition to self-organization and self-government, simplified large-scale replication.

Institutionalization is observed in the formation of financial inclusions in social networks. The course of institutionalization is analyzed using a three-agent model and characteristics of agent behavior. The mechanism of institutionalization can be built according to a three-agent model, and by analyzing the behavior of agents, it is possible to determine the main causal relationships, conditions, and results of its formation. The institutionalization of financial inclusions is based on large databases and new knowledge that comes at the disposal of financial intermediaries.

The institutionalization of financial and commercial processes in social networks is focused on databases. However, this information does not explain organizational changes. Knowledge is not a traditional entity. In addition, each site in its own way solves the problem of the functioning of financial investments. In some cases, it all comes down to simple recommendation systems that social networks provide to financial intermediaries on various terms; in others, social networks are evolving their way of delivering financial services. In the latter case, social networks consider the mechanisms of state regulation. The transition to institutionalization is also associated with the financial culture of society, which can both stimulate and limit its course.

Entities that are process-oriented in terms of execution time are practically unlimited in their work. Deep learning allows recommender systems to replicate skills and expand almost indefinitely as needed throughout the site. Optimization allows you to regulate decision-making processes.

Different roles, interests, and tasks of agents - for example, financial intermediaries determine the demand and supply of network users for financial services, rank the positions of supply and demand - require different sets of methods, tools, and the study of different databases. The most common algorithms use autoregressive tools. They can be coded in different programming languages.

Financial inclusion in social networks, as in other complex digital systems, creates new challenges for experimentation, testing, and widespread use of social, financial, and technical systems. In such systems, autonomous agents interact both locally and remotely with other agents to not only make intelligent choices, but also save time and resources. As a result, the productivity and efficiency of economic and social systems increase.

The accelerated development of the new takes place during the activation of the mechanism of self-organization of the system through the interaction in financial applications with social networks. So, agents in the process of agreeing on the conditions for the consumption of financial services adjust to each other. Although such complex systems are deployed and managed using a centralized infrastructure (financial intermediaries, social networking sites and their processing power), the socio-technical nature of these systems requires new approaches. These approaches should be cost-effective, build trust and enhance transparency, and be consistent with the social values of network users (including privacy, autonomy, fairness, and fairness in choosing and receiving services).

In this article, we define financial investment in social networks as a potential set of financial services that network users receive when using social networks. Financial inclusions are distinct from, but dependent on, and may be an element of traditional financial intermediation and financial start-ups but are (i) embedded in social networks or (ii) financial functions are performed directly by social sites. We consider the first option in connection with the expansion of financial intermediation to social networks - the use of social networks by financial intermediaries to scale their activities; the second option is to expand social networks in the financial sector to retain network users, increase network traffic and monetize network services.

The results of the study of this article can serve as a guide for further study of the evolution of financial and trade services and their integration into social networks as a dynamic process with unexpressed equilibrium points.

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Open Innovation and Crowdsourcing: Challenges and Opportunities for Serbian Railways

Nenad Stanisavljević
Infrastructure of Serbian Railways
Belgrade, Serbia
nenad.stanisavljevic@srbrail.rs
ORCID ID 0000-0003-1723-7103

Danijela Stojanović
Institute of Economic Sciences
Belgrade, Serbia
danijela.stojanovic@ien.bg.ac.rs
ORCID ID 0000-0002-9728-8586

Luka Petrović
Faculty of Organizational Sciences, University of Belgrade
Belgrade, Serbia
lukapet.93@gmail.com
ORCID ID 0000-0002-5768-4349

Abstract—The paper presents research that proposes prototype solutions based on open innovations, the Internet of Things, and crowdsourcing, which can increase traffic safety and reduce human casualties and material damage. The paper's authors conducted the research in cooperation with the Faculty of Organizational Sciences (FON) students in Belgrade and railway experts. FON students were presented with seven typical situations on the railway in Serbia. Traffic safety is often endangered, with human casualties and significant material damage, and the cause of these negative phenomena and accidents is not the railway. Traditional technical-technological solutions to these traffic problems to increase safety are extremely expensive and functionally complex, so they cannot be comprehensive, universal, and global. After the research, prototype solutions based on crowdsourcing principles were proposed, based on open innovations and the Internet of Things, to reduce the number and consequences of such characteristic situations on the railway. The research results confirm that open innovations based on crowdsourcing and the Internet of Things can increase safety in specific segments of railway traffic.

Keywords - Open innovation, railways, crowdsourcing, Internet of Things, transport, prototype

I. INTRODUCTION

There are typical situations in the railway traffic in Serbia. Safety and accidents with human victims and significant material damages are often endangered, which causes a negative attitude of public opinion towards this traffic system. At the same time, the cause of these negative phenomena and accidents is not the railway.

Such situations in railway traffic occur along with the entire territory of Serbian railways. They are numerous, from extraordinary events at road crossings, through accidents due to electric shocks from the contact network above the track and walking on the open railway, to the theft of railway parts and equipment. In a situation when, after several decades of insufficient investments in the railway, a comprehensive process of modernization of the railway infrastructure and rolling stock in Serbia has begun, such cases and the consequences they bring with them have highly negative connotations.

The stated typical situations on the railway can be solved with traditional and modern technical-technological solutions. However, they are costly and functionally complex, so such cases cannot be resolved uniquely on the entire territory of Serbian railways.

The development of the Internet of Things has enabled the wider community to define problems and offer solutions in many areas of social action (Bogdanović, et.al., 2021; Stojanović, et.al., 2022) and even in railway transport (Zhong, et.al., 2021). At the same time, in this way, railway companies have the opportunity to seek solutions to specific issues of their functioning and business, both outside the traditional and classical frameworks of innovation.

Despite that, Serbian railways have not tried to develop prototype solutions by applying open innovations based on the Internet of Things, thanks to which issues in specific segments of traffic will be resolved, especially when it comes to increasing safety and reducing human casualties and material damage.

Based on knowledge of open innovations and railways, an analysis of the possibility of applying open innovations based on crowdsourcing and the Internet of Things in this transport system in Serbia aims to improve safety and improve the functioning operation of railways comprehensively. At the same time, in realizing this project task, all challenges, limitations, and directions of development in this area when it comes to the railway are considered.

II. BACKGROUND

The term "open innovation" was first used by Chesbrough in 2003 in a paper (Chesbrough, 2003). According to this author, open innovation represents the use of knowledge from the company and its environment to accelerate internal innovation processes with external expertise and increase the market for external placement of existing internal innovations (Chesbrough, 2012). It is a sixth chronological innovation management model (Trott, 2017), which began in 2000 and is still ongoing. It is characterized by a combination of ideas from the internal and external environment to advance the development of new technologies.

Until about twenty years ago, innovative activities in companies were limited by the boundaries of those companies. This means these companies have implemented creative and development projects exclusively in controlled conditions, with their internal resources and knowledge and without competitiveness.

However, the development of modern technologies, especially the Internet of Things (Santoro, et al., 2018; Wang, et al., 2021), opportunities for capital inflows, an increasing number of experts in various fields of social life, as well as an increasing number of options to quality and innovative solutions come from outside the company (Cruz & Astudillo, 2020), conditioned that the previous traditional and closed innovation processes no longer give the expected results (Dhal, et.al., 2018; Radenković et al., 2020).

In such conditions, the previous model of closed innovation was faced with a shorter life expectancy for new products and rising costs of technological development. Its efficiency was constantly declining (Dodgson, et.al., 2008). Therefore, the concept of open innovation was introduced, which enabled companies to use knowledge from the immediate and widest social environment, from other companies, research organizations, educational institutions, local governments, and even directly from the citizens themselves (Santoro, et.al., 2018; Wang, et.al., 2021; Stojanović, et.al., 2020).

Accordingly, open innovations are a "distributed innovation process based on managing knowledge flows beyond the organization's boundaries" (Chesbrough & Bogers, 2014; Bogers, et.al., 2018). The critical factors for the success of open investments are clear goals, enabling cooperation, transparency, rewarding participants, finding the proper channels, and commitment (Subtil de Oliveira, et.al., 2018).

The European Commission promoted the Open Innovation 2.0 approach to synergy and integration of innovation processes, which was based on cooperation, innovation ecosystems, and joint value creation (Curley & Salmelin, 2013; Lopes, et.al., 2021). The development of information technologies and the emergence of the "Industry 4.0" paradigm have created the conditions for innovation processes today to represent the integration of knowledge in business, education, public and state administration, non-governmental sector, and individuals (Stojanović, et.al., 2021; Hizam- Hanafiah, & Soomro, 2021).

While many studies over the past two decades have addressed the challenges of the benefits of open innovation strategies or the benefits that can flow from them, few authors have analyzed the difficulties in implementing open innovations and tried to guide managers to direct such processes to better evaluate and more successfully apply open innovations. There are international research and development organizations, such as the Institute for Industrial Technology Research, that deal with a platform-based system of open innovation and its generation from idea to commercialization to create social and economic value (Wang et al., 2021).

In the professional literature, but also in practice, the concept of open innovation is based on the crowdsourcing approach, in which the "mass of individuals" (crowd) is a source of knowledge, leading to faster, more innovative, and better solutions (Estellés-Arolas, et.al. 2012). Crowdsourcing is most often used to gather ideas at the beginning of the innovation process, which is key to successfully implementing a project (Sarić, et.al., 2022). Author Jeff Howe (Howe, 2008) defined crowdsourcing as the process by which a particular task is transferred from specialized individuals in the form of an open call to an undefined, large group of people outside the firm. If the necessary conditions are met, the community will almost always achieve better results than any employee within one company.

Open innovations are applied in various sectors and areas of social life, with the best results being obtained just when cross-sectorial cooperation is achieved. The railways and the railway industry, which are multidisciplinary and complex systems, are, thanks to this, particularly susceptible to the application of open innovations.

With the development of the Internet of Things and social networks, open innovations based on the Internet are increasingly replacing open innovations in the traditional sense, which represent organizational internal and external interaction in a limited area. Online environments offer new ideas, products, and services. Public sharing can link knowledge management and open innovation, enabling companies to reduce risk, improve speed, and open innovation platforms to reach innovative resources. This is confirmed by data collected through semi-structural interviews with eight railway transport experts (Babaei Ebrahimabadi, et.al., 2019).

In the previous two decades, Serbian railways almost did not apply the concept of open innovations as a proposal for solving specific issues of functioning and business in railway transport, and the professional literature did not deal with this topic. Meanwhile, in European and world railway companies, the application of open innovations gave original, efficient, and high-quality answers to existing problems (Dodgson, et al., 2015; Thurner & Gershman, 2014; Hanley, et al., 2022).

Thus, the international company for the production of high-speed trains "Alstom" used open innovations to solve the problem of fallen withered leaves, which caused adhesion between rails and train wheels ("Open Innovation in Railway: Example of AlstomTM | ideXlab"). Indian Railways organized an open session on future innovations in business, after which over 100,000 innovative proposals ("Improving Indian Railways with Open Innovation") arrived online. At the open call of the Eurotunnel, which connects France and Great Britain below the English Channel, 38 companies from these two countries applied with innovative proposals for improving the maintenance

of railway vehicles ("CPC and Eurotunnel Invite SMEs to Provide Railway Innovation Solutions").

Mafex, the Spanish Railway Industry Association, which brings together 90 companies, implemented the Rail Activacion project with funding from the European Union's research and innovation program Horizon 2020. The main goal of this project was to create and direct railway operations and organizational mechanisms for small and medium-sized enterprises from the railway sector to take over innovation in the workplace as part of the open innovation ecosystem. Rail Activation is the first business model of its kind in the railway industry, thanks to which employees become dedicated workers through the adoption of innovations in the workplace. Within this project, research was realized, including 203 respondents from 16 European countries. (RailActivation project website http://railactivation.eu/)

III. METHODOLOGY

Students of the University of Belgrade, Faculty of Organizational Sciences (FON), were presented with seven characteristic situations in railway traffic in Serbia, in which safety is often endangered, with human casualties and significant material damage, which causes negative public attitude towards this traffic and business system. All this causes considerable damage to the "Infrastructure of Serbian Railways" and the railway operators in Serbia, especially in the period of substantial infrastructural and investment investments in this transport system.

Representatives of the "Infrastructure of Serbian Railways" presented to FON students the following characteristic situations on Serbian railways:

1. Traffic safety at road crossings;
2. Accidents from electric shock from the catenary above the railway;
3. Creating conditions for easier use of the railway for persons with reduced mobility and disability;
4. Destruction of the protective fence along the railway;
5. Noise from railway traffic;
6. Theft of parts of railway infrastructure and equipment;
7. Accidents on the open track.

FON students were divided into seven groups, with between three and six participants. After getting acquainted with the topics, groups of students could request additional information for a better approach to solving problems.

Each group proposed a prototype solution for one of the seven presented topics based on information, analysis, and research, based on crowdsourcing, open innovations, and the Internet of Things, to reduce the number of such situations and their consequences on railway traffic. In cooperation with FON students, the authors of this paper conducted this research for three months in 2022.

IV. RESEARCH AND OBJECTIVES

Within the research conducted in cooperation with FON students, with the help of experts from the "Infrastructure of Serbian Railways," seven distinct areas in railway traffic were defined, which frequently occur, resulting in human casualties, endangering traffic safety, tremendous material damage and deteriorating public attitudes towards this traffic system.

The paper aimed to find and propose prototype solutions on crowdsourcing principles and based on information, analysis, and research of the mentioned situations, which will reduce the number and consequences of such events on Serbian railways. The prototype solutions result from crowdsourcing and the application of open innovations based on information technologies, mainly on technologies of the Internet of Things. The following seven areas and characteristic situations in railway transport have been defined, with significant detrimental consequences for human lives and property:

Traffic safety at road crossings

Description of the situation: When crossing the railway, drivers of road vehicles do not respect the road signalization (Andreja's cross, STOP sign), do not stop in front of road crossings, cross the railway carelessly, and irresponsibly, slip under lowered ramps and break them. All this leads to accidents at road crossings, for which, according to official statistics, drivers of road vehicles are responsible in 95% of cases and in which there are fatalities.

Terms of reference: Proposed open innovation that will increase the attention of road vehicle drivers, improve compliance with traffic signals, increase traffic safety and reduce the number of accidents at road crossings.

Accidents from electric shock from the overhead contact line

Situation description: Young people in train stations climb on freight cars for selfies or fun. While climbing, they enter the circuit around the contact network, where the voltage is 25 thousand volts, and they are killed due to an electric shock. On average, five young people die each year in this way.

Project task: Proposal of open innovation that warns young people not to climb on wagons, approach the circuit from the catenary, and threaten the dangers of the catenary above the railway. That proposal reduces the number of such cases and the number of human victims.

Creating conditions for easier use of the railway by persons with reduced mobility and disabilities

Description of the situation: In many railway stations in Serbia, persons with reduced mobility and disability do not have adequate conditions for the use of these facilities. This is especially true of the large number of stations in Serbia built several decades ago when social awareness

and responsibility were not at a high level. This applies to people with reduced mobility, blind and partially sighted, and deaf and hard of hearing people who have difficulty using railway services and facilities.

Project task: Proposal of open innovations to enable disabled people to make more accessible and safer use of railway services and facilities.

Destruction of the protective fence along the track

Description of the situation: A protective fence has been installed along the railway along the first Serbian high-speed railway Belgrade - Novi Sad, and on a small number of other railways in Serbia. Citizens are destroying this fence along the railway to cross the railway in illegal places, thus endangering their lives and traffic safety.

Project task: Open innovations based on which citizens will be warned not to do so, and damage to the protective fence along the railway will be registered and detected the fastest.

Noise from railway traffic

Description of the situation: More and more often, the railways are addressed by citizens from the settlements near the railway, with remarks that the railway is making too much noise and asking for the installation of sound fences along the railway.

Project task: Regular monitoring of noise along the railway through open innovations to a timely response.

Theft of parts of railway infrastructure and equipment

Description of the situation: Thefts of parts of the railway infrastructure and equipment are daily, and the damage that the railway suffers because of that is measured at the annual level of tens of millions of dinars. In addition, in this way, the safety of railway traffic is endangered, transport is interrupted on certain sections, and it happens that those people are killed during the theft.

Project task: Open innovations that will protect railway infrastructure and equipment, with the aim of reducing the number of such cases and material damage caused to railways.

Accidents on the open track

Situation description: People are injured while moving on the railway so that a train hits them. Some suffer because of their carelessness (phone calls or earphones) because they come to the railway zone and the train runs over them. Other people commit suicide. In none of these situations can a train driver avoid an accident.

Project task: Proposed open innovations, which will warn careless people that they are moving in the railway zone, that a train is coming and that they are in danger.

V. RESULTS

Students who participated in the research and application of crowdsourcing should have proposed a prototype based on open innovations as a solution for specific situations in railway traffic and did not say that this transport system is a great challenge in this area. In the past decades, there were no significant investments in railway infrastructure and vehicles and almost no investments in maintenance, which is why this type of transport was slow and of poor quality.

Although the investment process in the railways worth about five billion euros has begun in the past few years and the first Serbian high-speed railway at 200 km / h has been built, this attitude of researchers shows that more time is needed for this mode of transport to become attractive, challenging and promising for researchers and students, not only when it comes to the application of open technologies, but also modern technical and technological solutions in the modernization of railways and trains.

The students were most interested in creating a prototype based on open innovations, which would create conditions for people with reduced mobility or disabilities to use the railway more easily. In this way, they showed a high level of social awareness and responsibility for solving the problems of people with special needs. In the coming period, this can direct future research on the principles of open innovation in this area, but at the same time initiate the railway to address the issue of people with special needs much more actively on the principles of open innovation.

On the other hand, none of the student groups showed interest in finding a prototype solution for accidents that occur on the railway from high voltage electric shocks from the contact network above the railway. The participants in the research did not sufficiently or at all recognize the danger posed by the contact network above the railway with a voltage of 25 thousand volts, which kills an average of five young people a year, primarily due to selfies or climbing wagons. Since the participants in the research were also young, the lack of interest in this problem may mean that students were not aware of the potential dangers of electric shock in this situation, but also that the railway did not get to know the young people well enough by climbing on the wagon and approaching the catenary above the track, they can get hurt. Both reasons in the coming period should direct further activities of the railway to solve this problem, both by finding a prototype of open innovations based on the Internet of Things and by applying modern technical and technological solutions.

Although all groups during the research had the opportunity to turn for additional information and explanations for each of the areas and characteristic situations in railway traffic, the research group used this opportunity to propose a prototype solution for the protection of railway parts and theft equipment, the aim of which was to reduce the number of such thefts and material damage to the railway on that basis.

The questions that this research group of students asked to find the best prototype for the protection of railway parts and equipment from the theft were:

a. What equipment needs to be protected?
b. How has the problem of equipment theft been solved so far?
c. In which places do thefts most often occur?
d. In what time interval do theft of equipment most often happen?

Students who participated in this quarterly research on the above issues and areas of railway safety proposed a prototype of open innovations based on crowdsourcing, which answered the project task and offered solutions to specific situations on the railway. In addition, during the research, students developed solutions based on project management and proposed marketing plans for product and service development.

During the preparation of the open innovation prototype, the researchers faced the limitations and challenges posed by a complex technical-technological system such as the railway. Widespread (3,500 km of railways in Serbia), a large number of executors in the organization and functioning of railway traffic, the impact of other traffic participants and service users on railway safety, complexity and interdependence of infrastructure and transport capacities, significant funds needed for investment and maintenance of railways, etc.

These are just some of the limitations that students encountered when researching and finding open innovations as a proposal for solving specific issues of railway safety.

At the same time, when finding open innovations in the form of prototypes, students, in addition to these limitations, had in mind the possibilities for their practical application, including technical-technological and financial aspects. With the proposed open innovations, the participants in the research offered solutions based on the Internet of Things, which can increase safety and reduce harmful consequences in specific segments of the functioning of railway traffic.

VI. CONCLUSION

Solving problems in railway traffic by applying open innovations represents a complete business novelty in the functioning of this transport system.

Until now, railway companies have not practiced trying to solve specific problems in their functioning with open innovations. The classical approach to solving the mentioned situations in railway traffic is costly and technically and technologically complex, so its application is limited and more difficult. Therefore, there is a justified business and functional need for the railway system to solve certain characteristic situations for traffic safety by applying open innovations, which can be much easier to use, more straightforward, cheaper, and more rational while achieving the desired effects.

In this research and work, for the first time, open innovations and prototype proposals based on them are proposed as a new solution to essential issues of railway traffic safety. The first such attempt after the research is a significant business and technical-technological innovation in approaching the most complex topics of railway safety, even when the proposed prototype solutions apply only to the local level and specific segments of the global problem.

The realized research confirmed that the application of open innovations based on crowdsourcing and information technologies, mainly on technologies of the Internet of Things, can improve traffic safety in specific segments of railway transport.

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Open innovations and the role of hackathons

Tamara Naumović

University of Belgrade
Faculty of organisational sciences
Belgrade, Serbia
tamara@elab.rs
0000-0001-9849-7665

Boris Vajagić

University of Belgrade
Faculty of organisational sciences
Belgrade, Serbia
boris.vajagic@elab.rs

Lazar Cvetković

University of Belgrade
Faculty of organisational sciences
Belgrade, Serbia
laki.cvetkovic@gmail.com

Miloš Proročić

University of Belgrade
Faculty of organisational sciences
Belgrade, Serbia
mp20200008@student.fon.bg.ac.rs

Abstract— The beginning of 21st century marked a paradigm switch in regards to Research and Development (R&D) programs conducted in companies, internally. Generating new ideas and developing new products "behind closed doors" was considered "the right-way", where companies could control product development from the idea to the point of commercialization. With the emergence of start-ups, this closed-innovation approach was replaced with open-innovation model. This model allowed companies to commercialize their ideas and outsource innovations from other firms, partners, individuals, etc. One popular way of outsourcing are hackathons. Hackathons have made a significant impact in the world of digital innovation – starting out as student indoor hang-outs to worldwide organized events. This study researches the topic of open innovation focusing on the role of hackathons. Main goal is to provide a comprehensive overview of the open innovation model and hackathons. Further, research will be focus on analyzing data and discussion about hackathon events that happened in the last decade at the Faculty of organizational sciences, University of Belgrade.

Keywords - open innovation, hackathon, research and development

I. INTRODUCTION

Research and Development (R&D) used to be considered a valuable strategic asset [1] for any company that wanted to make competitive product on the market. Generating new ideas and developing new products "behind closed doors" was considered "the right-way", where companies could control product development from the idea to the point of commercialization[1][2]. The beginning of 21st century marked a paradigm switch in regards to R&D [2]–[4]. With the emergence of start-ups, this closed-innovation approach was replaced with open-innovation model [1][5]. This model allowed companies to commercialize their ideas and outsource innovations from other firms, partners, individuals, etc.[1].

One popular way of outsourcing are hackathons. Hackathons are organized as time-bounded (typically 24 hours) intense competitions, where multidisciplinary teams generate innovative solutions to a given problem [6]. Hackathons have made a significant impact in the world of digital innovation – starting out as student indoor hang-outs to worldwide organized events[7].

This study researches the topic of open innovation focusing on the role of hackathons. Main goal is to provide a comprehensive overview of the open innovation model and hackathons. Further, research will be focus on analyzing data and discussion about hackathon events that happened in the last decade at the Faculty of organizational sciences, University of Belgrade.

II. RESEARCH METHODOLOGY

This research is based on systematic literature review of the key topics, such as open innovations and hackathons, and data analysis of hackathons held at Faculty of organizational sciences, University of Belgrade, from year 2013 to present.

The literature review follows five-stage process defined by [8]:

1. Definition of search criteria
2. Literature search
3. Literature refinement and article selection
4. Analysis of selected articles
5. Presentation of findings

Data analysis was conducted in several steps:

1. Collecting available data
2. Sorting and "cleaning" data
3. Systematization
4. Analysis
5. Visual representation

III. LITERATURE OVERVIEW

A. Open innovations

The term open innovation emerged in early 2000s and was promoted by the prof. Henry Chesbrough [1], [2], [4], [9]. It was used to describe a paradigm-shift where an organization seeks for innovation outside of their own internal R&D centers, knowledge base, sources and resources, using various external sources (such as customer feedback, published patents, competitors, external agencies, the public etc.) to drive innovation [2][10].

The old model of generating new ideas can be described as closed innovation model [1], [2]. Companies and organizations would firmly rely on their internal resources and R&D centers to create ideas, develop product or services and bring them to the market, believing that successful innovation requires control [1]. Investing more in internal R&D, hiring top-of-the-class graduates and experts and aggressively controlling their intellectual property, was the right way – formula that will inevitably bring profit [1], [10].

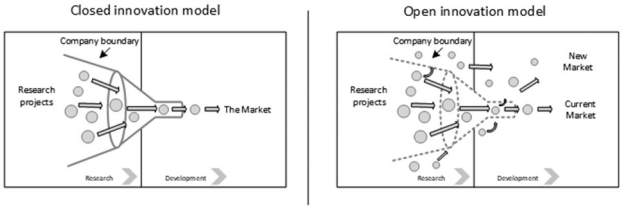

Figure 1 Closed vs Open innovation model [1]

The open innovation model arose as a consequence of changes in society and industry – mobility of knowledge workers and the rise of new form of financial structure - venture capital [1], [10], [11]. These changes opened company boundaries of innovation processes and a new research paradigm was created allowing the creation of projects from internal or external sources and allowing new technology to enter at any stage (research, development, placement, etc.) [11]. This model, allows company to attack the cost side of the traditional R&D method, utilizing external R&D resources to save time and money and up the ante on the revenue side by licensing out internal technologies [11].

B. Hackatons

Hackathons are organized as time-bounded (typically 24 hours) intense competitions, where multidisciplinary teams generate innovative solutions to a given problem [6]. Hackathons have made a significant impact in the world of digital innovation – starting out as student indoor hang-outs to worldwide organized events [7]. Gaining popularity over the years, hackathons evolved from geek student competitions to an event that many software companies, organizations, even government agencies organize with the purpose of encouraging digital innovation with their assets and resources [7].

In early 2000s, hackathons became prominent and were seen by companies and venture capitalists as a mean of rapid software and technologies development and discovery of new areas for innovation and financing [7].

Briscoe and Mulligan [7] classified hackathons in two major groups:

1. *Tech-centric* which focus on software development using specific technology or developing a specific application
2. *Focus-centric* which target social issues and/or business objectives through software development.

Although, hackathons can be great way for participants to self-improve, learn, network [7][12] and for companies, organizations and other organizers to generate new ideas [6], [13]–[15], the question about the future of those projects still remains [14], [16], [17]

Majority of the conducted research focuses on the hackathon event itself and not the outcomes. Authors in [17] point out that there is limited research done on corporate hackathons, which comes as a surprise knowing companies increasingly invest in hackathons to encourage internal innovation [18], [19].

Study [16] has shown that only 5% of all hackathon projects are continued for more that 5 months. The same study also differentiates between short- and long-term continuation, where [16]:

- short-term continuation is dependent on the number of technologies a team uses to create a project and winning a prize at a large event, while
- long-term continuation is dependent on skill diversity and skill matching among team members and their intention to expand their project's reach.

Study [17] focused their research on five teams from Microsoft's OneWeek hackathon in summer 2017, aiming to identify how attitudes and activities before, during and after a hackathon can foster or hinder potential outcomes related to projects and individuals. Their work identified several aspects of a theory on the continuation of hackathon projects in a corporate setting:

- Career oriented leadership
- Expertise focused learning
- Project-focused preparation
- Matching skills and tasks
- Hit the ground running and freeze the project before the end
- Find a home
- Evolution not revolution

IV. DATA ANALISYS

The data that's the focus of this analysis is gathered from the Association of Students of Information Science FONIS at the Faculty of organizational sciences. This association has been the main organizer of student hackathons at the faculty since 2001. This study covers the data gather from year 2013. to present of the FON Hackathon event.

Research was focused on growing interest for hackathon participation by students and companies' involvement in hackathon organization.

A. Hackathon themes

When first organized, hackathon was an internal event for FONIS members who wanted to test their skills in competitive setting.

In 2010 hackathon became an open event for students of the Faculty of organizational sciences, and since 2015 event has been opened for all students in Serbia. Hackathon themes varied through years and show the rising interest of companies' involvement in the events.

Table 1. Hackathon themes

	Theme	Who set the topic	Year
1	System of scheduling appointments and ordering student service certificates	FOS[a]	2013
2	FOS alumni management system	FOS[a]	2014
3	Open data	MESTD[b]	2015
4	Development of applications with use in the field of environmental sustainability	SBB[c]	2016
5	Development of applications for business improvement during the EXIT festival based on data from base stations	Telekom Srbija	2017
6	Application of ICT to improve security in large cities	SAGA[d]	2019
7	Development of applications to encourage sustainable development in cities	FONIS	2020
8	Proactive and/or reactive action in emergency situations	Raiffeisen bank	2021
9	Development of ecological awareness and application of environmental protection principles	Levi9	2022

[a] Faculty of organizational sciences
[b] Ministry of education, science and technological development
[c] Serbia Broadband
[d] Saga New Frontier Group

B. Hackathon applicants and participants

Number of applicants and participants also varied through the years showing the increased popularization of hackathon events.

In the first year, number of applicants was 23, compared to year 2022, where that number was ten times the size, counting 240 applicants. The Fig 2. clearly shows the continuous increase in interest for participation in hackathon events.

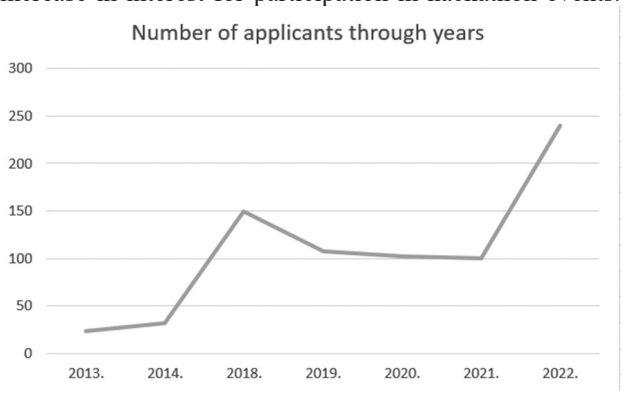

Figure 2 Number of applicants through the years

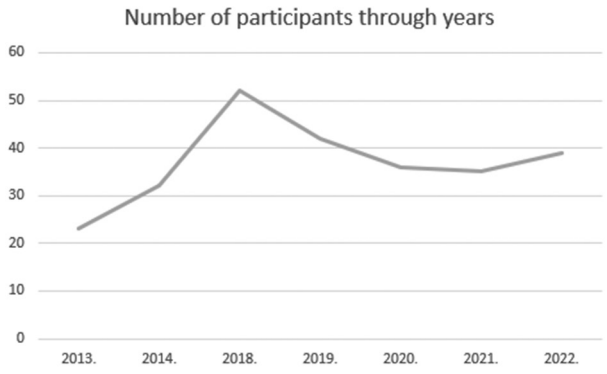

Figure 3 Number of participants through the years

Number of actual participants didn't vary much in quantity as the organizing capacity of the FONIS organization didn't change through years. Number of teams was constantly between 8 and 10.

Following charts show the diversity of participants studying origin for the last three years (Figure 4).

It is interesting to see the increase of the number of employed participants.

As mentioned before, FON Hackathon became open for all students in Serbia in 2015, but it is interesting to see that 5 high-school students participated in university level hackathon in year 2022 (Fig. 5), even though high-school level hackathons were organized as well.

V. CONCLUSION

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.

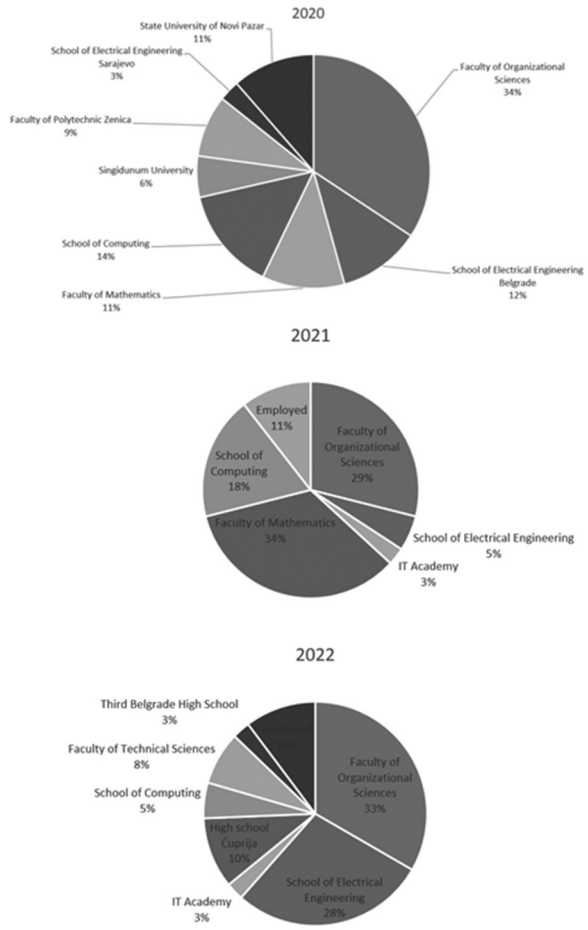

Figure 4 Participants' alma mater for years 2020-2022

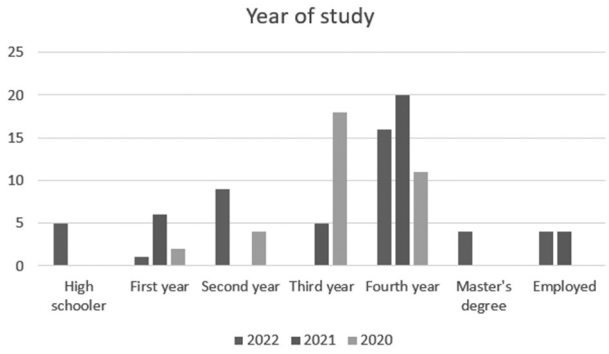

Figure 5 Participants' year of study

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EBT 2022

IOT AND SMART ENVIRONMENTS

A Modeling, Simulation, and Setting the Control Parameters for Automation of Irrigation System Using PID and ANN methods

Ravi Kant Jain

Senior Principal Scientist, Information Technology Group,
and Professor, AcSIR,
Head, Engineering Services Division (ESD-Institute)
CSIR-Central Mechanical Engineering Research Institute (CMERI)
Durgapur-713209, India
rkjain@cmeri.res.in; jainravikant@gmail.com
ORCID:0000-0002-8106-1256

Abstract— Irrigation systems have been demanding the automation of the system for getting faster and more precise manner of agriculture which will be enhanced the productivity rate and reduced the processing time and labor cost. During automation, irrigating the large areas of plants is a difficult job. To overcome such problems, irrigation scheduling techniques can be applied to monitor the soil and crop conditions. Irrigation scheduling plays a vital role when irrigating the land and how much water is to be applied. This improves the irrigation system as well as reduces the irrigation cost and increases crop yield. For this purpose, modeling, simulation, and setting of the control parameters for the automation of the irrigation system are carried out using Proportional-Integral-Derivative (PID). Further, to improve the performance of the control system, Artificial Neural Network (ANN) based intelligent control system is applied for effective irrigation scheduling where evapotranspiration, ecological conditions, type of crop, and the amount of water are estimated for irrigation The model is simulated using MATLAB software, and it is found that ANN-based intelligent control systems can provide a better solution for saving the resources and can also provide optimized results to different types of agriculture cultivation.

Keywords - ***Irrigation systems, PID control system, Artificial Neural Network (ANN), Irrigation Scheduling, Control system, etc.***

I. INTRODUCTION

The intelligent systems have been providing the solution for the environment to build the decisions making system for futuristic aspects and analysis of their surroundings which plays a vital role in human society's accomplishments to be self-sufficient in food and living of life requirements. Irrigation is the most important part of agriculture in many parts of the world where water is an inadequate resource and irrigation techniques must be automated with precision and accuracy so that limited resource can be utilized effectively and efficiently manner. During automation, the design of a control system for irrigation scheduling is the most essential aspect where irrigation scheduling is to attempt on when to irrigate and how much water will have to be supplied. This is focused on the fixed-rate or variable rate of its control system. For this different types of controllers are attempted such as ON-OFF controller, PD, PI, PID, etc. [1,2]. The major disadvantage of ON-OFF controllers cannot give optimal results for varying time delays phenomenon and varying system parameters of the controller whereas PD, PI, and PID give slightly better results than an ON-OFF controller. Artificial Neural Network (ANN) controllers have the potential whereby set up the input parameters like soil moisture, air temperature, humidity, radiations etc., the model of control system can be developed which provides the output information for evapotranspiration, type of crop, ecological conditions, the amount of water required for irrigation. Using proposed this method, effective irrigation scheduling can be achieved to the level of water, moisture in the soil, use of pesticides and fertilizers, etc.

The main objective of this paper is to develop a model for a control system where a PID system is applied and further improvement of the system, ANN control technique is applied for effective irrigation scheduling for agricultural land. The classifications of the crop into different types of areas can be set according to the requirement with different environmental conditions in similar resources so that these can be identified in a group in the same category. Therefore, irrigation needs can be identified with lesser water requirements.

This paper is presented as follows: a brief report of a literature survey for different controllers application towards irrigation applications is discussed in Section II. In section III, a novel concept on PID controller enabled in an irrigation system is proposed where the major focus is on minimizing the drawbacks of the ON-OFF control system. In section IV, a system architecture of ANN Controllers' application in the irrigation scheduling is discussed. The conclusion is written in Section V.

II. BRIEF LITERATURE SURVEY ABOUT MODELING, SIMULATION, AND APPLIED CONTROL SYSTEM ON THE IRRIGATION SYSTEM

In the past, some researchers have reported on automated irrigation systems where different types of control

systems are identified. Ding et al. [3] have focused on the fuzzy self-adaptive PID controller which is applied to the automatic control system of canal operation. During operation, the controlled parameters are set based on fuzzy logic reasoning and the optimal best fine-tuning of PID controller parameters. Colaizzi et al. [4] have applied a plant canopy temperature for improving irrigation systems towards crop management where a remotely sensed plant canopy temperature theory has been applied. Shirazpasha et al. [5] have attempted automated irrigation for farms or nurseries which gives information to farmers about the exact amount of water requirement. This turns valves ON-OFF using a solenoid valve and microcontroller. Pavithra et al. [6] have developed an android phone-control irrigation system where Application Programmable Interface (API) is applied to develop Android applications platform using the Java programming language. Goyal et al. [7] have emphasized modeling of daily pan evaporation in subtropical climates using various controllers which increases the accuracy/precision of daily pan evaporation estimation during subtropical climates. Rodriguez et al. [8] have developed a control algorithm for automatic irrigation scheduling in a soilless culture where the control system is based on a PID algorithm and it provides the automatic operation with the minimum cost. Goodchild et al. [9] have attempted on a PID controller for providing the proper control of soil moisture conditions by supplying the exact amount of water according to the requirement of the plant. subsequently, the PID controller is modified by changing the environmental conditions such as different rainfall, high-temperature conditions, etc so that the controller can work under different conditions such as watering, windup, plant stress conditions, etc. Poyen et al. [10] have attempted an ANN controller which is applied for precise moisture control in smart irrigation. The controller interacts with the requisite soil moisture and calculated soil moisture conditions. Lozoya et al. [11] have presented a model of control strategy applied to an irrigation system for making efficient use of water for large crop fields, that is applying the correct amount of water at a suitable place at the exact time. Ghodake et al. [12] have focused on the design of an automated drip irrigation system where a feasibility study has been carried out regarding cost-effectiveness. Shitu et al. [13] have summarized the review on smart different control systems for water management applications whereas Guo et al. [14] have attempted the real-time control system for irrigation applications where a model for predictive control is applied for finding the plant's desired root-zone deficit level with specified variable rainfall parameters etc. Sheikh et al. [15] have emphasized the importance and significance of modernization of irrigation in the agriculture field by applying a PID controller where all-natural parameters including temperature, air humidity, wind speed, radiation, and soil moisture are taken into account. Munir et al. [16] have employed an IoT system for smart energy consumption and smart irrigation in tunnel farming where a set of sensors records the plant data efficiently and their water requirement. An application is also developed for monitoring and controlling the irrigation system. Sudharshan et al. [17] have attempted on renewable energy-based smart irrigation system where the fuzzy logic algorithm is used to control the solenoid valve and data from the sensors are sent to the adafruit.io cloud platform so that users can monitor the moisture and humidity level etc. Jacob et al. [18] have attempted on modeling the automatic sprinkler irrigation process using a PID controller and finite-state machine where automatic control logic is designed for automatic irrigation systems in real-time. Gonzalez-Briones et al. [19] have attempted an intelligent multi-agent system where the data are gathered from wireless sensor networks for potato crops. Further, the data have been uploaded to the cloud. EL-Zemity et al. [20] have developed a wastewater treatment model with smart irrigation utilizing a PID controller where the PID gain parameters are tuned using MATLAB and the correlation for the performance of the wastewater treatment processing is achieved. Abioye et al. [21] have attempted an IoT-based monitoring framework using ES Presso Lite and V2.0 module which interfaces the various soil moisture sensors to measure soil moisture contents for mustard leaf plants. Poyen et al. [22] have applied a fuzzy rule-based controller to control the check the water wastage by providing an optimal irrigating environment for farming where the necessary control action regulates the actuators by supplying the right amount of water to the farm. Further, Jain et al. [23,24] have demonstrated an IoT-enabled smart drip irrigation system using web/android applications for agricultural applications whereas in this paper, modeling, simulation, and setting of the control parameters for automation of irrigation system using PID and ANN methods are proposed which will help in an irrigation scheduling. This is a novel part of this paper.

III. DESIGN OF PID BASED AND ANN-BASED CONTROLLERS FOR AUTOMATED IRRIGATION SYSTEM

A. Modelling of system parameters for PID controller towards automated irrigation system

For designing the controller for an automated irrigation system, several parameters like the kind of soil, kind of plants, leaf coverage plays, etc play an essential role during the cultivation of crops where an optimal decision is required for providing the water requirement. For taking the optimal decision, the controller should be designed in such a way as to how much water (and/or fertilizer) will be used in respective irrigation sessions/areas and repeatability can be itself accordingly to the requirement. In the pre-defined control/direct control method, there is no feedback from the controlled object. For taking the account of a feedback system, the study on irrigation sessions is required where repeatability is a major concern according to irrigation session/area. Considering these aspects, a PID controller i.e. a close loop system is proposed for a feedback control system where the process variable may be fixed with a setpoint, and produced an error signal will be corrected as per requirement. This controls the output

parameters of the system and this process may be continued up to the zero error signal or the process variable value will be equal to the set point. During operation, the input parameters are considered as soil humidity, air humidity, temperature, radiation, wind speed, and salinity and the output parameters are taken as opening and closing the operation of the valve for water requirement or fertilizer, and a combination of both, opening and closing walls, turning energy systems (like lights, ventilation, heating, etc), etc.

During the development of the controller, the following steps are attempted as given below;

i. **Input data from sensors**: In this step, various parameters like soil moisture, air humidity, temperature, radiation, and wind speed are collected. Then these parameters are needed for the next step as input.

ii. **Development of Evapotranspiration model**: During the development of the model, this block transforms the four input parameters for achieving the actual soil moisture.

iii. **Required soil moisture condition**: This block gives information about the amount of water required for the appropriate growth of plants.

iv. **Application of PID and ANN controller**: In this step, by applying the application of PID and ANN controller, the requisite soil moisture and actual soil moisture can be compared which helps in the decision-making process dynamically.

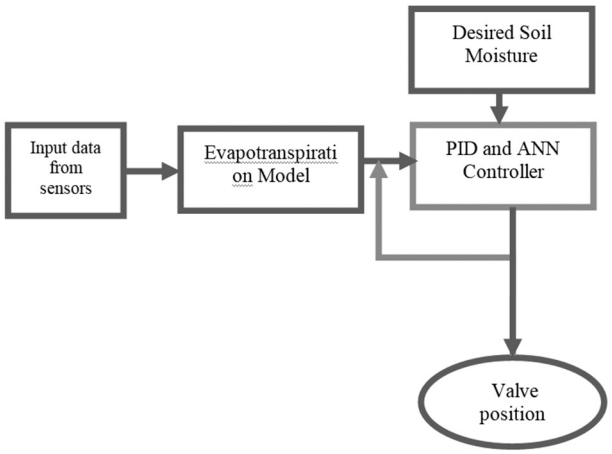


Fig. 1. Block diagram of basic irrigation control system

The input for the irrigation control system is simulated using SIMULINK in a MATLAB environment as shown in Fig. 1 where the following inputs are considered.

B. Modelling for input parameters from acquired sensors

For estimation of humidity from the environment, the four input parameters such as air humidity, temperature, radiation, and wind speed are considered which affects the evapotranspiration model.

i. **Temperature**: The temperature is the essential parameter for monitoring and control of the irrigation system which is illustrated as a continuous sine wave signal and simulated for the day and night temperature transformation. If any sharp changes occur in exceptional cases such as deserts etc. The following input variable parameters are considered as given below;

- A sine wave with an amplitude of 5 ºC is considered
- A frequency of 0.2618 rad/h for a time period of 24 h is measured (i.e. 0.2168 rad/h = 2pi/T=2pi/24).
- A constant bias (offset) at 30 ºC is taken

After simulation, it is found that the air humidity can reach the maximum temperature of 35°C (mid-day) and the minimum can reach +25°C (mid-night). In this manner, the temperature can be found on any particular day by setting the variable parameters as shown in Fig. 2.

ii. **Air humidity**: For considering the air humidity, the following parameters are taken.

- A sine wave is taken with an amplitude of 10%
- Bias of 60% (constant);
- A frequency of 0.2618 rad/h is measured for the period of 24 h.

iii. **Wind speed**: For considering the air humidity, the following parameters are taken.

- A sine wave with an amplitude of 1 km/h is taken
- Bias of 3.5 km/h (constant) is considered
- A frequency of 0.2618 rad/h is measured for the period of 24 h.

iv. **Radiation**: By considering the maximum possible radiation at the earth's surface (Rmax), the model is developed.

- A sine wave with an amplitude of 2MJ/m2 is taken
- The bias of 112MJ/m2
- A frequency ranging of 0.2618 rad/h is measured for the period of 24 h.

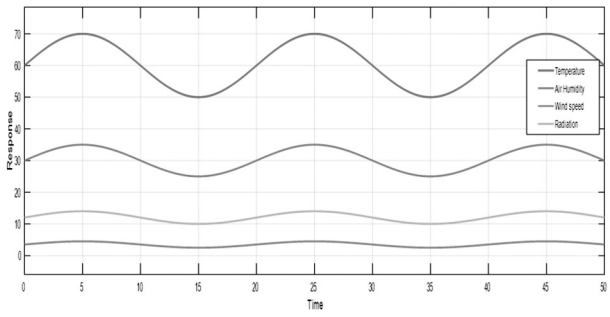


Fig 2. Input Parameters of Evapotranspiration model-Graphical representation

C.Required Soil Moisture Condition

It is dependent relative to the type of soil, kind of plant, type of growth parameters, type of land, etc. The required soil moisture is found as shown in Fig. 3.

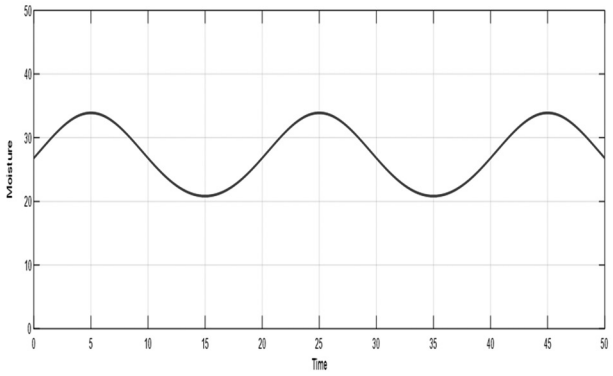


Fig. 3. Required soil moisture behavior

D. Evapotranspiration Model

A Penman-Monteith equation is considered based on an estimation of reference evapotranspiration eq. [25] where the equation can be presented by a combination function of maximum and minimum temperature, radiation, wind speed, and vapour pressure. The Penman-Monteith eq. [25] is written as given below;

$$Et_0 = \frac{0.408\,\Delta(R_n - G) + \frac{\gamma \times 900 \times u_2}{T+273}(e_s - e_a)}{\Delta + \gamma(1+0.34U_2)} \quad (1)$$

$$\Delta = \frac{4098\, e^0(T)}{(T+273.3)^2} \quad (2)$$

$$e^0(T) = 0.6108\exp\frac{(17.27T)}{(T+273.3)} \quad (3)$$

$$\gamma = \frac{C_p}{\varepsilon\lambda} P \times 10^{-3} = 0.001628 \times \frac{P}{\lambda} \quad (4)$$

ET_0 = Reference evapotranspiration [mm day-1],

G = Soil heat flux density [MJ m-2 day-1],

R_n= Net radiation at the crop surface [MJ m-2 day1],

U_2= Wind speed at 2 m height [m s 1],

T = Mean daily air temperature at 2 m height [°C],

D = Slope vapour pressure curve [kPa °C-1],

e_s= Saturation vapour pressure[kPa],

e_a= Actual vapour pressure [kPa],

e_s-e_a= $e^0(T)$ =Saturation vapour pressure deficit [kPa],

P = Atmospheric pressure [kPa],

g = Psychrometric constant [kPa °C1],

$e^0(T)$ = Saturation vapour pressure at the air temperature T [kPa],

z = Elevation above sea level [m],

C_p= Specific heat at constant pressure, $1.013x10^{-3}$ [MJkg-1 °C-1],

ε = Ratio molecular weight of water vapour/dry air =0.622,

λ = Latent heat of vaporization, 2.45 [MJ kg-1].

E. Input and output of the controller

The controller has two inputs i.e. the required/desired soil moisture and calculated soil moisture from the evapotranspiration model. There is only one output of the controller, also called control input for the valve position. It builds the system configuration straightforwardly.

IV. RESULTS AND DISCUSSIONS

The above-mentioned requirement in mind behavior of the controller is simulated in SIMULINK-MATLAB software and the block diagram is shown in Fig. 4.

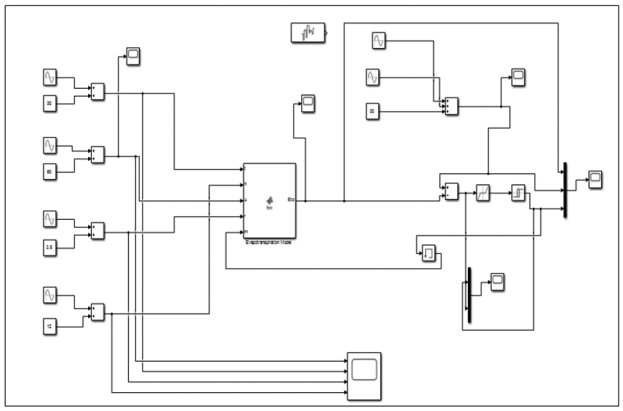


Fig. 4. ON-OFF based control system with Evapotranspiration model

At first, the ON-OFF controller is implemented along with the evapotranspiration model where reference (Required) Soil moisture is taken into account and simulated. It is found that the ON-OFF control-based system shows continuous oscillation at the output as shown in Fig. 5. This shows that the system is unstable and shows oscillating behavior. From input "Subsystem" to output "PID Controller", the output of step response before tuning is shown in Fig. 6. It is found that this ON-OFF control-based system is not stable.

For improving the control system and finding the stability of the control system, a PID control is applied using SIMULINK-MATLAB software as shown in Fig. 6. This helps in improving the real-time process parameters (such

as moisture, humidity, temperature, sunlight intensity, etc.) of the control system.

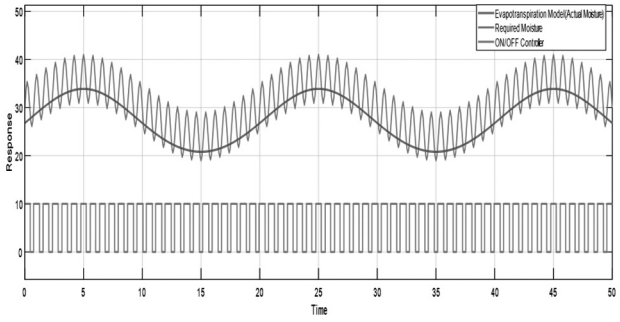


Fig. 5. Simulation results of ON-OFF control based system

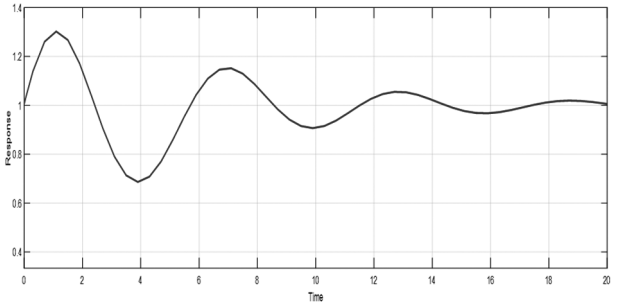


Fig. 6. The output of step response before tuning of PID control system

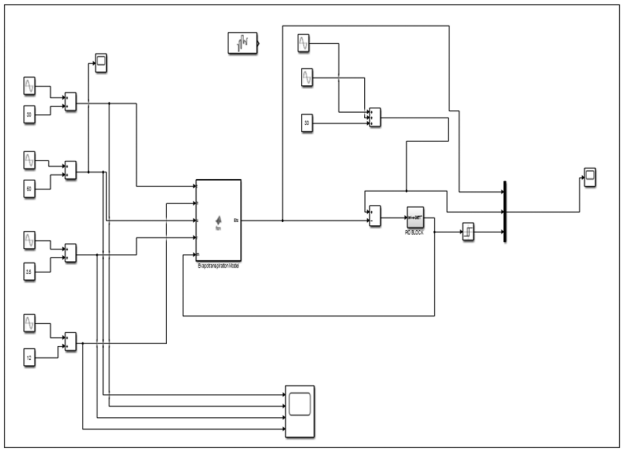


Fig. 7. PID based control system with Evapotranspiration model

By applying a PID control system, the closed-loop irrigation control improves crop yields condition and it also helps in effective resource utilization. By controlling the irrigation system, the changes in soil moisture meet the requirement of water for crop yielding. After applying a PID control system, the system reacts in a faster manner which provides precise manner change in environmental conditions like under-watering, rainfall, plant stress, and windup conditions. For obtaining PID gain parameters, the transfer function of the system is given below:

$$F(s) = \frac{-2s^2 - 2s - 1}{s^2 + s} \quad (5)$$

This shows that systems have two degrees of freedom and the system has oscillating behavior. During applying the PID tuner in the SIMULINK model, the value of kp, ki, and kd are given in Table 1. The obtained performance parameters of the PID control system are shown in Table 2.

Table 1. k_p, k, k_d values in PID Tuner

k_p	k_d	k_i	N
0.4755	0.4867	0.2722	1.7464

$$\frac{u(s)}{e(s)} = k_p + \frac{k_i}{s} + k_d\left[\frac{Ns}{s+N}\right] \quad (6)$$

k_p is the proportional gain, k_i is the integral gain, k_d is the derivative gain, and N is the filter coefficient respectively. After applying PID gain parameters, system response and Root Locus plot are shown in Fig. 8 and 9. These show the system is stable and the poles are negative and the Left side. The simulation results are shown in Fig. 10.

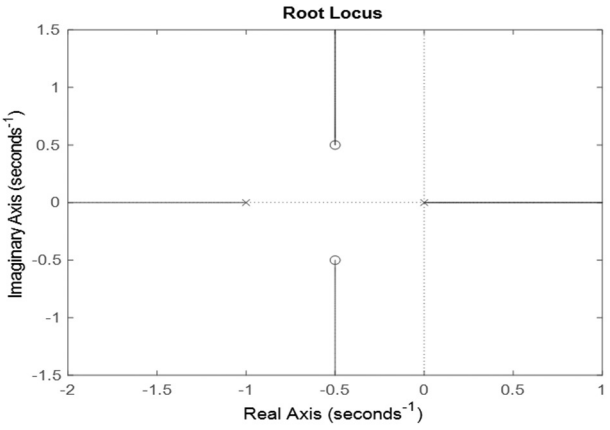
Table 2. Obtained performance parameters of PID control system

Controller Parameters

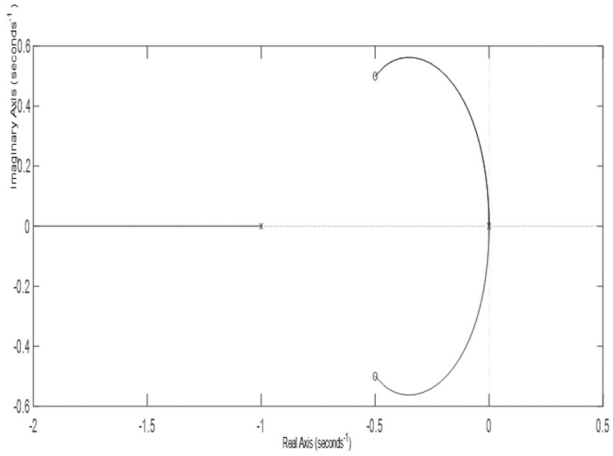
	Tuned	Block
P	-0.47141	-0.47556
I	-0.5052	-0.48672
D	0.25777	0.2723
N	1.8288	1.7465

Performance and Robustness

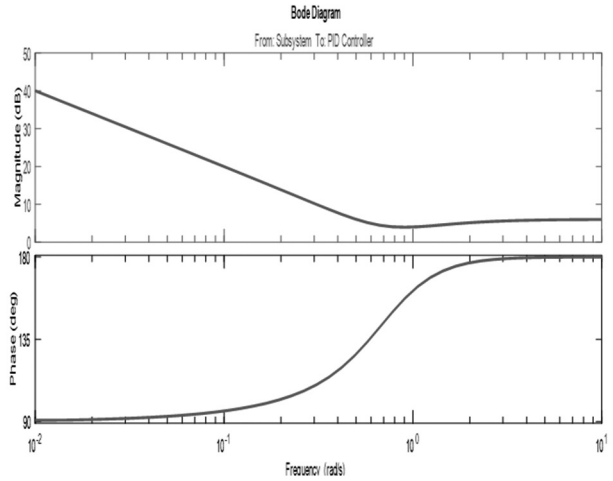
	Tuned	Block
Rise time	1.46 seconds	1.48 seconds
Settling time	12.3 seconds	12.4 seconds
Overshoot	14.7 %	14.8 %
Peak	1.15	1.15
Gain margin	-Inf dB @ 0 rad/s	-Inf dB @ 0 rad/s
Phase margin	111 deg @ 1.83 rad/s	110 deg @ 1.75 rad/s
Closed-loop stability	Stable	Stable



(a) Root Locus before tuning



(b) Root Locus after tuning



(c) Bode plot of PID controller

Fig. 9. Root locus and Bode plot of ON-OFF control based system

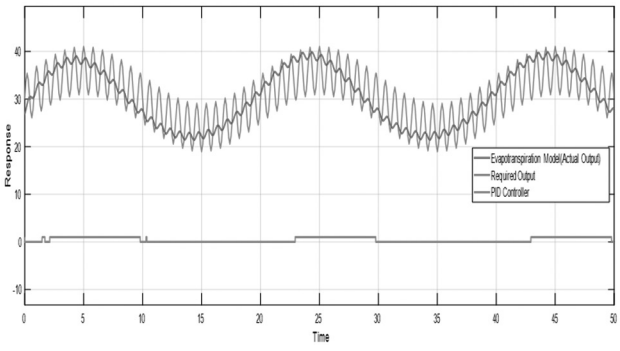


Fig. 10. Simulation results of PID based control system

Further, ANN method is applied in the control system for finding effective irrigation scheduling. This is modeled on the brain where neurons are connected in complex patterns to get the processed data by sensing through sensors and training the data and store in memories. This is a system based on the operation of biological neural networks or it is also defined as an emulation of a biological neural system.

During the implementation of the ANN Controller, the following parameters are considered in the design of control architecture in the SIMULINK model.

- Topology type: Distributed Time Delay Neural Network
- Name of training function: Bayesian Regulation function.
- Performance: Sum squared error is taken as a performance measure.
- Goal value: 0.0001.
- Learning rate: 0.05.

The SIMULINK model is shown in Fig. 11. During the training of the neural network model, the direct cascade controller along with the Evapotranspiration model is applied. The controller target is to achieve the actual soil moisture to the required soil moisture so that the resources like water and energy can be optimized. During analysis, the control valve is considered as an open condition and the required soil moisture limits go beyond the measured soil moisture and the control value should be considered a closed condition. The performance of the actual soil moisture shows without any oscillations as shown in Fig. 12.

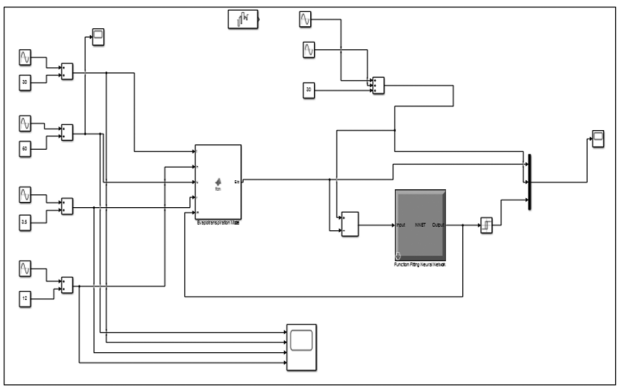


Fig. 11. Simulink Model of ANN Controller

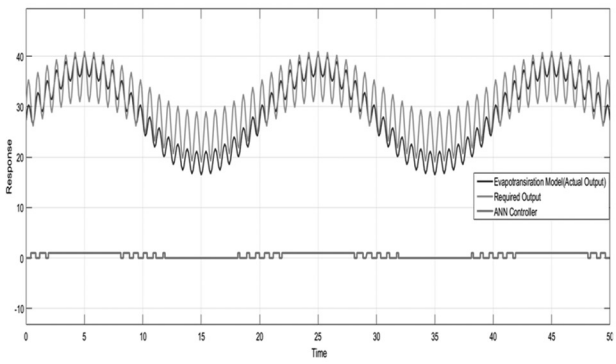


Fig. 12. The output of the Simulink Model of the ANN Controller

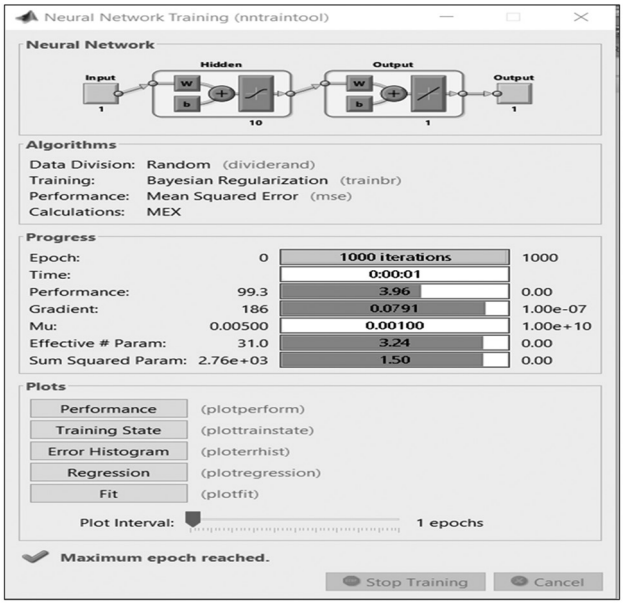


Fig. 13. Training the ANN Model

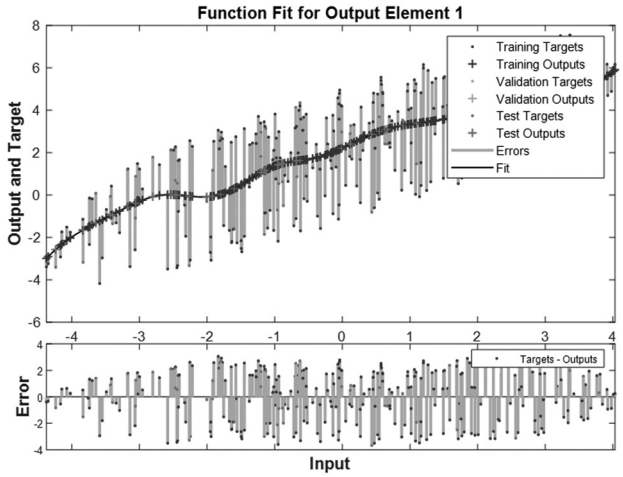


Fig. 14. Variations of the input-output model

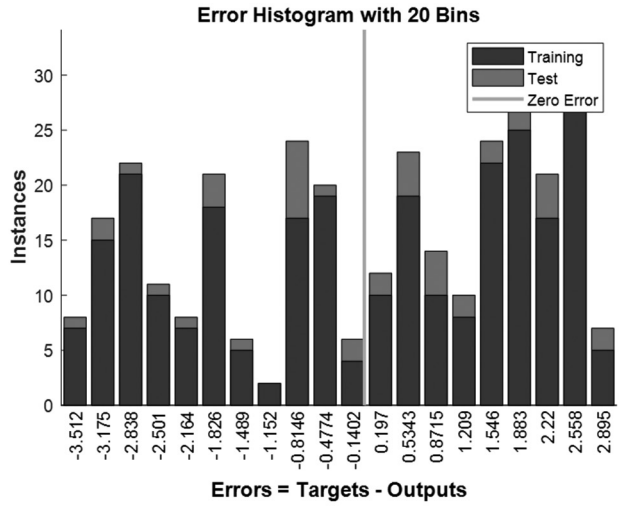


Fig. 15. Error histogram with 20 bins

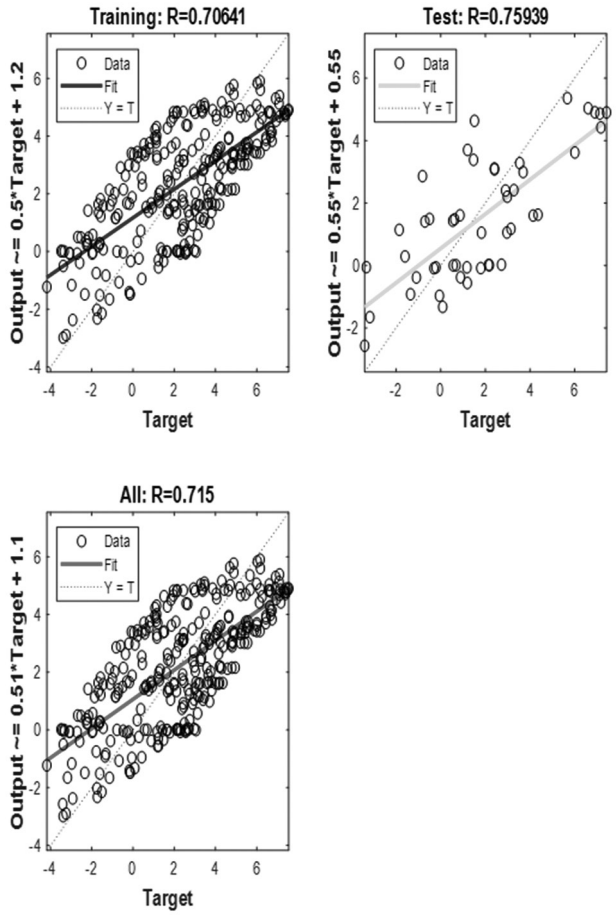


Fig. 16. Trained and tested output data of ANN model

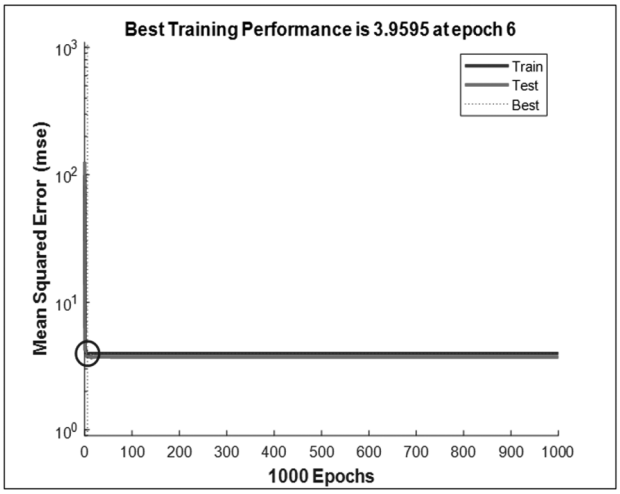


Fig. 17. Best training performance in terms of mean square error

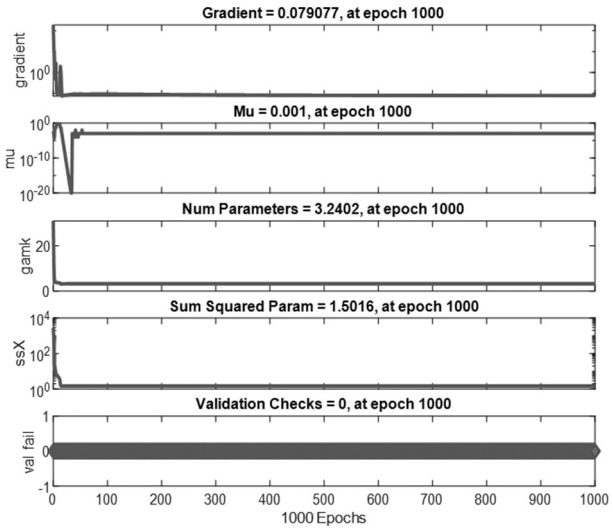


Fig. 18. Best performance of ANN controller

The following observations are envisaged as given in Table 3.

Table 3. Training and testing data

	SAMPLES	MSE	R
TRAINING	221	3.95948e-0	7.00783-1
TESTING	48	3.73856e-0	7.56047e-1

From Fig. 13 to Fig. 18, it is observed that:

1. The regression value of the model tested is 0.75 thus the model is 75 percent accurate in terms of predicting the optimal output.
2. The ANN controller controls the valve effectively where a low energy system is required for operating the system. Therefore, both energy and water can be saved in the environment.

Hence, by applying ANN controller, a cost-effective and result-oriented irrigation control system has been achieved which can be directly implemented for practical implementation.

V. CONCLUSION

In this paper, the control of drip irrigation systems is discussed by applying different types of control systems such as ON-OFF, PID, and ANN. The proposed ANN control method is also compared with PID and ON-OFF controller. It is found that the ON-OFF controller-based system fails suddenly due to its limitations where the PID controller is provided a solution for a stable control system by tuning the control gain parameters. The ANN-based approach has provided the trained data for drip irrigation scheduling and the results show a better implementation and more efficient control method. This ANN controller does not need the aforementioned knowledge of the system and has the intrinsic ability to self-adjust the changing conditions. It is important to note that ANN-based systems can provide a better solution for saving a lot of resources like energy and water and can also provide optimized results for different types of agriculture cultivations. In the future, this controller will be implemented with hardware in crop cultivation.

ACKNOWLEDGEMENT

The authors are grateful to the Director, CSIR-CMERI, and Durgapur India for providing the permission to publish this paper. Miss Khushali Bilare, from MANIT, Bhopal (Summer Intern at CSIR-CMERI) has carried out this work under my supervision during her summer internship at CSIR-CMERI, Durgapur.

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NFC enabled Wi-Fi managging system for ESP32 based IoT system

Nikola Mitrović

Department of microelectronics,
Faculty of electronic engineering
Niš, Serbia
nikola.i.mitrovic@elfak.ni.ac.rs

Milan Đorđević

College of Applied Technical Sciences
Niš, Serbia
milan.nebojsa.djordjevic@gmail.com

Sandra Veljković

Department of microelectronics
Faculty of electronic engineering
Niš, Serbia
sandra.veljkovic@elfak.rs

Danijel Danković

Department of microelectronics
Faculty of electronic engineering
Niš, Serbia
danijel.dankovic@elfak.ni.ac.rs

Abstract— This paper presents system that manages Wi-Fi credentials for ESP32 based IoT system. Managing system is based on NFC technology. Paper offers a solution for the problem of frequent changing of Wi-Fi credentials when an IoT system is moved from place to place and needs to connect to different access points. NFC technology is chosen as a medium because it is widely accessible in modern smartphones, and also offers low-cost solutions. Data containing SSID name and password of access point that IoT system should establish connection to are written into NFC tag using smartphone. Using designed system, that data is transferred to ESP32. Speed and form of that data transfer is analyzed. In systems where speed is not of dominant interest, described system can deliver appropriate results.

Keywords - Internet of Things, Wi-Fi, ESP32, NFC.

I. INTRODUCTION

Continuous growth of the Internet of Things field led to development of many devices that are able to perform many specific tasks using many different communication methods. Great versatility of IoT devices, beside many qualities, also constantly brings some new challenges [1, 2]. Depending on the special application of the device and the primary wireless communication method, different applications put pressure on different resources of devices. This paper concerns systems where the primary wireless communication method is through local accessible Wi-Fi access point. One of the specific problems that occurs in the later phases of Wi-Fi enabled products implementation is the method of acquiring Wi-Fi configuration data (SSID name and/or password) for local access point [2-4].

In the most cases, during the testing and debugging phase, Wi-Fi credentials are hardcoded into the code. Development of the device also includes testing of other properties of the device, so most of testing engineers are focused on operation of the device. Still, most of the IoT devices that uses Wi-Fi as a primary wireless data transfer method are designed to have vast area of application, meaning, beside other, that it can be used in various places, using different access points. To fully exploit this capability, it is needed that designed devices have intuitive and straightforward method of inserting SSID name and password for the targeted access point. This problem is usually solved with adding of some input circuit that can enter these credentials. Most basic solution is to connect a small keyboard and a display so that all of the needed data can be entered. Still, this solution impact the size of the devices drastically and demands supply for many components. Solution is improved with adding of touch-screen displays. In that way, keyboard is not necessary anymore. Display is anyway part of almost all devices, so this improves the solution drastically. On the other hand, touch-screen displays demand a lot of memory resources by the driving MCU, robust libraries and are still not suitable for low-cost solutions. Therefore, it is needed to develop a method that is versatile to use, energy efficient and adapted to low-cost IoT solutions [3, 4].

II. METHODOLOGY

Basic use of the Wi-Fi managing system is to ensure that Wi-Fi credentials are dynamic and editable. Dynamic credentials are usually realized using dynamic buffer. During development phase, credentials for the main access point can be loaded to the buffer. If the main access point is accessible, after booting, device attempts to connect to the main access point. If it succeeds, it remains connected for the further operation. However, it is needed to accordingly handle cases when the connection is not successful. Sometimes, connection fail because of temporary spontaneous disruptions. In those cases, with multiple connection attempts, device finally connects and operate further, before it returns to sleep or low energy mode. There are cases when the mainly used access point is simply unavailable (in case of power shutdowns, constant obstacles or simple modem or router malfunctioning). Then, it is still needed to perform measurements and or actions, but instead of sending it, data is stored into the back up memory unit, most often a SD card [5, 6]. Even more often, it occurs that device used on one location using an access point should be mobile, and needed to use in different locations. On

every different location, device connects to a different access point. Therefore, it is needed to allow simple process of inserting credentials. Proposed solution focuses on this problem.

Most of the modern smartphones come with NFC (near field communication) module. NFC is a wireless short-range and high frequency communication technology that allows the exchange of data between devices [7]. It is is based on RFID principle. System consists of a tag and a reader. When a tag is put close enough into the reader field, data is transferred using load modulation. Comparison between RFID and NFC technologies are given in table I [8, 9].

TABLE I: COMPARISON OF RFID AND NFC TECHNOLOGIES

	RFID	NFC
Communication type:	Unidirectional	Bidirectional
Range:	< 1 m	< 0.1 m
Operating frequency:	LF – Microwave range	13.56 MHz
Set-up time:	< 0.2 s	< 0.2 s
Avg. consumption:	< 35 mA	< 15 mA
Tag data size:	< 1 kB	< 8 kB

Main difference between the most of commercial RFID systems and NFC systems is that using NFC, unlike RFID, data transfer can be done in both directions, both from a tag to a reader and from a reader to a tag. A lot of NFC tags come with enough memory to take enough data (commercial ranging from 512 B to even 8 kB), and are widely available as flexible tags, gluing tags or even wearable tags. In this paper, Wi-Fi credentials managing system is implemented using NFC data transfer. There were researches concerning using NFC for information transfer [9, 10]. It was concluded that this technology requires minimum human operation and that it offers a lot of possibilities for further implementation.

III. EXPERIMENT

In order to connect to the new Wi-Fi access point, data containing new Wi-Fi credentials is to be transferred to NFC tag. Tag is then put in front of the reader, where the data is read and transferred to the ESP32 device. Data is then parsed and two specific strings (SSID name and password) are extracted. ESP32 attempts to connect to the local Wi-Fi network using extracted data. Block schematic of the experiments is shown in the Fig. 1.

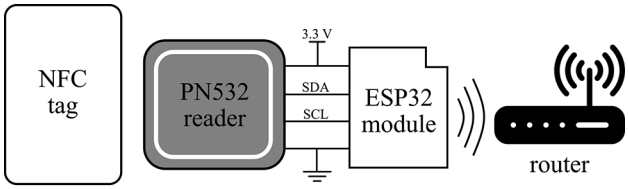

Fig. 1.Block schematic of the setup.

A. Used devices and tools

Tags used in these experiments are widely accessible Mifare Classic tags [11] with a memory size of 1 Kilobyte (kB) that use ISO 14443 standard. This type of tags contains Unique Identifier Number (UID) and is NFC Data Exchange Format (NDEF) enabled. UID for every tag is different, seven bytes long and cannot be changed. Tag being NDEF enabled means that it can receive NDEF messages. Writing data to a tag corresponds to sending appropriate NDEF message to the tag. NDEF content of the tag is formattable and rewriteable. In this paper, only NDEF method for data transfer is used.

For the transfer to be accomplished, it is needed to write data into NFC tag. In described experiments data containing Wi-Fi credentials is loaded into the tag via Android smartphone. Freeware third party application NFC Tools is used [12]. Using this application, it is possible to write different types of data to the tag (simple strings, active mobile phone number, Wi-Fi credentials, links, and other). Data is written with selecting specific options and putting tag close to the smartphone.

Data is read from the tag using NFC reader. For these experiments, PN532 reader is used [13]. It is a NFC reader with square embedded antenna that can read multiple types of the NFC tags (including Mifare Classic tags) in the 13.56 MHz range. It is based on 8051 MCU and can communicate with other devices using SPI, I2C or UART protocols. This reader is selected because it can read both UID number of tags and NDEF messages.

Main part of the setup is ESP32 board with WROOM2 chip, manufactured by the company Esspresif [14]. This device is selected because it contains Wi-Fi module and therefore can connect to Wi-Fi networks. The module support 802.11 b/g/n protocol in the standard Wi-Fi frequency range (2.4 GHz - 2.5 GHz). Besides Wi-Fi capabilities, chip contains peripheral units for many serial interfaces (I2C, SPI, UART), as well as RTC and Bluetooth modules. These properties make this chip suitable for many IoT applications using different methods [15, 16].

In these experiments, PN532 and ESP32 are connected over two lines, using I2C interface. After reading NDEF messages, raw data is sent from the PN532 to the ESP32. Data is then processed and the connection is attempted. Software for the data receiving, data parsing and Wi-Fi connecting is manually coded and flashed to ESP32.

B.Experiment setup and results

Experiments are divided into three rounds. In the first round, Wi-Fi credentials are written on the NFC tag using NFC Tools. Tag is then put in front of a reader in order to start data transmission. When that is done, an external timer is started. Wi-Fi credentials in the form of string data are transferred from the tag to the reader and then from the reader to ESP32 over I2C. ESP32 receives the string, parses the data and tries to connect to the access point with the given credentials. When the connection is successful, ex-

ternal timer is stopped. In this way, it is possible to measure time between the putting of a tag in front of the reader and the successful connection. Figure 2 shows the results from ten consecutive connection attempts.

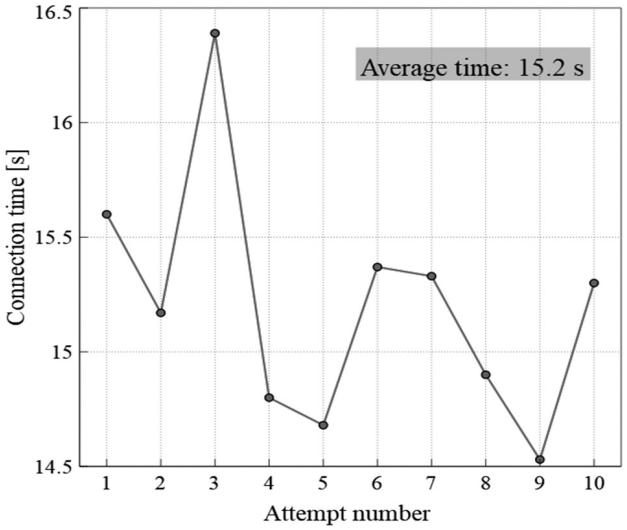

Fig. 2. Connection time for ten connection attempts with received credentials..

After every attempt, devices were reset, so that process can be started from the beginning. During all ten attempts, distance between the ESP32 and the router access point is kept constant. As can be seen from the Fig. 2, time between putting tag in front of a reader to establishing connection is ranging from 14.53 seconds to 16.39 seconds. Average time for connection is 15.2 seconds. These results are in line with the similar research [10]. It is worth mentioning that the length of the credentials was 20 characters in total (10 for SSID name and 10 for password). Still in order to further analyze needed time, it is necessary to divide measured time into time for NFC data transmission, time for data processing and time for Wi-Fi connecting. In order to tackle this complicated problem, second round of experiments has to be done.

When the Wi-Fi credentials are hardcoded, and no external components are connected to the ESP32, average connection time is 5.5 seconds. It means that the processes of tag reading, data sending and processing consume around 10 seconds. To investigate time needed for every of the mentioned actions, logic analyzer probes are connected to the SDA and SCL pins of the PN532 reader, with the goal to determine starting and ending point of the data transmission between the PN532 and ESP32. For this purpose, USB logic analyzer LHT00SU1 is used. Second round of ten connection attempts are made again. Table II shows the measured results.

TABLE II: PERIOD OF DATA TRANSFER STEPS

Attempt	Time [s]				
	Reading	Data sending	Data parsing	Connecting	Total
1	6.39	2.056	0.820	5.73	15.03
2	7.35	2.036	0.780	5.16	15.33
3	7.52	2.030	0.790	5.39	15.73
4	6.91	2.052	0.780	5.47	15.68
5	7.08	2.039	0.780	5.70	15.60
6	6.65	2.041	0.780	5.35	14.83
7	7.57	2.055	0.830	5.72	16.17
8	6.96	2.039	0.800	5.49	15.29
9	8.03	2.047	0.790	5.44	16.31
10	6.72	2.050	0.780	5.12	14.67

As can be seen, longest process is reading of the data from the tag by the PN532 reader, ranging from 6.39 s to 8.03 s. Time for data transmission is guided by the used I2C protocol, so no noticeable difference between these times is expected. Same can be said for the time used by ESP32 for parsing the data. Also, as expected, after the Wi-Fi credentials are extracted, around 5.5 seconds is needed to establish Wi-Fi connection. Different times for reading data from the tag can be explained by the fact that the tag was not always put in the exact same position in front of the reader. Tag was always put in the reading range, but slight time deviations are caused with this difference.

Third round of experiments has the same setup as the previous ones. In this round, for every connection attempt, settings of the router (SSID name and password) are changed. In every change, length of these data is increased, starting from 10 characters (5 for SSID name and 5 for password) to 30 characters (15 for SSID name and 15 for password). This means that after every attempt, NFC tag should be formatted and then rewritten with the new Wi-Fi credentials. Again, timer is started when tag is put in front of the reader, and stopped if and when the connection is successful. This approach is used in order to see whether the different size of Wi-Fi credentials impacts total connection time by critical amount. Measured results are given in the Fig. 3.

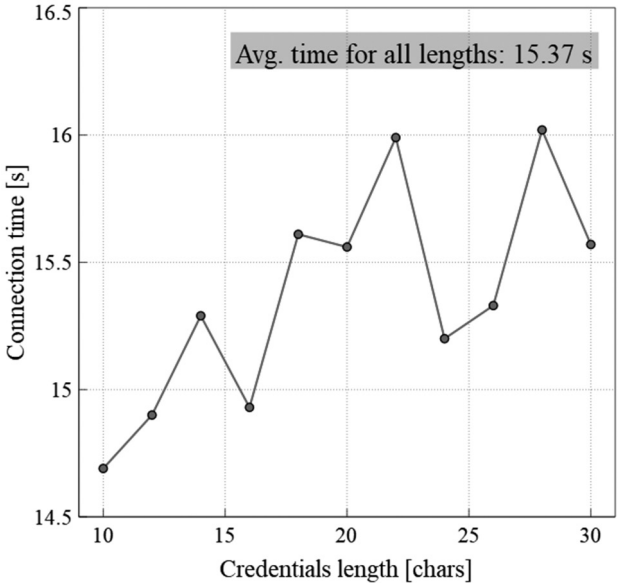

Fig. 3. Connection time for connection attempts with received credentials of different length.

As can be seen from the Fig. 3, different size of the credentials does not impact total connection time drastically. Main reason for this is in the principle of NDEF messages that used type of tag/reader uses to transfer data. Regardless of amount of data written to the tag, total memory of tag is always read by the PN532 reader. Content of total memory is being sent to the ESP32, and that is the reason why specific data parsing is needed. After credentials are extracted, ESP32 establishes Wi-Fi connection regardless of their length.

IV. FUTURE WORKS

One of the improvement points and the future steps of the proposed solution is to embed the tag into the PN532 reader, and to connect additional devices for proximity measuring to the reader. When the NFC writing smartphone is put in front of the tag embedded into the PN532, proximity circuit activates. It turns off the PN532 using additional circuitry, and enables NFC data transfer between the smartphone and the tag. When the writing into the tag is finished, and the smartphone is removed, proximity circuit deactivates and turns on the PN532 reader, that can now read data from the embedded tag. Using this improved solution, user of the system would not need to have a tag with the system.

Also, other improvement point lies in adding some small visual indicators (LEDs) or even small display that will inform the user about ongoing communication and active steps. Since plastic obstacles do not disrupt the NFC, and since the PN532 antenna is embedded into the PCB, it is possible to provide custom encapsulation of the proposed solution that can be adapted to the working environment. It is also worth mentioning that not only Wi-Fi credentials can be transferred using NFC. With the use of described tools, it is possible to send custom strings concerning many options in the generic IoT systems.

V. CONCLUSION

Simple Wi-Fi management solution for ESP32 based IoT systems that is based on NFC is presented in this paper. The problem of changing Wi-Fi credentials that ESP32 system tries to connect to, with the help of additional free tools can be solved using NFC tag data transfer. Connection does not establish instantly, it is needed averagely more than 15 seconds, but in the application where connection speed is not mandatory, proposed solution can provide reliable results. Described system does demand adding NFC reader to the IoT system, but it compensates with greater versatility and higher connectivity with other devices.

ACKNOWLEDGMENT

This work was supported by the Republic of Serbia under the Grant No. 451-03-9/2021-14/200102.

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Designing a data streaming infrastructure for a smart city crowdsensing platform

Aleksa Miletić

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
aleksa.miletic@elab.rs
0000-0001-8940-9897

Petar Lukovac

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
petar.lukovac@elab.rs
0000-0003-4561-8886

Branislav Jovanić

Intitute of Physics
University of Belgrade
Belgrade, Serbia
brana@elab.rs
0000-0003-4130-1638

Božidar Radenković

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
boza@elab.rs
0000-0003-2111-7788

Abstract— This article considers the problem of designing data streaming infrastructures for crowdsensing systems. The goal is to propose an infrastructure that would provide a scalable and seamless collection of various data in smart city, such as noise, vibrations, air quality, citizens' health parameters, etc., streaming collected data into the cloud infrastructure, and preparing it for further analysis. The paper focuses on the aspects of modelling data streams, and the implementation using the Apache Kafka software. The prototype of the proposed system is implemented within the private cloud infrastructure of the Department of e-business, Faculty of Organizational Sciences.

Keywords - data streaming, crowdsensing, smart city, IoT

I. INTRODUCTION

Streaming data can be beneficial to any industry that deals with big data. It is used to integrate, process, filter, analyze and react to collected data as it is received in real-time. Today, it is used in many applications such as online-shopping, recommendations on streaming services, fraud detection etc.

Data stream refers to an ordered sequence of data, which is unbounded and continuously updated. It typically stands for a continuous transfer of a large quantity of small data, from a data producer to a data consumer. Data in data streams are processed sequentially and incrementally, one at a time or in small batches. Processed data streams are then used for further analysis, using various algorithms [1].

Data streams can be found in various business activities and domains, including banking, commerce, production, healthcare etc. A specific importance was put on data stremaing architectures with the development of Internet of things, since sensors typically generate numerous streams of data, which are then transfered to a cloud storage [9].

Comparing to traditional batch processing, data streaming approaches provide data in near real time, allowing for real-time analytics and quicker insights. Using streams, data can be frequently updated, and the users can be notified about the changes of interest. Unlike the traditional request-response paradigm, it focuses on push notifications to users, without explicits users' requests.

The aim of this paper is to point out the problems that exist when designing data streams, to give certain guidelines on how to solve these problems, and to define system architecture for measuring noise, vibrations in traffic, allergens, and air quality in smart cities.

II. THEORETICAL BACKGROUND

Data stream is an abstraction representing an infinite and ever-growing dataset. The dataset is infinite and ever-growing because over time, new records keep arriving [4].

Event streams are arranged. The events have an order in which they are performed, but it is difficult to anticipate which event will perform next. On the example of crowdsensing system about the amount of allergens in the air, the easiest scenario is to show harmfulness of air in a certain part of the city, but there is possibility for the user to enter their chronic and seasonal diseases and to be notified if they are near, for them, harmful part of the city. The difference between event streams and database tables is that the database tables are considered unordered, and the „order by" clause is not part of the relational model, but had been added to make data easier to display [4].

Immutable data records. Once events are triggered, they can't be changed anymore. If the user updates their chronic and seasonal diseases, the old ones won't be deleted. The difference between database tables and event streams is that we can update or delete data in the database tables, but they are considered as an additional transactions. Instead, we can store transactions in a data stream [4].

Event streams are replayable. This is a good feature of event streams because there would be a problem if there

are events which occurred a few months earlier, or if we manage to change it, there would be no record that that event ever happened before [4].

The data that are sent through the stream are different from system to system. The size of events that are sent through stream can be very small and can be huge. Data that are sent can be key-value pairs, JSON structures etc. In Kafka there are topics which are used to organize messages and each topic has unique name. There are producers which send data to the topic, and then they are redirected to subscribed consumers. Producer is an application that represents the source of the data stream. Consumers are applications that consume records from Kafka cluster.

III. DATA STREAM MODELLING

Apache Kafka is a data streaming platform whose ability is to process several trillion requests in one day [6]. Today, Kafka is used for streaming data in real-time, storing a large amount of data, and analyzing the same data. The advantage of the Apache Kafka tool is the ability to store data on Kafka, which can actively monitor the transaction execution process. Unlike the MQTT or AMQ protocol, Apache Kafka allows users to receive messages that are important to them. In this case, a user will receive data only when he wants to list them.

Topics are like folders in a filesystem, and events are files in that folder. Kafka is a multi-producer and multi-subscriber, so it can receive data from zero or more producers and send it to zero or more consumers. Data from a topic can be read whenever there is a need for it. Also, the data is not deleted immediately after use, but a certain period is defined in which data is stored, and after that period it is removed. Kafka's performance is effectively constant with respect to data size, so storing data for a long time is perfectly fine [7].

The main question in topic design is: How do we decide on which topic to send the next event? If topics aren't designed in an appropriate way it can later bring us to redesign topics, that is creating a topic model from the beginning. Bellow will be described good practices for creating topics.

As mentioned, Kafka is a platform for streaming data, and one of the main things which need to be designed in Kafka are topics. Topics are an ordered collection of events that are stored in a durable way, which means they are written to disk and they are replicated. There are problems in topic design: whether different types of data should be put into one topic, whether a couple of topics can be merged if they are logically connected, how to protect sensitive data sent to a topic, etc. The answers to these and some similar questions will be given below.

According to Martin Grotzke and Daniel Orner, Kafka topics should be designed as follows [2][3]:Cases for which topics should be designed:

- Topics can be separated by domains and subdomains to which events relate. If two events are logically different then they should be put in different topics. When a topic is created, there should also be created object schema, and only objects which satisfy that schema could go through the topic. Each topic should represent one type to work with. Meaning is lost if there are mixed types in one topic.
- If there is a strong connection between two events, should consider whether they can go to the same topic. Also, if there is an exact order in which events should be called, then they should go in the same topic.
- If we withdraw some data, among which there is sensitive data of some user, that data should be separated from the others, and therefore a new topic should be created in which they would be placed.
- Frequently triggered events (e.g. a sensor that sends data multiple times per second) should be placed in special topics [2]. In most cases, you'll want to have exactly one producer and one or more consumers. If more services need to send the same kind of data, that's a clue that your service boundaries are not well-drawn, or that one service should be talking to the other one in some different way instead. This applies to event, entity, and response topics.
- In some cases, you should have the opposite: one or more producers and exactly one consumer. This applies to request topics, ensuring only one system processes each request. You can think of it as a funnel instead of a branch-out.
- Standardize topic names to make it simple when creating new ones. One possible format is {BoundedContext}.{Subdomain}. For example: Noise.NoiseCreatedEvent, Allergens.ParticleSize, AirQuality.Temperature.

Maximal number of topics is infinite. Minimal number of topics should be near number of different things which are send from producer to consumer.

Table 1, relationship between few and a lot of topics[5]

Less topics	***More topics***
Consumer may have to filter messages	Consumers can read only topics they care about
Less processing overhead of managining masters and consumers	Slower restarts, other processing overheads
Less configuration to manage	More flexibility in configuration

Streaming is becoming more and more popular because it is not necessary to store a large amount of data, but it can be quickly analyzed and gain insight into the data. The most important thing is to determine the current data, whether it is 2 minutes, 1 day, or maybe a certain number of events (100). The time period we need is called windowing.

There are methods which define length of window [10]:

- Tumbling window - these are windows that have a clear duration and are constant. This means that after the completion of one, the next one continues.
- Sliding window - these are windows that are timed, but it is possible to overlap multiple windows.
- Session window - does not depend on the period, but on the activity of the event in a particular period. This means that certain windows have a shorter period if the time flow is longer.
- Events can be selected by occurrence time:
- Event-time represents the time of occurrence of the event.
- Processing-time represents the time when the event was processed by the system

There must be a certain period of time that would indicate that certain data is current and that is useful for the system. If a certain event is delayed when arriving in the system by more than the defined value, it will not be included in the set of events for processing. This time period is called the watermark [10].

IV. DATA STREMING INFRASTRUCTURE FOR THE SMART CITY CROWDSENSING SYSTEM

The goal of the system proposed in this paper is to provide an adequate data streaming infrastructure that would serve for crowdsensing data in the smart city (Figure 1). The proposed system can support a large number of IoT subsystems as producers, as well as a large number of various consumer applications. Within this paper, only a few examples of IoT subsystems are presented: measuring noise, measuring vibrations, measuring air quality, and measuring allergens.

Within the proposed system, measurements are done using crowdsensing, where a large number of participants collect and provide data. Collected data is sent to the cloud, and accepted using an ingress service. Collected data streams are then transferred to the back end of the system, where they are being transformed and prepared for further analysis. Processed and analyzed data are delivered to consumers through various delivery models (pull, push) and through various applications. Client applications are connected to the system through API of access services.

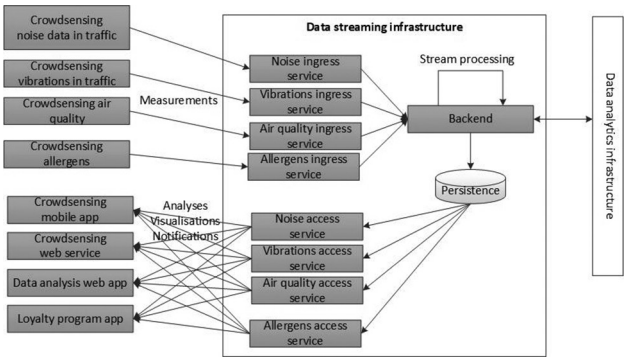

Figure 1 – The overview of the proposed system

The main components of the proposed system are [8]:

- IoT devices are used for collecting data from sensors. If needed and possible, data measured from each sensor is processed and transformed at the edge device, and then sent to the cloud.
- Mobile applications for crowdsensing are used to collect measurements using participants' mobile devices. They provide collecting data such as noise at micro-locations, vibrations in public transportation and traffic, etc.
- Data streaming infrastructure includes several components: 1) ingress services for every device with different measurements, i.e. a service that receives data from IoT systems and mobile applications; 2) stream processing cluster, which enables the transformation of data streams; 3) access services for every type of measurement which enables communication with consumers of the data, i.e. applications that use the data streams.
- Data analytics infrastructure provides services for real-time analytics. It enables the implementation of advanced analyses, machine learning techniques, or other predictive models.
- Consumer applications include various mobile, smart watch, or other applications that consume crowdsensed data in any form. They usually present data using adequate visualizations and enable notifications.

V. IMPLEMENTATION DETAILS

Table 2 represents Kafka topics used for implementing the proposed system. Within each topic, data is streamed in a form of key-value pairs.

Table 2. Specification of topics within the proposed system

Topic	***Description***
raw_noise_ measurements	The topic for accepting traffic measurement data. The following data will be stored: devices that measure noise volume (sensors - name and type of sensor and mobile phone - mac address) - latitude and longitude, user from whose device noise is measured - username, name, surname, measured frequency - volume frequencies, municipality - the name of the municipality
raw_noise_ measurements _anonymized	Anonymous data when measuring traffic noise
average_noise_ time_location	Calculations of averages for a location at selected time periods; a topic is created for each combination of predefined time slots (daily, hourly) and selected locations of interest.
max_noise_ time_location	Maximal measured values for selected time periods at a location.

raw_vibration_measurements	The topic for accepting data from traffic vibration measurements. The following data will be stored: devices that measure vibrations (sensors - name and type of sensor and mobile phone - mac address) - latitude and longitude, a user from whose device the vibration is measured - username, name, surname, measured frequency - frequency, municipality - the name of the municipality
raw_vibration_measurements_anonymized	Anonymous data when measuring vibrations in traffic.
average_vibration_time_location	Calculations of averages for a location at selected time periods; a topic is created for each combination of predefined time slots (daily, hourly) and selected locations of interest.
max_vibration_time_location	Maximal measured values for selected time periods at a location.
raw_airQuality_measurements	The topic for accepting air quality measurements. The following data will be stored: devices that measure air quality (sensors - name and type sensor) - latitude and longitude, air quality measured for a short period of time, municipality - the name of the municipality
raw_airQuality_measurements_anonymized	Anonymous data when measuring air quality.
average_airQuality_time_location	Calculations of averages for a location at selected time periods; a topic is created for each combination of predefined time slots (daily, hourly) and selected locations of interest.
max_airQuality_time_location	Maximal measured values for selected time periods at a location.
raw_allergens_measurements	The topic for accepting allergen measurements. The following data will be kept: place where measured - name, address, latitude and longitude, weather forecast for that place - temperature, humidity, rain level, and cloud level, wind type - name, direction, and strength of wind blowing, device for measuring allergens - name, type of particle measured by the device - name, a measurement performed by the device - measured value.
raw_allergens_measurements_anonymized	Anonymous allergen measurement data.
average_allergens_time_location	Calculations of averages for a location at selected time periods; a topic is created for each combination of predefined time slots (daily, hourly) and selected locations of interest.
max_allergens_time_location	Maximal measured values for selected time periods at a location.

VI. CONCLUSION

In this paper, the focus is on defining the architecture when creating Kafka topics. The article indicates the most common mistakes and the most common problems that developers encounter when creating Kafka topics and is pointed out how to prevent these problems. It also explains what data streaming is and the focus is on Apache Kafka which is one of the most used tools for data streaming, as well as the key concepts of Apache Kafka: consumer, producer, watermarking, and windowing.

The plan of future development is the development of an IoT crowdsensing system based on data streaming architecture, using Apache Kafka, and based on the model presented in this paper. Sensor data will also be collected and sent via the MQTT protocol to Apache Kafka, where it will be processed and displayed to users in mobile applications.

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Digital twin as a driver of digitalization of organizations' activities and creation of digital models

Mikhail Kolbanev

Information Systems and Technologies
St. Petersburg State University of Economics,
St. Petersburg, Russia
mokolbanev@mail.ru
https://orcid.org/0000-0003-4825-6972

Tatyana Astakhova

Information Systems and Technologies
Nizhny Novgorod State Engineering and Economic University
Knyaginino, Russia
ctn_af@mail.ru
https://orcid.org/0000-0002-7032-0697

Anna Krasnova

Information Systems and Technologies
Nizhny Novgorod State Engineering and Economic University
Knyaginino, Russia
shochina96@mail.ru
https://orcid.org/0000-0001-8796-3667

Anna Romanova

Information Systems and Technologies
Nizhny Novgorod State Engineering and Economic University
Knyaginino, Russia
anya-romanova-07@yandex.ru
https://orcid.org/0000-0002-8940-8111

Abstract— This article discusses the positive and negative aspects of the transition of organizations to digital activity, as well as the problems encountered on the way of organizations in digital activity transformation and the use of digital twins. The main national programs of the Russian Federation for the development of new breakthrough technologies are described. A simulation model of the operation of a multiple access system with synchronous-time access to the on-air data transmission medium is presented. It is used to justify the correctness operation of metamathematical model, which was designed using the AnyLogic software product.

Keywords - simulation model, mathematical model, digital twins, digital transformation, breakthrough technologies, digitalization of activity

I. INTRODUCTION

From 2000 to the beginning of 2010, the potential for productivity growth in most developed countries in the conditions of economic and technological mode began to run out, thereby leading to significant decrease in productivity, sharp drop in return on investment due to traditional technologies reaching their "ceiling" of productivity, which could not be solved only with the help of public policy on the application of macroeconomic measures. Under these conditions, countries began moving to new models of management.

Humanity is entering a new era, the era of intelligent technologies. Everything that surrounds us is rapidly changing and evolving. We are entering an age where intelligent systems are able to perform the functions of optimization, decision making, automatic analysis and many other functions while interacting with the real world in real time [1]. We call all these large-scale changes taking place in the industrial and economic sphere the “Industrial revolution”, or “Industry 4.0”, which is based on the transition from mass production of standardized products to flexible high-performance one that produces individualized products.

Recently, there has been a transformation of activity models in various fields, caused by new "breakthrough" digital technologies, which should ensure the international competitiveness of both the entire country and individual companies that form the infrastructure for digitalization. One of the main impulses is the exponential growth in the diversity, quantity and quality of information, as well as the relationship between various areas of life.

Industry 4.0 involves the creation of cyber-physical systems, through which real objects are connected to information processes or virtual objects through information networks and the Internet. This revolution includes a number of breakthrough technologies that contribute to the revival of the venture capital segment, as well as intensive efforts in the field of these breakthrough technologies. In Russia, on June 4, 2019, the national program "Digital Economy" was adopted during the meeting of the Presidium of the Presidential Councel. This program includes the following main general purpose technologies:

- big data;
- neurotechnologies and artificial intelligence;
- distributed ledger systems;
- quantum technologies;
- new production technologies;
- industrial Internet;
- components of robotics and sensorics;
- wireless communication technologies;
- technologies of virtual and augmented reality.

II. ANALYSIS OF TRANSITION TO DIGITAL ECONOMY

The explosive development and spread of new technologies, their penetration into all spheres of human activity has already begun to lead to rapid and profound changes in global market, structure and nature of modern industrial production, economy and social sphere.

In the "Strategy for the Development of the Information Society in the Russian Federation for the period 2017 - 2030" definition is given: "digital economy is an activity in which the key factors of production are data presented in digital form, and their processing and use in large volumes (including directly at the time of their formation) allows to significantly increase efficiency, quality and productivity in various types of production, technologies, equipment, storage, sale, delivery and consumption of goods and services" [2].

Transition to digital economy requires significant transformation almost all areas where business interacts with people, society and government: technology, organizational structure, staff competencies, supplier relationships, business models, target markets, product and service portfolios, mechanisms of labor remuneration, intellectual property rights, legal contracts, taxation, accounting, customer relations and others [3]. It is important to note that any changes lead to both positive and negative consequences (Table 1).

Table 1. Positive and negative results of transition to digital economy

Positive issues	***Negative issues***
– production of new products and services, – opportunities for geographical and functional expansion of trade, – increase in labor productivity, – improving the efficiency of all industries, – improving the quality of products, – increased competition.	– possibility of mass unemployment, – risk of reducing the income of total population, – fundamental change in many foundations, – disappearance of entire sectors of economy, – disappearance of many specialties, – new security issues.

In order to see all fundamental technological tasks that need to be solved when building new models of activity in digital economy it is advisable to apply an architectural approach. The architecture of digital economy in the form of stratified hierarchical model, which contains two groups of levels (infrastructural and subject-oriented) is presented on Figure 1 [4].

New solutions are emerging at the intersection of several digital technologies. A prime example is the concept of digital twins, which combines technologies of computer-aided design, modeling of physical processes, cloud computing, the Internet of things, artificial intelligence, machine learning and increases the range of digital technologies used as they become available.

A cyber-physical system is the interaction between digital twins and physical object, which is a complex system of computational and physical elements that constantly receives data from the environment and uses these data for further optimization. The “core” of the system in the form of AI (artificial intelligence) and other technologies receives data from sensors in the real world, analyzes these data and uses them to further control physical elements. Due to this interaction, the cyber-physical system is able to work effectively in changing conditions in real time.

The concept of creating digital twins can be traced from the creation of physical products to virtual models of twins. Having gone through certain stages, from writing a plan on paper to creating models on a computer, you can see that at each new stage, new digital technologies and methods of modeling, forecasting, analysis, and training were added to the concept.

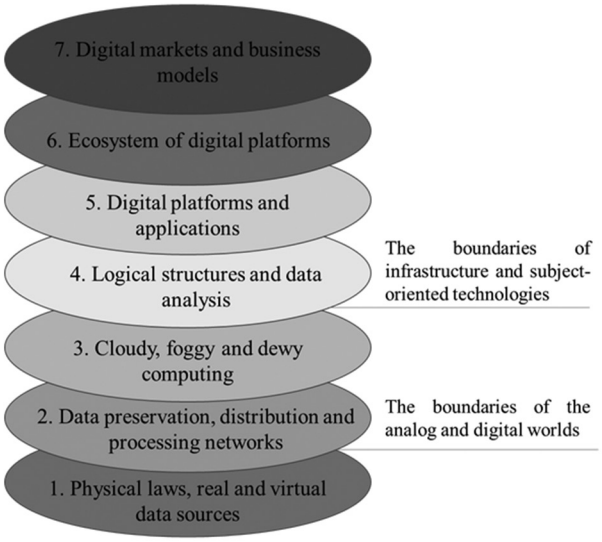

Fig.1. Architectural model of digital economy

A digital twin, according to classical definition, is a digital copy of living or artificial physical object [5]. The term digital twin refers to digital copy of potential and real physical assets (physical twin), processes, people, places, systems and devices that can be used for various purposes. Digital twins are designed to facilitate the means of controlling, understanding and optimizing the functions of all physical assets, ensuring smooth data transfer between physical and virtual world [6].

The definitions of digital twin vary due to the scope of its application. In relation to production processes, digital twin is a digital model of some physical entities created in cyberspace that interact in real time. In relation to this model, physical entity is original.

III. DIGITAL TWINS IN OPTIMIZATION OF MANUFACTURING PROCESSES

Manufacturing processes are becoming more and more digital; this trend has high speed and huge opportunities. Digital twins in enterprises work as following: data collection and cleaning, then data enrichment, and at the last stage, unique knowledge about process or object is obtained.

It is also worth noting that with the digitalization of production new business models will be built in any case. So digital twin is the best solution for demonstrating how this or that development will work. Digital twin is not only a visualization of physical object, but also insertion of all physical models in it, which will accurately describe its behavior. Some experiments can be carried out while creating such complex model; this mechanism of testing will not lead to high costs. After designing twins, it is necessary to verify all its models. The use of digital twins is aimed at reducing the time spent on developing new technologies.

Nowadays the digitalization of industry is no longer a fashion trend, but a necessary condition for maintaining competitiveness both in domestic and global markets. The development and implementation of advanced technologies requires large financial investments from organizations, which slows down the process of transition to "digital world".

In our opinion, this process (the process of using digital twins in organizations) is hindered by the following factors:

1. Lack of highly qualified personnel.
2. The absence of unified methods for verifying digital models.
3. Lack of payback of this technology in the shortest possible time.
4. Large financial investments in the concept of digital twins.

In 2021 research and consulting company Gartner in its report updated the maturity curve of emerging technologies, one of which is the digital twin (Figure 2). According to the result of research, it can be concluded that we need more than 10 years to increase labor productivity with the help of digital twin technology.

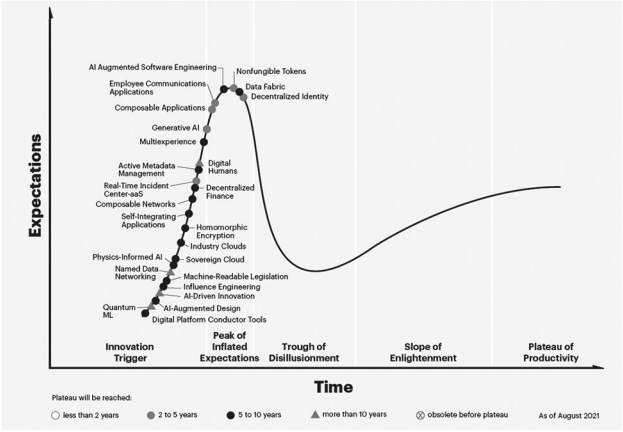

Fig.2. Hype Cycle for Emerging Technologies, 2021 [7]

Specialists of the Center "New Production Technologies" of Peter the Great St. Petersburg Polytechnic University (SPbPU) together with the specialists of Russian Federal Nuclear Center - All-Russian Research Institute of Experimental Physics (VNIIEF) in accordance with the "Program of National standardization for 2020" and the "National Standardization Program for 2021" developed the national standard GOST R 57700.37-2021 "Computer models and simulation. Digital twins of products. General Provisions" [8].

Within the framework of developed standard, for the first time such definitions as “model adequacy”, “product model validation”, “digital product model”, “digital (virtual) tests”, “digital (virtual) test bench” and “digital (virtual) testing polygon” are given.

The digital twin of product is based on digital model of product, which in turn is “a system of mathematical and computer models, as well as electronic documents of product that describes the structure, functionality and behavior of newly developed or operated product at various stages of life cycle, for which, based on the results digital and (or) other tests in accordance with GOST 16504, an assessment of compliance with the requirements for the product was completed ... ".

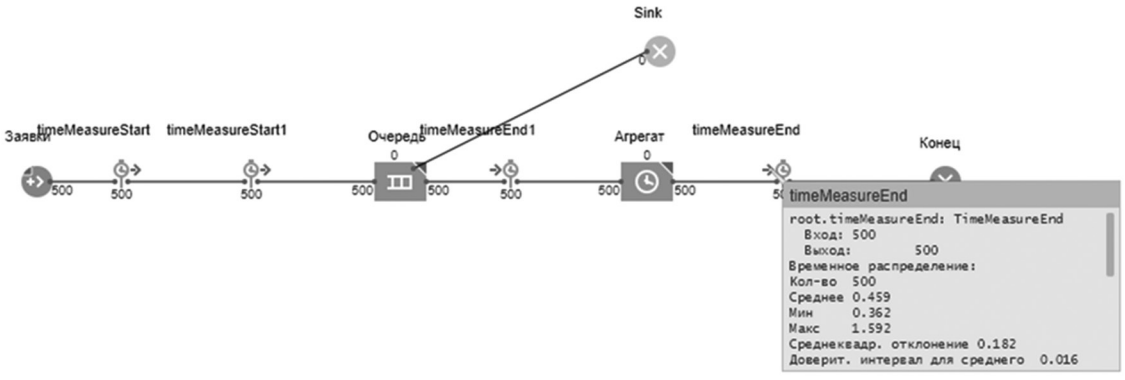

Fig.3. Simulation model

IV. BUILDING A SIMULATION MODEL

Verification of models with data from the real world implies the automatic supply of mathematical and simulation models of digital twin with structured up-to-date initial data from basic information components that describe the system in various aspects and are filled from related software systems in real time as they arise.

On the basis of WSN (wireless sensor network), the interaction of IoT smart things (which is one of the technologies of digital twins) is implemented [9,10]. The life time (or working time) of WSN 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 energy indicators of information interaction of smart things is considered as a necessary task.

When developing a simulation model, a multiple access system with synchronous-time access to on-air transmission medium was taken. It can be represented by the M/D/1 queuing system.

In the course of analytical solution, formulas were obtained and probabilistic-temporal and probabilistic-energy characteristics were calculated [11]. So the simulation model will determine which parameters affect the simulated system and how these parameters are related to each other.

To assess the quality of information interaction – random process of transmitting messages in WSN of the Internet of things – we use given mathematical model [11].

Based on it, we will write the final formulas for calculating the BTC (probabilistic-temporal characteristics) of the process of transmitting messages to WSN:

$$\bar{t} = \frac{N \cdot T_{ок}\,(\lambda \cdot N \cdot T_{ок}\text{-}2)}{2(\lambda \cdot N \cdot T_{ок}\text{-}1)} \quad (1)$$

where, N is the number of smart things, T_{ok} is the time interval reserved for each station, λ is the intensity of the message receipt for transmission.

To substantiate the correctness of metamathematical model, a simulation model was designed using the AnyLogic software product. This simulation development environment is one of the few programs that support multimethod simulation, which gives great opportunities in creation and implementation of digital twins.

The simulation model is shown in Figure 3. It includes several related modules: Request - the flow of request arriving in the system, Queue - the queue of application awaiting the receipt of application in the system, Server - a device processing the flow of requests, End - the end point of requests. To measure indicators in the model, timeMeasureStart (the beginning of the measurement period) and timeMeasureEnd were added (the end of the measurement period). If the request does not wait for receipt, then the queue can discard it in Sink (end).

The simulation was carried out with the following initial data λ=1 [s], $N \cdot T_{ok}$=0,362[s], N=15000, T_{ok}=0,000024[s].

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 requests in the queue, the average time the request was in the queue, the number of requests left the system and the average time of requests in the system in general.

V. CONCLUSION

Conducted research made it possible to determine a number of positive and negative issues that organizations face when transforming activities. The analysis of digital twins' impact on the optimization of manufacturing processes was carried out.

This paper presents a program that will allow you to design a simulation model of M/D/1 type for queuing systems. In this model the features of multiple access with synchronous-time access to broadcast medium (used for transmitting messages by smart things) were taken into account. These features have a common distribution and there is only 1 service device for them. As a result of the work, the program provides probabilistic-temporal characteristics for analysis according to M/D/1 model, such as: the number of requests in the queue, the average time the request was in the queue, the number of requests left the system and the average time of request in the system in general.

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Monetization and pricing of the 5G-enabled smart residential services

Mirjana Stojanović

Faculty of Organizational Sciences
University of Belgrade
Belgrade, Serbia
stojanovic.p.mirjana@gmail.com
0000-0002-3869-3899

Abstract— Fifth generation of mobile networks (5G) brings superior performances and promises to enable numerous innovations. To capitalize on its potential, the operators worldwide explore the best strategies on how to monetize the 5G capabilities, leveraging on new partnerships and entering into new ecosystems. This paper narrows the monetization question to the segment of residential users and addresses the use of 5G network slicing capability and appropriate pricing strategies. It aims to illustrate monetization possibilities that operators have in the domain of smart residential services and to outline the requirements that such scenarios impose on operators' business support solutions.

Keywords - 5G, network slicing, monetization, pricing, smart residential services

I. INTRODUCTION

Operators around the world are launching the fifth generation of mobile networks (5G). The significant capital investment they have made in technology enabling this just increases the importance and urgency of finding new revenue streams. That is why their focus is shifting from technology to the opportunities of monetizing superior capabilities of new networks [1]. While connectivity remains the core of their offering, the growth in the saturated telco market can come only from innovation. Novelty is required in terms of services, but also in terms of business and monetization models. Operators are still formulating and evaluating their industry strategies, business models, and corresponding use cases [2], [3].

The revolutionary potential and improvements that the 5G can bring to different industries, and consequently the monetization prospects from the enterprise segment have been already identified. However, the new value proposition for the consumer market and corresponding monetization opportunities are still to be explored in detail [4], [5]. This paper aims to address the monetization possibilities in the case of 5G-enabled services intended for the residential customer segment. It is organized as follows. Chapter II provides an overview of the recent academic and industry papers and engagements relevant to this subject. Chapter III explores the new pricing and charging methods for residential subscribers, as a part of new business models enabled by 5G network technology. It also defines the requirements of operators' business support systems (BSS). Chapter IV discusses the proposed monetization and pricing models, their implications on the operator's business, and gives suggestions for future work.

II. MONETIZATION AND PRICING INNOVATIONS IN TELECOMMUNICATIONS NETWORKS

A. Related works

Over the years, the offerings of telecommunications operators have evolved from voice-centric to the provisioning of broadband data services. To differentiate themselves from the other players in the market, operators have been deciding to build their competitive advantage based on attractive pricing or based on service quality [6]. At the same time, both the telco industry and scholars have been exploring how the quality of service (QoS), expressed using measurable technical parameters or quality of experience (QoE), based on subjective user perception, can influence end-users willingness to pay for new telco services. Different pricing frameworks proposed in the literature, have taken into consideration the network operation mode, availability of network resources, and user's sensitivity and adaptability to service price change or service quality degradation [7].

The development of the Internet of Things (IoT) has opened up the possibilities for operators to step out of their traditional roles. Besides the network and communications, operators could select to offer devices, platform and data storage, and data management and data processing [8]. The taxonomy of the pricing models applicable to IoT communication and data collection as presented in [8] differentiate the following:

1. Economic concept based pricing models including:
   - Cost pricing
   - Consumer perceived value pricing
   - Supply and demand model
   - Smart data pricing
   - Option pricing
2. Optimization-based pricing models including:
   - Game theory and auction-based pricing

- Utility maximization
- Knapsack problem [8]

Finally, for the subject of this paper important aspect is the pricing of the smart services for individual or residential customers. In the bibliometric analysis conducted in [9] , the authors found out that despite a growing interest and a significant number of papers related to the various topics associated with smart services, relevant economic aspects such as pricing strategies are rarely considered in the literature [9].

B. Monetization possibilities in 5G networks and ecosystems

The transition from 4G to 5G is not a one-step jump, but rather, a multi-step evolution over many years. Each incremental step in this evolution enables enhancement of the existing use cases and/or introduction of new use cases. [10]. Consequently, in the case of 5G offerings that leverage enhancement of the existing network capabilities only, applicable pricing and monetization strategies are similar to the existing ones. For the improved offerings related to mobile data or IoT, operators adjust the legacy tariff schemes.

This has been confirmed in the first 5G offerings to the consumer market. Operators tried to attract users by applying different changes in the existing pricing strategies for mobile data, e.g. [11]:

- Increasing both the data volumes and/or data rates and corresponding prices of their plans (i.e. “more for more” strategy)
- Increasing the data volume and/or data rate on premium price plans, keeping its pricing constant to allow premium users to experience the benefits of 5G.
- Keeping the data volume in the plan constant, but reducing its price to incentivize the users to experience 5G [11]

These strategies have shown more or less success depending on the local market specificities. However, 5G is much more than increased data volume or speed. The real increase in operators’ revenue from the consumer segment is expected to come from the new content, applications, and services enabled by 5G, such as for example apps and services including AR/VR [11], [12]. In this context, the crucial feature of the 5G network, and one of the initial goals when it was designed, is a great level of adaptability to different requirements. Adaptability is achieved through the concept of network slicing [13]which allows the definition of a required logical network end to end. Network slicing enables the same physical network to efficiently embrace a plethora of services with very different service level requirements. The realization of this concept leverages the technological advancement in the areas of Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) that allow the implementation of flexible and scalable slices [13]on common network infrastructure. The concept of network slicing allows different communication needs to be addressed in an agile way and at the same time revolutionizes operators' business prospects. This is a complete change of paradigm: instead of considering mobile network capabilities for defining a commercial offer, network characteristics can be defined according to the requirements of the planned commercial offer [2].

To capitalize on network slicing business potential requires a reconsideration of the legacy business models and allied charging and settlement rules. Basic charging models related to network slices as identified by TM Forum [13] are the following:

3. *Resource-Based Model.* This model assumes charging based on resource deployment (e.g., core, radio, transport resources), irrespective of consumption. In the typical case for such a mode, the slice consumer controls the resources deployed for the slice as well as who can consume the slice [13].
4. *Consumption-Based Model (As-a-Service Model).* Charging based on resource consumption (e.g., duration during which slice was configured and active or a number of users/devices connected with slice). In this case, a network slice is offered as-a-service platform where multiple consumers (typically enterprise) join and consume the same slice [13] .
5. *Value/Performance-Based Model* charges the value that the slice is bringing to the slice consumer. Value is delivered through the commitment to the relevant Service Level Agreement (SLA) or as the slice contribution in the overall service offered to the end-user [13].
6. *Capability Based Model.* In this case, network slice management capabilities are offered to the enterprise customers to manage the slice themselves [13]

The final charging and billing scenario may be a combination of one or more models outlined above. Additionally, a service scenario could include one or more slices [13].

Furthermore, the 5G network allows everything to be connected, from people to things, which will generate huge volumes of data. Data monetization could unlock a significant revenue stream for the operators. The most advanced among them are currently exploring how can monetize their massive data asset based on blockchain technology. [2], [5]

Most of the foreseen 5G use cases will be enabled through the operator partnerships with the third parties. In the new ecosystems, they can offer a powerful wireless communication infrastructure empowering and enabling others to innovate, then share the revenue with them. Besides the connectivity, operators can expose to the partners and monetize the other assets and capabilities they have in their organization (e.g. IoT platform)[3], [5].

III. MONETIZATION OF NETWORK SLICING IN THE SMART RESIDENTIAL SERVICES

This paper focuses on the monetization possibilities related to 5G-enabled services which span different aspects of people's daily lives in their homes. These services are referred as smart living services or smart residential services. Examples of such services are residential community management (e.g. smart waste management, etc), monitoring of health parameters for the people with chronic diseases, robot assistance for the disabled or elderly people living alone, innovative retail and delivery services, or the advanced gaming and entertainment services (e.g. immersive experience of the different sports or art performances) [14]. The majority of these services also rely on the slicing concept [15].

Following the increasing needs of the urban population related to online education and entertainment, this paper further explores the scenario related to immersive learning services. It assumes that the offering to the residential segment can be expanded by introducing different extended reality (XR)-enabled training courses, which both kids and adults can attend from their homes. Depending on the training subject, the traditional learning content can be enriched by everything from virtual reality (VR) to mixed reality (MR), augmented reality (AR), and haptics. The main actors in such a scenario are the end-user, operator, devices provider, and learning content provider. Mian interactions between them, assuming that the operator is the key player in the ecosystem, are outlined in Fig 1 below.

The proposed scenario includes a Business to Consumer (B2C) interactions between the operator and the residential user and Business to Business (B2B) interactions between the operator, device provider, and learning content provider. On top of the base subscription, the operator sells to the end-user the immersive learning service, which is actually a bundle that includes learning content, corresponding 5G enabled devices (e.g. AR/VR glasses, smart gloves, headset, etc), and the appropriate connectivity for this type of service. To enable an immersive experience when learning for example how to play some instrument or how to get another hands-on skill, connectivity requirements are very strict (e.g. low latency), thus operator will implement it through a dedicated network slice. Referring to the network slice charging models [13] described in the previous chapter, the model proposed for this case would be a Value-based model, i.e. operator should build the end-user premium price considering the meaningful experience that such a service will bring to him/her. Further differentiation can be made by introducing some of the well-known concepts from mobile data pricing, i.e. to offer dynamic incentives to those end-users who are ready to accept to use the service only when the network resources are idle.

A. Impact on operator's charging and billing systems

The new generation of the mobile network forces an evolution in operators' charging and billing solutions. The 3GPP 5G Core updated architecture and standard define new charging requirements, where the most important include a 5G Charging Function (CHF). They also replace the previous diameter-based protocols with the new Service Based Interface (SBI) to implement the new REST-based 3GPP charging architecture. These major changes will affect not only the real-time (online) charging systems but also have an impact on back-office and offline processes such as CDR (Call Detail Record) handling, roaming reconciliation and charging, revenue assurance, and billing [3], [10].

Additionally, evolved charging and billing solutions should be capable to support new 5G specific parameters, such as Network Slice Selection ID (NSSID).[10], [16].

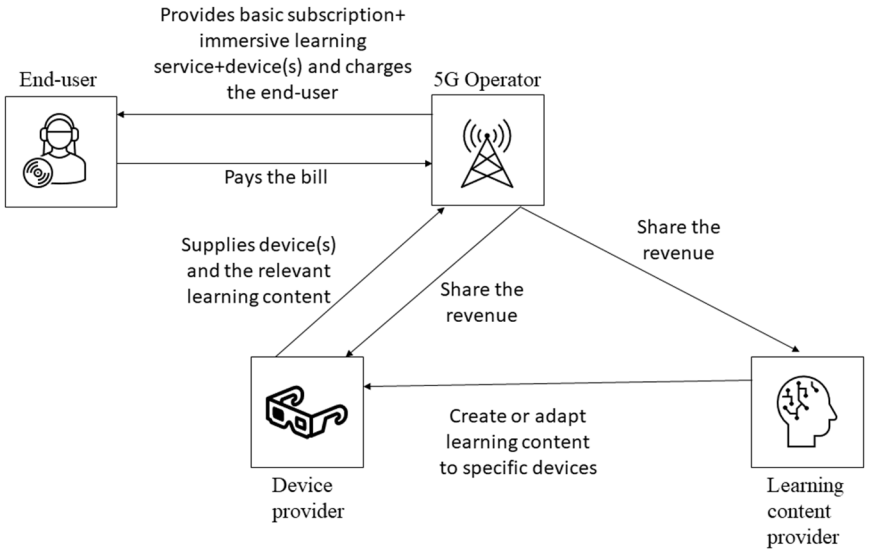

Fig. 1 Immersive learning scenario

For the immersive learning scenario outlined above, the operator's business support solutions (BSS) should be capable to charge the customer for the basic subscription plus the premium for the service-specific bundle including a dedicated slice. In the B2B part of the proposed scenario, the operator needs specific agreements with device provider(s) and learning content provider(s). For the topic of this paper, it is important to mention that the operator business support solutions should be capable to support revenue share with the partners mentioned above and based on the different parameters defined in the agreement.

IV. DISCUSSION AND IMPLICATIONS

Monetizing the opportunities that 5G enables in the residential consumer segment will require new and more dynamic ways of selling connectivity to the end-users. In most cases, this will require an operator to satisfy a combination of instant, personalized, and application or service-specific requirements for network performance.[13] Overall user experience will depend not only form the service delivery but also on the way the service is packed and priced [3]. 5G monetization models should be simple and understandable for the end-users and at the same time capable to support complex interactions with partners, which put new demands on operators' business support solutions [16].

This paper provides an overview of the possible scenario and thus can be sued as a starting point to define a detailed pricing strategy for a smart living service that uses network slicing capabilities. Lack of details, for example, the proposal of 5G specific parameters from the Event Data Record (EDR) that could be used for charging, presents the main limitation of this paper. This is planned to be specified in future work and taken into consideration within the analysis of the complete business model and detailed impact on the operators' BSS.

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Internet of Things and The Smart City Project Case Study – The Smart City of Tripoli – Libya

Asmaeil Ali Mohamed Akhmaaj

Faculty of Organizational Sciences
University of Belgrade
Belgrade, Serbia
asmaeil.Akhmaaj@gmail.com

Abstract— The recent increment of population in the urban areas requires well-operated and well managed cities with lots of automation in various aspects of everyday life. The backbone of this smart city is the Internet-of-Things (IoT) technology. Smart city concept has gained importance in urban development literature and there have been many initiatives and projects around the world implementing the smart city concepts.

The urgent need for development and expansion in the city of Tripoli requires us to shift to the smart city model, with its attendant challenges. As well as laying the basis for a new service to be added to the smart city project so that it can be used as much as possible

The city of Tripoli has gone through many political and economic eras, which affected the course of its development and created some obstacles. In this paper, we explained the smart city project for the city of Tripoli and what has been achieved from it so far with the design of a new service for the smart city of Tripoli.

Keywords - smart city, internet of thibgs, Tripoli

I. INTRODUCTION

Internet of Things refers to a type of network to connect anything to the Internet based on the stipulated protocols through information sensing equipment to conduct information exchange and communication in order to achieve intelligent identification, positioning, tracking, monitoring and management (Domenech, et al. 2019). The smart city refers to the city based on a correct technological basis, including regulation and coordination between government services and the development and coordination of its infrastructure in a way that provides the greatest level of welfare for citizens (Pereira, et al. 2018).

The Internet of Things (IOT) was coined by a member of the RFID development community in 1999, and it has only recently become more relevant in the real world, thanks to the growth of mobile devices, embedded and ubiquitous communication, cloud computing, and data analytics (Ovidiu, et al, 2013).

The Internet of Things (IOT) is a network of physical objects, according to the most common definition (Lytras, et al. 2020). The internet has evolved into a network of devices of all types and sizes, including vehicles, smart phones, home appliances, toys, cameras, medical instruments and industrial systems, animals, people, and buildings, all connected, all communicating and sharing information based on predetermined protocols in order to achieve smart reorganizations, positioning, tracing, safe and control, and even personal real-time online monitoring, upgrade, and proc (Ovidiu, et al, 2014).The researcher defines IOT into three categories as below:

Internet of things is an internet of three things:

1. People to people
2. People to machine / things
3. Things / machine to things / machine, Interacting through internet.

The Internet of Things (IoT) is a concept and a paradigm that considers the pervasive presence in the environment of a variety of things / objects that can interact with each other and cooperate with other things / objects via wireless and wired connections and unique addressing schemes to create new applications / services and achieve common goals. The research and development challenges to create a smart world are enormous in this context. A world in which the real, digital, and virtual collide to create smart environments that improve energy, transportation, cities, and a variety of other areas (Ovidiu et al, 2013) and (Ovidiu, et al, 2014).

The term "Internet of Things" refers to a broad concept of things, particularly everyday objects, that are readable, recognizable, locatable, addressable via information sensing devices, and/or controllable via the Internet, regardless of communication means (whether via RFID, wireless LAN, wide area networks, or other means). Everyday objects include not only the electronic devices we encounter or higher-tech products such as vehicles and equipment, but also things we don't normally think of as electronic - such as food, clothing, chairs, animals, and so on (Ovidiu, et al, 2013). (Ovidiu, et al, 2014).

The goal of the Internet of Things is to allow things to connect with anything and anyone at anytime, anywhere, and using any path/network and service (Hussein, et al. 2019).

The Internet of Things is a new Internet revolution. Objects gain intelligence and make themselves recog-

nizable by making or enabling context-related decisions, thanks to their ability to communicate information about themselves. They can access data that has been aggregated by other systems or they can be parts of more complex services. This shift coincides with the emergence of cloud computing capabilities and the Internet's transition to IPv6, which offers nearly limitless addressing capacity (Ovidiu, et al, 2013). (Ovidiu, et al, 2014).

More than half of the world's population lives in cities, which are expected to grow by 2.5 billion people by 2050. They must deal with rising environmental pressures and infrastructure needs, as well as residents' demands for a better quality of life at a reasonable cost (Goldsmith, et al, 2017).

Cities can use smart technologies to address these issues, and they are already enabling the next wave of public investment. It all begins with information. Cities generate oceans of it, in all their complexity and scope. Finding insights in all of that data aids municipal governments in

responding to changing circumstances, wisely allocating resources, and planning for the future. Furthermore, providing individuals and businesses with real-time data empowers them to make better decisions and take a more active role in shaping the city's overall performance. Cities become more livable and responsive as they become smarter, and we are only beginning to see what technology can do in the urban environment (Cooke, 2018).

The development that took place in the World Wide Web for information and communication technology on the lifestyle of the population in cities and regions made it easy for them to get community services (cadastral) and infrastructure services (linear) and reflected on the improvement of those services to the cities by connecting those cities enabled ICT, which has the ability to provide real-time information on the various components of the city in time and space through sensing technology that provides decision makers in cities with sufficient information to take the appropriate warnings , The city's population and its territory and that this transformation that has occurred in the cities came as a result of knowledge on the one hand, and techniques that have led to the development of creativity and innovation on the other hand, information and digital data from a third party, and this is part of a new pattern of smart cities, which is a necessity for the future under The challenges posed by cities in the future (Al-Hader, et al, 2019).

Smart city is the place where the movement of individuals, governments and businesses that deal with individuals in the city administration and government companies with smart information technology in an orderly fashion and is linked to these multiple or varied with Internet objects and components city components by sensors and global positioning devices (Basu, et al. 2019).

In this paper, we briefly discussed what the Internet of Things is, and how the Internet of Things enables different technologies, their architecture, characteristics and applications, as well as presenting smart cities, their characteristics, applications, and challenges. We presented the smart city project for Tripoli and what has been achieved from it. As well as the project of the future city of Tripoli and its challenges.

II. THE SMART CITY OF TRIPOLI

1. City Location

Tripoli is the capital and largest city of Libya, with a population of about three million people. It is located in the northwest of Libya on the edge of the desert, on a point of rocky land projecting into the Mediterranean Sea and forming a bay in the coordinates of (32°53′14″N 13°11′29″E) and is 1507km2 in area. It includes the port of Tripoli and the country's largest commercial and manufacturing center. It is also the site of the University of Tripoli.

2. The comprehensive development plan of Tripoli (CDP)

The comprehensive development plan for the city of Tripoli in 2008, which was prepared in 2000, faced a big problem, which is that its proposals and plans were not implemented due to the large number of abuses on the land allocated for its projects. In order to implement this, the Tripoli municipality entrusted the 2015 development plan project to a group of Chinese companies (CCF).

The study included three axes:

1. The regional framework of the State of Libya.
2. Integrated structural plan for the municipality of Tripoli.
3. A plan to update the master plan and land uses for the municipality of Tripoli.

The study focused on the city center of Tripoli, and the Chinese CCF study expected an increase in the population of Tripoli in 2008 from 1.8 million to 3 million in 2015, the study included three alternatives (Tripoli Municipality, 2017):

1. Urban axes that organize development along selected axes towards the main transport routes of the city.
2. Urban edges: They are alternatives to the Tripoli belt to stop the housing expansion.
3. City Center Development: This is to expand the city of Tripoli in a circular motion to include all government institutions and public services.

3. The comprehensive development plan for the city of Tripoli

The Tripoli municipality contracted with a Libyan national company in 2008 to prepare the comprehensive development plan for the city of Tripoli 2030 according to

stages (Tripoli Municipality, 2017):

Stage One	The main report includes a review of past experiences, the reality of the situation and guidance	Jan-2010 (Done)
Stage Two	It includes alternatives to the development plan and outlines of strategies	Aug-2012 (Done)
Stage Three	The restoration of the comprehensive development plan for the municipality of Tripoli and action plans includes: -Preparing a draft of the comprehensive development plan. - Creating action plans	Oct-2012 (Done)
Stage Four	The final version of the master plan includes: - Preparation and execution	Dec-2015 (Not Done)

The civil war and political problems have caused delays in many major development projects in the State of Libya, including the comprehensive development plan for the city of Tripoli, but after the end of the civil war and the country's deviation to a state of peace, development plans can continue again.

4. Smart city applications in Tripoli, Libya

The development and development of the city of Tripoli in order to make the city of Tripoli a smart city born of development and information and communication technology, which is employed for the benefit of the city and its residents through the urban administration implemented by the local authorities in the city. That is why sustainable cities are playing their role through information and communication technology through smart management in the field of linear infrastructure (transport, water, energy and waste), and the smart sustainable city uses information and communication technology to improve the quality of life for city residents (Rabei, 2017).

And development, strategy and technology are all axes that contribute to the growth and development of the city, and there is a rule of Greek philosophers saying (everything changes and everything is in constant movement) and the city changes rapidly and dramatically due to migration from the countryside to the city, especially the capital, which leads to pressure on linear and survey services and the occurrence of problems in the city and requires the development of a strategy that contributes to addressing those problems.

III. DESIGNING A NEW SERVICE FOR SMART CITY TRIPOLI (SMART STREET LIGHTING)

Street lighting is a communal utility that uses a significant amount of electricity. According to research, between 18% and 38% of power resources are used to meet this need. With an increase in demand for electricity and a big disparity between supply and demand, issues such as power outages and inefficient consumption, such as bright street lighting in low-traffic areas, result in huge waste. It is necessary to improve consumption with Smart Street Light without jeopardizing public safety.

The Smart Street Light System is an intelligent street lighting control system that leverages artificial intelligence (AI) to provide automated services.

The Internet of Things (IoT) is principally responsible for enabling the notion of Smart Street Lights by gathering various sorts of electronic data from various physical objects and sending that data to the devices via sensors. The cost of street lights can be greatly lowered as a result of this, and the money saved can be used to invest in other aspects of the country's growth.

IoT technology can overcome various concerns with the current manual street light system, including connectivity challenges, timing issues, and maintenance issues. The technology is based on automation, which reduces the amount of manual labor required.

Many communities are modernizing their street lighting in multiple ways, including switching to LEDs and introducing smart lighting solutions. This smart city IoT use case has a number of advantages, including increased energy efficiency and lower energy and maintenance expenses. Smart lights can alter their brightness automatically in reaction to periods of inactivity, as well as send maintenance information for faster response times.

Figure (1) Smart Street Lighting is depicted in this image. The light gets brighter as the object goes closer to the light pole, and dims as the object moves away from it.

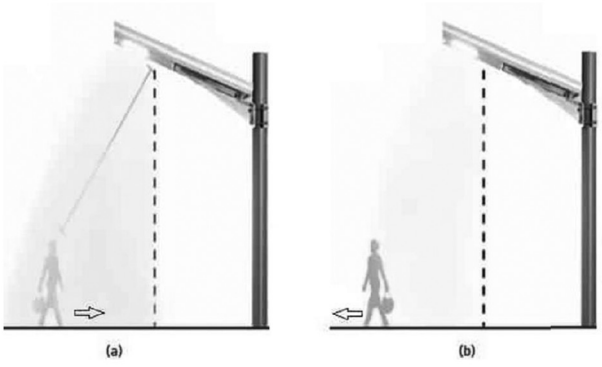

Figure 1 - Smart Street Light (a) Bright Light (b) Dim Light (Saed, 2017)

Architecture of Smart Street Light System

1. Smart Street Light System consists of the following components:

A. IR Sensor

An infrared sensor is an electrical device that detects infrared radiation to identify properties of its environment. These sensors are capable of detecting both motion and the heat of nearby objects. The electromagnetic spectrum's infrared radiation portion has wavelengths that are longer than visible light wavelengths. LED and Receiver are included with the IR Sensor. When the thing gets closer, it detects it and sends an Arduino answer

B. UART

Universal Asynchronous Receiver/Transmitter is the microchip that controls the computer's interface to the attached Street Light System.

C. LDR Input

Light-sensitive devices, also known as photo-resistors, that work with electromagnetic radiation are known as Light Dependent Resistors (LDRs). Because they are constructed of semiconductor materials, they cause significant resistance. It operates on the basis of photoconductivity. When the LDR is exposed to light, its resistance decreases and current flows into the first and second resistors' bases, respectively. The resistance of LDR is quite great when it is maintained in the dark.

D. LED

A light emitting diode (LED) is a semiconductor light source with two leads. The lighting system of the Smart Street Light is represented by these diodes. The quantity of light it emits is proportional to the amount of light it receives. The street light bulb is turned on and off using a relay.

2. Advantages of Smart Street Light system:

1. Street lights that turn on and off automatically.
2. Cost-effective.
3. Communication across the airwaves.
4. The use of less energy.
5. CO_2 emissions are reduced, and so light pollution is reduced.

3. Disadvantages of Smart Street Light System

1. The expense of implementation is substantial.
2. Troubleshooting the system in the event of a fault or repair is difficult.
3. Environmental circumstances have the potential to harm the system.
4. Implementing the service in the Smart City of Tripoli

As part of the transition to a smart city, the city of Tripoli is obligated to use modern technologies associated with artificial intelligence applications such as the smart lighting, and it is considered a part of the smart energy transition process. As been said in the advantages of this service it should mainly reduce the power consumption on the streets which reduces the maintenance cost as so.

IV. DISCUSSION AND IMPLICATIONS

The Tripoli Smart City project is an important project in all respects, whether for the residents or the government itself. Its importance to the government stems from the transition to e-governance, overcoming the difficulties facing future and sustainable development projects, and providing new sources of income while reducing public spending expenses.

It also gives the green light to internal and external investment projects and encourages foreign capital to invest in the city, which creates new and diverse job opportunities and provides opportunities for other projects that were not available before.

The effects of this transformation on the population will be for the better in all cases. The shift to smart systems will ease the difficulties facing the daily tasks of the population and allow them to enjoy speed in completing tasks and obtaining government services.

Smart city services will facilitate the lives of citizens and encourage community coexistence among the residents, which will facilitate life matters and create a suitable climate for both housing and work.

The impact of this transformation will extend beyond the city of Tripoli and will encourage the rest of the cities to turn into smart cities as well, which will create a state of development throughout the country.

V. CONCLUSION

1. The success of smart cities depends on the existence of sustainable development and the continuous provision of electric energy, to connect the smart devices in the city of Tripoli with the global positioning devices.
2. The 2030 comprehensive development plan suffices to make Tripoli a smart city.
3. The city administration does not deal with urban variables that do not cause confusion in the environment of smart cities.
4. The comprehensive development plan for Tripoli 2030 did not include recreational areas, which are the purifying lungs of the city's residents.

VI. RECOMMENDATIONS

1. Since the center of the capital, Tripoli, meets all the requirements of smart cities, it must include all parts of the city and be an experience for the rest of the Libyan cities.
2. It is possible to rely on thermal and alternative energy to fill the shortage of thermal energy in the city of Tripoli.
3. The use of foreign expertise, similar to the countries that have implemented the smart city system.
4. Connecting the city of Baghdad with other cities with express transport lines, and the trip stops in the areas surrounding Tripoli, similar to the lines of Eastern and Western Europe.
5. Establishing a university city outside the capital, where communication and information technology is available to relieve pressure on community services within the city.

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EBT 2022

SMART HEALTHCARE

Strategic marketing planning in secondary healthcare institutions

Miroslav Kendrišić

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
miroslav.kendrisic@gmail.com

Artur Bjelica

Faculty of Medicine
University of Novi Sad
Novi Sad, Serbia
artur.bjelica@mf.uns.ac.rs
0000-0002-1219-4936

Branka Rodić

Academy of Applied Studies Belgrade, The College of Health Sciences
Belgrade, Serbia
brodic@gmail.com
0000-0003-1965-3899

Dušan Višnjić

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
dusan.visnjic15@gmail.com

Tamara Đorđević

Faculty of Organisational Sciences
University of Belgrade
Belgrade, Serbia
djordjevic.tamara2@gmail.com

Abstract— The subject of the research is examining the readiness for introducing CRM and crowdsourcing services in secondary healthcare institutions. The research was conducted in the healthcare institution of secondary type among healthcare workers through an online and offline survey. The obtained results show that healthcare workers are ready and willing to implement innovative CRM services and crowdsourcing models like crowd wisdom, crowdfunding, crowd voting and crowdsensing in healthcare institution. The results present the basis for strategic marketing planning and the introduction of innovative services in the healthcare institution of secondary type.

Keywords - strategic marketing, healthcare, CRM, crowdsourcing

I. INTRODUCTION

This paper is explained briefly why marketing planning has an important role in today's business of secondary healthcare institutions, as patients' satisfaction must be the main objective which requires a thorough knowledge of their needs and expectations.

To understand the impact of marketing strategies on the quality of healthcare services, it is important to understand today's medical consumers who prefer to look for medical information online. With digital marketing, almost all online activities can be tracked and measured. With marketing performance information, healthcare professionals, and healthcare organizations can make a strategic marketing planning how to improve their services. However, to successful manage all of these functionalities and information there is a need to implement a CRM model that aids in fulfilling all this activates at the right time, by the right people with as few mistakes as possible [1].

Customer relationship management (hereinafter: CRM) is an innovative technology that seeks to improve customer satisfaction, loyalty, and profitability by acquiring, developing, and maintaining effective customer relationships and interactions [2]. CRM is very important to be used in healthcare because it improves the service in many ways that finally manifests in saving lives. Some of the services that CRM provides are online consultations, online appointments, clear use of healthcare institutions resources, data management, digital patient history and many more.

Crowdsourcing services can be used to encourage interaction and improve communication among key stakeholders. It includes crowd wisdom, crowdfunding, crowd voting and crowd sensing. These systems can improve efficiency and make business easier in many ways for secondary healthcare institutions. For example, these systems can be used in getting needed healthcare resources, collecting money for curing people, consulting with other healthcare workers as well as creating a platform for sharing patient opinions. Crowd wisdom aggregates collective intelligence and collaboration among medical experts to collaboratively solve medical cases [3]. Crowdfunding is the practice of funding a project or enterprise by collecting small amounts of money from numerous people, typically via online platforms. In the last decade, using the crowdfunding model for covering medical expenses has gained popularity [4]. Crowd voting allows stakeholders to express their opinion and desire through an online platform. This helps medical institutions to gain insight into the opinion of many people in an easy and efficient way. It presents democratization in decision-making by including all stakeholders [5].

This research examines the healthcare workers' readiness for introducing both CRM and crowdsourcing services in secondary healthcare institutions. The results should provide insight into new innovative services that could improve the e-business of healthcare institutions, communication among stakeholders, and strategic marketing planning.

II. STRATEGIC MARKETING PLANNING IN HEALTHCARE

A.Strategic Marketing Planing

Planning is a coordinating activity that prioritizes giving focus to the organization's activities. Strategic and calculated decisions are made at corporate and functional levels. While the form and presenting style of marketing plans can be different, a common purpose is shared – to identify, select and implement the right marketing activities. Strategic marketing planning helps healthcare institutions to determine the future direction of business improvement. Defining time periods, cost, profit, products, and customer-related goals give a proper framework for the organizational directions. A marketing mix consists of: product strategy, prices, distribution, promotion, advertising, sales, controlling & monitoring, and ethical considerations [6].

Each of these segments is crucial in providing healthcare in an effective and economical reasoned way. New technologies can improve data collecting, data analysis, enable multichannel communication, CRM and application of digital marketing strategies. By improving these processes, the whole business effects can be tracked in real-time and can significantly affect strategic marketing planning. It is important to analyze, determine and select which new technological features and models could and should be implemented to benefit the operation of the healthcare system.

B. Aplications in Healthcare

Before defining any action plans in any segment, it is important to define a clear goal for the strategic marketing plan. Healthcare institutions can have many different goals for example:

- A marketing goal would be - to improve access to counseling services to all members of the local community.
- A business goal would be - to increase the number of new clients by 10%.
- An operational goal would be – to add seven internal surgeons to the medical staff of the center by August.
- A customer-oriented goal would be – to improve patient-doctor communication channels.

Selected goals and objectives must be reflective of and consistent with strategic planning. Taking into account current capabilities and newly acquired capabilities healthcare institutions can define and prioritize goals in defined timeframes. By elaborating and determining each part of the previously described marketing mix healthcare institutions can focus on any goal and bring it to fruition.

C. Advertising and promotion

In public healthcare systems, the decision-making process is very centralized. This is very hard for secondary healthcare institutions to make decisions when it comes to product strategy, prices, distribution, sales, controlling & monitoring and ethical considerations. On the other hand, advertising and promotion are areas where they have the most autonomy.

Advertising is primarily done using the secondary healthcare institutions' website. The visual design is traditional, and the focus of the user interface design is functionality. The content mainly focuses on providing information about the secondary healthcare institution concerning services, work hours, employees, location, and other practical information like news, projects, donations and job offerings. However, there is an opportunity to expand this in numerous ways. By expanding the communication with clients to social media platforms and making it interchangeable to use these channels, patient's user experience could be improved. Furthermore, improving this communication creates an opportunity to better include the patients in many activities the healthcare institutions carry out. For example, fundraising, planning new initiatives, sharing experiences, etc. Successfully combining social media, a marketing idea and the healthcare institutions website has been proved very successful before [7].

III. CRM IN HEALTHCARE

A. Customer relationship management

From a healthcare point of view, CRM can be defined as an approach to learning about patients in order to communicate appropriately, and to build good relationships in order to deliver timely information, with the patients' results tracked to make necessary adjustments [2].

Customer relationship management is especially important in healthcare because patients, their health and satisfaction are an indicator of the success of the operations of the health institutions. Demand for health services has increased due to the extension of life expectancy, but also the level of education of the population. In addition to demand, expectations are also growing, related to the outcome of the service, quality of service and attitude towards the patient. Next to modern equipment and the expertise of employees, the patient also expects appropriate treatment: kindness, respect, a sense of security and trust. These trends are global, and as such have caused healthcare facilities around the world to seek assistance in implementing CRM methodologies and technologies.

Application of CRM technologies in a public healthcare system is different than in a private one due to decision making autonomy [8]:

- Collection of detailed patient data. Aggregating information such as the history of treatment, results of various tests, laboratory analyzes, recordings, smart device health measurements, and a family history of illness would allow health care providers to offer better, more specialized and timely care.
- Educating patients and raising awareness of the importance of screening. One of the ways to improve health, not only in a specific institution but in the whole of Serbia, is a transfer from curative to preventive. Disease prevention or at least early detection of the disease would significantly reduce, above all, the death rate from curable diseases, but also the cost of treatment the health care system of Serbia, which is in itself over-indebted. To achieve this, the first step is raising the health education and literacy of the population, and then educating people about the importance of regular preventive examinations.
- Improving efficiency. Excessive reliance on human labor can lead to missed activities, data entry errors, duplicate entries, incorrect entries and archiving errors. With the introduction of the CRM system, the process of entering and monitoring business simplifies, and the number of errors is minimized. It is possible to increase efficiency and influence patients as well, by sending reminders for upcoming examinations and requests from the patient to confirm or cancel the arrival within a specified period.

CRM can contain multiple functionalities focusing on communication between different stakeholders. It also opens an opportunity of integrating various crowdsourcing models in the operational structure of healthcare institutions.

B. Crowdsoursing services in healthcare

Crowdsourcing is a way of obtaining information or input into a task or project by gathering the power of a large number of people, normally via the internet [9].

Models of crowdsourcing that can be implemented in healthcare services are crowd wisdom, crowdsensing, crowdfunding and crowd voting.

Crowd wisdom aggregates collective intelligence and collaboration among medical experts to collaboratively solve medical cases. For example, CrowdMed platform uses the crowd wisdom model for collaboration among an interdisciplinary team of medical experts with an aim to provide knowledge and skills for saving lives [3].

Crowdfunding is the practice of funding a project or enterprise by collecting small amounts of money from numerous people, typically via online platforms. In universal healthcare systems, medical crowdfunding is a viable option to finance alternative, complementary, experimental and scientifically poorly supported therapies not financed by the health insurance fund. Further analysis of the most common diseases and disorders listed in crowdfunding campaigns might provide guidance for national health insurance funds in extending their list of funded medical interventions [4].

Crowd voting allows stakeholders to express their opinion and desire through an online platform, too. This helps medical institutions to gain insight into the opinion of many people in an easy and efficient way. Delegating the right to participate in the solution of minor local problems, authorities make strategic decisions on their own, without relying on the resources of a “smart crowd” [5].

C. Digital marketing strategies in healthcare

The application of digital marketing strategies improves communication between healthcare institutions and stakeholders. Digital marketing strategy involves the application of various techniques such as e-mail marketing, viral marketing, social media marketing, affiliate marketing, loyalty programs and others. Through social media, patients can be provided with information on disease prevention, doctors' advice can be provided, doctors can exchange opinions and experiences from practice an in this way improve healthcare [10].

IV. READINESS OF INTRODUCTION CRM AND CROWDSOIURSING SERVICES IN SECONDSARY HEALTHCARE INSTITUTION

A. Research context

This research examines the willingness of healthcare professionals to use CRM systems as an innovative approach to managing relationships with patients, and readiness for adopting innovative crowdsourcing models for doing business in secondary healthcare institutions. For crowd wisdom, we tested if health workers are ready to use collective opinion as one of the ways for finding the answers to the health problems of their patients.

In the context of crowdfunding, we tested if the hospitals are ready to collect funds for the necessary equipment such as various appliances, beds and other needed resources by donation of all stakeholders interested in participation. Crowd voting, a democratic way of making important decisions, is one of the possibilities that would help the employees to express their needs.

B. Sample

The research was conducted through surveying healthcare workers of a secondary healthcare institution. The respondents were people in different positions (doctors, nurses…) and of all age groups. By using both online and offline questionnaires we collected a sample of 80 respondents.

C. Instruments

Questionnaire used in this research consists of twenty

questions that are divided into three main parts.

The first one is a description of CRM and crowdsourcing services in a secondary healthcare institution. Here, respondents can be introduced with keywords. Therefore, the whole concept of how a new website should look, with all its functionalities, is described.

In the second part of this questionnaire, we wanted to collect demographic data of our respondents. This part consists of five questions and gives us answers on what their occupation or age group is.

The final part consists of fifteen questions that examine how much health workers are willing to work in a new environment that would use the implemented CRM system. The questions cover all the functionalities that the new site should have. Including all crowdsourcing systems. Possible answers in this part are formed using the Likert scale.

Table 1. Analysis of all survey question

Questions	Mean	SD	Validation of hypothesis
Do you agree that the introduction of CRM services would improve the communication and organization of the hospital's business activities?	4.575	0.75	Yes
Do you think that an integrated platform with all the important information about the patient (health picture, age ...) would ease your work?	4.7	0.48	Yes
Are you ready to take the time to answer the patient's questions on the website and write useful tips related to a topic in the field of medicine?	4.2875	0.96	Yes
Do you think that online consultations could be a more efficient form of communication in certain cases	4.3875	0.81	Yes
Are you ready to provide new ideas for solving problems in the health institution, solving complex medical cases or launching initiatives for the introduction of new healthcare services?	4.4	0.85	Yes
Would you use the "Collaborate" functionality to consult with colleagues?	4.7125	0.5	Yes
Would you use the “Survey” option to contribute in the form of voting in support of he initiatives within your healthcare institution?	4.525	0.87	Yes
Do you think that a newsletter would be a useful way to inform the patient about current topics?	4.63	0.69	Yes
Would you like to get the opinion of patients about your work?	4.525	1	Yes
Do you think that the scheduling of examinations, could speed up and ease the existing way of working?	4.7875	0.49	Yes
Do you think that crowdfunding would improve the financing of treatment of special cases or projects aimed at improving the business of the health institution?	4.3625	0.87	Yes
Do you think that crowdsensing and the information you get through this service would improve your decision-making when treating patients?	4.2	1.08	Yes
Do you think that crowdwisdom and this type of collegial communication would improve the success in solving health cases at the departmental level?	4.4375	0.89	Yes
Do you think that crowdvoating would improve the decision-making process related to improving the business of a health institution?	4.475	0.67	Yes
Do you think that connecting the website with social networks would improve communication between healthcare professionals and patients?	4	1.25	Yes
Do you have satisfactory access to electronic devices and the Internet in your workplace in order to use the described functionalities?	4.33	1	Yes

V. ANALYSIS OF THE RESULTS

A. Results sample

In the conducted research, 80 health workers were examined, 72.5% of whom were women and 27.5% men. The respondents are of different age groups from 21 to over 50 years old. Most respondents were between 41 and 50 years, making up 35% of the total number. Second largest group are people over 50 years, making up 33.5%. Seventeen respondents are people from 31 to 40 years, and the youngest eight respondents have between 21 and 30 years. The level of education of the respondents varies and includes doctors, nurses, and technicians.

B. Research question

The first part of the survey is demographic one, questioning sex, age group, educational level and the professional position. Research questions are designed in the way to analyze the level of readiness of healthcare workers to introduce CRM as well as crowdsourcing systems. Questions encompass all crowdsourcing systems – crowd wisdom, crowd voting, crowdfunding and crowdsensing.

Our main hypothesis is that the majority of respondents are ready for the implementation of all CRM and crowdsourcing functionalities.

C. Analysis of results

The mean value for all questions is equal to or above 4 meaning that respondents agree or strongly agree with the given statement for introducing CRM or crowdsourcing services. Implicating those respondents agree with implementing this functionalities and models to improve the promotion and marketing segment of strategic marketing planning.

The standard deviation is mainly below one, meaning that the majority of respondents agreed and answered the same. Also, deviation from the expected value is small.

VI. CONCLUSION

Through its specificity, healthcare marketing is an interdisciplinary field because it uses certain concepts, methods, and techniques specific both to classical and social marketing. The effectiveness of its application can be found in the image of a healthy population, greater satisfaction of patients, better communication, a clearer picture of needs that need to be fulfilled, etc. The application of marketing in the field of healthcare was imposed by the problems in the health of the society and outdated and not so efficient healthcare systems.

This research is focused on strategic marketing planning in secondary healthcare systems. By surveying healthcare workers, it was tested the readiness for introducing both CRM and crowdsourcing services. The survey was conducted on a group that has different demographic characteristics; therefore, the outcome is relevant.

Crowdsourcing systems are inseparable part of CRM and include different models. Crowdsourcing has many benefits for both patients and healthcare workers. It is rapid, low cost, and can collect a huge amount of information from a large number of people. In particular, there is potential for crowdsourcing to capitalize on the input of interested and fit individuals who have the best ideas and bring a diverse set of skills and backgrounds to bear on the current task [11]. In this paper, it was described how crowd wisdom, crowdsensing, crowdfunding and crowd voting can be used to improve current healthcare system.

The result of the conducted survey shows that healthcare workers are willing to start using these services in their daily work. They consider that these systems are needed in order to increase efficiency and make work easier. These results and the conducted statistical analysis serve to determine further steps for strategic marketing planning in a secondary healthcare institution.

ACKNOWLEDGMENT

This research was funded by the Ministry of Education, Science, and Technological Development of the Republic of Serbia, grant number 11143.

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The Importance of digital transformation processes in medicines regulatory authorities for E-Health

Tatjana Stojadinovic

eDevelopment and IT Management
Medicines and Medical Devices Agency of Serbia
Belgrade, Serbia
tatjana.stojadinovic@alims.gov.rs
0000-0002-8952-2205

Ilija Antovic

University of Belgrade
Faculty of Organizational Sciences
Belgrade, Serbia
ilija.antovic@fon.bg.ac.rs
0000-0002-2673-6628

Abstract— The purpose of this article is to explore the digital transformation processes in medicines and medical devices legislative. The goal of this paper is to introduce the relationship of e-business in the medicines regulation with e-pharmacy and e-health in order to improve public health. The methodology for the development of e-services, methods for modeling and analysis of business processes, the reference model of e-business in the medicines regulation, e-services for import license for medicines are the main scientific contributions of this work. This paper shows a case study which refers to e-services development for medicines in the marketing authorization, implemented in Medicines and Medical Devices of Agency of Serbia, which is a major professional contribution of this work. This research is based on a qualitative case study – the project "Digital transformation on business processes in medicines and medical devices regulation" conducted from year 2018. to 2022.

Keywords - digital health, e-pharmacy, medicines

I. INTRODUCTION

Electronic business (E-business) is a modern form of business for an organization. The concept of e-business is represented and applicable in all activities and areas1. In a few decades, digital technologies have transformed the way communication, business, production of goods and services function, and the way people live and work. For developing countries, the digital economy is a way to stimulate economic growth, raise capital and labour productivity, reduce transaction costs and facilitate access to global markets. The development of digital technologies brings numerous benefits to society in terms of wealth creation, technological advancement and improved quality of life.12

Medicines regulation is a process encompassing various activities that aim to ensure the safety, efficacy and quality of medicines, as well as the appropriateness and accuracy of product information. Medicines regulation is public policy that restricts private sector activities to attain social goal set by a given country2.

The development of e-business in the medicines regulation, as one segment of e-government, envisages interactive electronic services tailored to the needs of citizens, government units, state administration, regulatory and educational institutions and businesses. Methodology for the development of e-services on the e-government portal and demonstration a study of the application of this method in the part of medicines and medical devices is very important for e-health and the-government development3.

The purpose of the research is analysis that encompasses application of e-business in medicines and medical devices regulation and the application of the method in development of e-services and e-submission in medicines regulatory authorities for process import licenses for medicines and medical devices in Serbia. This testing of e-readiness of the pharmaceutical industry for the project of e-submission that was implemented in April 2021 in the period with COVID in Serbia (RS). The significance of this paper is that it is one of the first e-services initiatives in RS.

II. DEFINITIONS AND METHODS

A. Definitions

This subchapter will show the definitions of e-business, e-health, e-pharmacy and e-government.

E-business is the exchange of standardized electronic messages between natural and legal persons in negotiating, contracting, purchasing, sales, payments, communication with the administration and the courts, and in all other business transactions for which the law allowed its application1.

E-Government uses the application of information technology to improve: efficiency, productivity, transparency and accountability of the Government in dealing with: citizens, businesses, industry, government units and private officials. E-government can be seen from the online access to services to tools for the construction and reconstruction of democracy4.

E-government is a Web-based technology that uses the local government as a communication channel, which is offered to visitors, business partners, local governments and employees. Business models, which are used in the development of e-government, are G2C (Government to Customer), G2B (Government to Business), G2G (Government to Government)...

E-pharmacy as a segment of e-health is the application of electronic commerce in the pharmaceutical industry, which encompasses on the one hand the business of companies in the pharmaceutical industry and pharmacies. Increased use of information technologies and the Internet provides powerful tools and makes them available to citizens, government agencies, and pharmaceutical industry around the world. As a result, there are changes in organizations, as well as in relationships between businesses, citizens and state authorities.

The development of e-business in the area of the regulations concerning medicines, as a subsystem of the e-government of RS, provides a unified environment for communication, better dissemination of information about medicines, and online education for health care workers as well as more effective operation in the health care and pharmaceutical sector, including the realization of the concept of e-government in the segment of regulation of medicines11.

B. Methods

This article does not contain any studies with human or animal subjects performed by any of the authors. This chapter will show the methodology of developing software in e-government and previous research on e-services.

Software design methods are specific strategies that propose and provide a set of notations which are used with the method as a description of the process that should be used when monitoring methods and a set of guidelines for the use of the method5.

This section will describe the methods, methodologies and software development models, which are used in e-government. Particular attention will be devoted to the life cycle of software and business intelligence, and SOA (Service Oriented Architecture7) and BPM (Business Process Modelling). The methods of the life cycle of the attention will be devoted to a single method of software development process. The integrated framework, which will be displayed and used in this paper, is based on the use of RUP (Rational Unified Process) methodology and agile methodologies, business intelligence (BI) with the principles of data mining and data warehousing, BMPL (Business Process Modelling Language) and UML (Unified Modelling Language) - notation and reengineering business processes. The main principles are incremental and iterative development, active participation of users, based on the development of models, testing and cooperation. The paper consolidated methods, techniques, standards and process models in the field of e-business and access to quality analysis, modelling and design of the portal system of the authorities od RS. Software Life Cycle Processes (SLCP)9 can be perceive through its processes, i.e. activities that make this process as well as through its models, methods and strategies. SLCP are defined by a number of reasons, including increasing product quality, facilitating human understanding and communication, support process improvement, and support management processes. Methods for SLCP can be said to describe the process of software development through its individual operations or processes.

BI is a set of tools and applications that enable the creation of a system for the collection, analysis and dissemination of business information, with the aim of making better business decisions6.

In SOA programming is based on the process approach and represents a higher step in the development of software engineering. SOA describes the concepts, architecture and procedural framework to ensure cost effective development, integration and maintenance of IS. SOA does not represent a radically new architecture, but rather the evolution of the well-known distributed architecture and integration methods.

BPM refers to the design, management and execution of the business process, and its strength lies in the unification and expansion of existing process oriented techniques and technologies..

III. RESEARCH

A. Case study

This research is based on a qualitative case study on the 2018-2022 project “Digital transformation processes in medicines and medical devices regulation”. The project holder is the Medicines and Medical Devices Agency of Serbia (ALIMS), RS Ministry of Health and RS Government. The project includes several actors: project team of Agency, a project manager, manager of Agency as a member of team, Office of Information Technology and Electronic Government in RS in the Prime Minister's Office formed 27.07.2017 (Directorate of Electronic Government until 27.07.2017) and Coordination Body for digitalization of health formed at December 2021. The results of the research can be applied in any European medicines regulatory authority.

B. Research aproach

The aim of research was to develop a national platform in RS, as the country on the Balkan Peninsula in the South-Eastern Europe, for the development of e-pharmacy, which enables the integration of regulatory bodies in the medicines and medical devices regulation and institutions of the pharmaceutical industry. The data studied in this paper are focused on the data of the institutions that first began using the e-services of the Agency government portal of RS. Among the various roles and interviewed respondents are the directors of the pharmaceutical industry institutions, information technology directors in the institutions of the pharmaceutical industry, responsible persons for submitting requests for obtaining a license for medici-

nal products and medical devices in the institutions of the industry, civil servants, and directors of state institutions. At the national level, the Project Electronic Application Submission of Client Support supports the development of the government portal in RS, which will enable the improvement of services to the pharmaceutical industry and citizens and contribute to the economic development of the country. The project is in line with the Electronic Administration Development Strategy and the Action Plan for the implementation of the Open Access Initiative. The project contributes to better implementation of the Public Administration and Public Health Reform Strategy and provides closer approximation to the best European and global practice in the field of good governance. The project is one of the aims of National Project: Digital Health in RS, which Program was adopted in December 2021. This chapter will show analysis and application of e-business in the medicines and medical devices regulation and the application of the method in development of e-services and e-submission in ALIMS from the previous chapter.

C. Analysis of application methods for digital transformation business processes for medicines

This subchapter shows analysis that encompasses application of e-business in the medicines and medical devices regulation and the application in RS. For medicines and medical devices regulation, e-business is used for collecting, recording, storing and securing data, and information about medicines is a source of necessary information for the daily work of doctors, pharmacists and other health workers. The development of e-business in the medicines regulation, as one segment of e-government of RS provides interactive e-services tailored to the needs of citizens, public authorities, regulatory and educational institutions and industry (producers, importers, representations, health care and pharmaceutical institutions).

The goal of this approach is the integration of e-government and the segment relating to the medicines regulation, ensuring the efficiency of process of modelling and model implementation, which should result in models that must be explicit, understandable, modular and can be effectively amended and supplemented, distributed and placed on a variety of computing platforms and operating systems in e-government8.

Without e-business in the medicines regulation it is impossible to develop e-health and e-pharmacy. Providing information on medicines is one of the e-services in the medicines regulation. Information about medicines is coming from routine sources, specific non-routine, library sources and research sources. Information on medicines, which must be precise and authoritative data are necessary for the daily work of doctors, pharmacists and other health workers in general and special branches of medicine, pharmacists in the production, medicines and pharmacies, as well as other professionals involved in health care, regulatory bodies. Integration of business in the medicines and medical devices regulation, government, health and ePharmacy in RS (Figure 1) uses e-business models to better communication, better management of documents and records in public administration, the pharmaceutical industry and the health system, as well as the achievement of measures directly connected to savings in dealing with several aspects (time - efficiency, money - economy). Networking of institutions in the field of information on medicines and medical devices affects how efficiently the business of ALIMS and health institutions, patients or the pharmaceutical industry is, which leads to a significant reduction in total costs and time saving. ALIMS was ready from the start to participate in the initiative to open data and thus enable that information on medicines and medical devices, and integration with other data, to get more value and become useful to other state bodies and institutions.

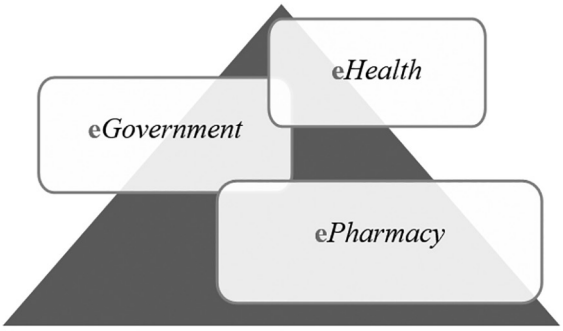


Fig. 1. Models of e-business between eHealth, eGovernment and ePharmacy

IV. RESULTS AND DISCUSSION

In this chapter, the results of the case study will be presented, as well as the preparatory phase of launching e-services development initiative in RS. This chapter will show concluding analysis and finding that encompasses application of e-business in the medicines and medical devices regulation and the application of the method in development of e-services and digital transformation business processes in ALIMS from the previous chapters.

A. Results of the preparatory phase-application of the methods

ALIMS is a public agency in RS, authorized (among other) to issue marketing authorizations, decide on their variations, renewals for human and veterinary medicine, as well as the registration of marketing authorizations for medical devices, quality control of medicines and medical devices that meet the requirements for efficiency, quality and safety. Transparency of the work is reflected through the portal of ALIMS where they meet all the criteria of functionality, defining the guidelines for making Web presentations of the state administration.

ALIMS participates in the development of eGovernment portal RS. The latest e-services "Downloading reg-

istry of medicines and medical devices" is set in 2015 on National Portal of eGovernment. State agencies and legal entities can retrieve the registry of medicines for use in human and veterinary medicine, as well as a registry of medical devices for which the ALIMS issued a marketing authorization, with the use of a qualified digital certificate. The aim of this service is to download data on medicines and medical devices in digital, machine-readable formats that can be used for further work and use in other state bodies and legal entities, especially in the context of the development of the e-Health of RS. Register of medicines and medical devices in the form of e-Service enable downloading of the codebook data on medicines and medical devices from the ALIMS database that are updated on a daily basis. This way ALIMS achieves more benefits for almost all sectors of society: new business and economic opportunities - turning data into economic systems at all levels and new innovative solutions - combining data from multiple sources, which then creates new values.

At the end of 2018 ALIMS has started a new project „Digital transformation business processes“ that will enable the integration of ALIMS and pharmaceutical industry, and includes e-submission request of clients in the pharmaceutical industry on the easiest way by selecting the appropriate eServices and completing the application form, which was given the opportunity to submit the attached documentation in electronic form with certain requirements. The basic idea of this project is to enable clients wishing to apply electronically. The vision of the project is to develop application forms for eGovernment portal where customers will be able to electronically fill patterns i.e. customer requirements and deliver them electronically with all the accompanying documentation. The project includes the development of about 60 eServices ALIMS and allows the pharmaceutical industry to operate without physical arrival at the location ALIMS by applying for the appropriate electronic service ALIMS. This is reached by using a digital certificate, which provides training and leads to the pharmaceutical industry when it comes to the development and application of informational technologies and provides additional support for the development of the same in RS.

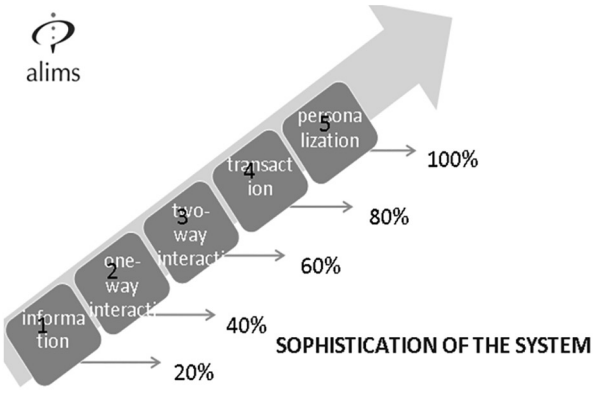


Fig. 2. Phase of sophistication of the portal

The functional area of e-services is enabled on the home web page of the ALIMS site and contains a list of all names of e-services published on the own portal of e-government inside the highest stages of sophistication: interaction, transacton and personalization (Figure 2).

The most important result is an increase in the number of completed applications form import licences form medicines and medical devices, for exmple on Figures 3 is attached example for number of solved request for medical devices.

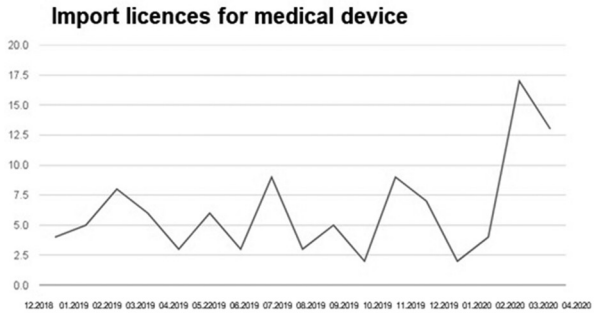


Fig. 3. Import licence for medical devices from December 2018 to 2020

B. Performance analysis and results

For the future of e-government, e-health and e-business in the medicines regulation in RS it is important to use the experience of other countries, with consideration of their successes and failures, as well as adapting this knowledge characteristics of socio-economic environment in RS.

Equally important is the cooperation with the Ministry of Health and the Government of RS, because in this way there is a solution that information subsystem of e-business in the medicines regulation integrates into the overall IS of e-government of RS leading into single architecture, which can be reached by working together and forming an agreement of all stakeholders, starting from the government, through the non-governmental sector, academic institutions, to the citizens themselves.

A good example of application of this project is open data about medicines and medical devices in human and veterinary medicine registered by the agency, whose main activity is the control of medicines and the placing of medicines on the market. ALIMS was among the first to adopt the concept of open data and thus contribute to the achievement of benefits for the economy in general, economic entities, state authorities, scientific community and other segments of the society in RS.

The registers of human and veterinary medicine and medical devices are presented in the forms of structured, open data formats and are presented as electronic services on the national portal of eGovernment.

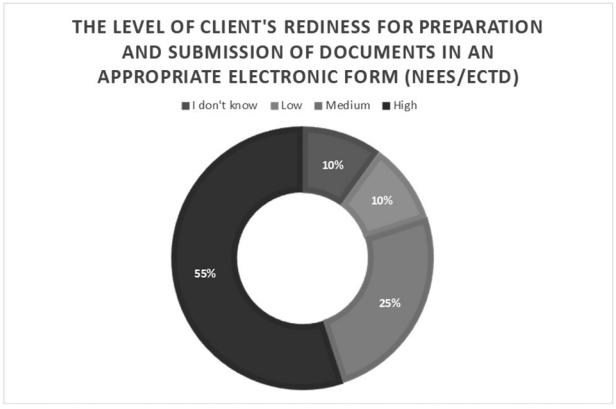
This data, which ALIMS made open additional en-

hanced through services such as the search for registered medicines and medical devices and issued certificates that exist from before, help monitor and respond to an adverse reaction to drugs and medical devices and identify fake medical products, and significantly make it easier for businesses in this area to do all this in order to achieve better health of the citizens of RS.

Based on open data sets for medicines and medical devices, some web applications and mobile applications have already been developed as Mediately databases of medicines.

The survey relating to the testing of e-readiness of the pharmaceutical industry for the project of e-submission was implemented in November 2020. The questionnaire was sent to all pharmaceutical institutions with a term of one month for an answer. Of the total number of participants, the survey was completed by 52% of participants. Most of the participants are familiar with the concept of electronic storage of data / documents and with the guidelines on the subject of filing documents (Figure 4).

The Agency's intention to move to an electronic system of communication was supported the most. The proposal to organize workshops and conferences on this subject in order to inform and educate the clients on time, in order to better and more successful transition to the new system of application was also well supported.



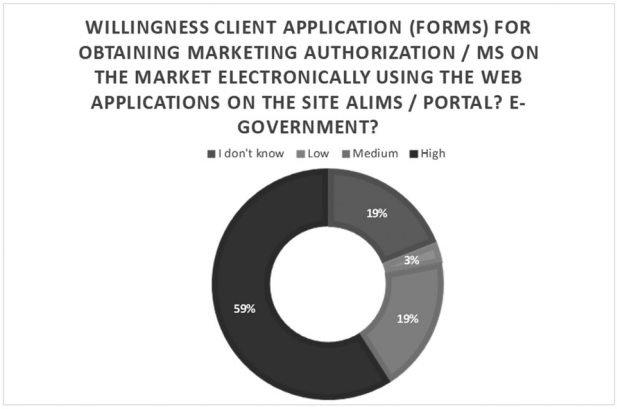


Fig. 4. The testing of e-readiness of the pharmaceutical industry in RS

V. CONCLUSION

This study confirms several benefits and challenges described in previous studies regarding e-services as described above. This is interesting, because at this moment there are few studies on e-services initiatives, especially in RS, where initiative e-government development and digital transformation has been launched and in its infancy. What this study highlights and contributes to, in addition to confirming the above studies, are the main lessons in terms of: The importance of actors who drive and realize initiatives, and the ability to overcome challenges, as well as the issue of private and public actors, together with the way a certain division of work is made when e-services or applications based are developed as part of a channel strategy. The methodology for the development of e-services, methods for modelling and analysis of business processes and reference model of e-business in the medicines regulation as one of the subsystems of e-government process met model in the context of e-government, life cycle business system design on the e-government network web portal and e-business in the medicines regulation, are the main scientific contributions of this work. Developing web software for e-business development in the medicines regulation, as subsystem of the e-government implemented in ALIMS are the main professional contributions of this paper. Improving e-business and digital transformation business processes in the medicines regulation, as a subsystem of e-government would have to aim: the development of interfaces and support for model specification systems through interaction with citizens, the economy, healthcare, pharmaceuticals and other public authorities, support the adopted modelling standards, integration of e-business in the medicines regulation, the e-government, e-health and e-pharmacy in RS, application of methods and techniques of life cycle business model which are presented in the paper, agile methods and application of SOA, BI, and BMP. The "e-filling clients' requests ALIMS" will enable the integration of ALIMS with pharmaceutical industry and provide electronic submission of customer requirements and questions, thus achieving significant savings for ALIMS as for the pharmaceutical industry in the RS.

In this way ALIMS fulfils its mission - to promote and improve the health of people and animals, as well as to contribute to the realization of the fundamental human right to access to quality, safe and effective medicines and medical devices.

Digital transformation of business processes in ALIMS provides a unique environment for communication, better information about medicines, education via Internet for health workers, as well as the more efficient operations in the healthcare and pharmaceutical industries and the realization of the concept of e-government in segment which regulates medicines and medical devices areas.

Based on the research in this paper, it can be concluded that e-services guarantees greater transparency of the work of state bodies, stimulates efficiency in government

and beyond, and enables citizens, companies and organizations to use public information several times for different purposes.

E-services strengthen entrepreneurship, influencing the development of innovative products and services, providing alternatives for decision-making in management, planning and science, and contributing to the creation of a knowledge-based economy.

Analysis and research conducted in the case study described in this paper point to the conclusion that the goal of the state should be that e-services of state farmers receive a useful value through the mixing of datasets in related institutions, the data of which are of great importance. The useful value of the data has been increased during the combination of data, which leads to the direct benefit of the public, the economy and the institutions themselves, State bodies of RS. In all the above ways, the state fulfils its mission - to promote and improve the business of all sectors, as well as to contribute to the achievement of the basic human right to access quality, accurate and efficient information.

The final goal of digitalization will be the next step and that: integration of eGovernment, eHealth and ePharmacy for the purpose of Human Health. That are realized for the benefit of the state, health system, economy and patients, and which are carried out through the improvement of cooperation between Ministry of Health, Agency, health and state institution, educational institution and patients with the use of open data and open eServices and G2B, G2C and G2G electronic forms application.

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A System to Monitoring and Managing the Anxiety Among the Young People Using Machine Learning

Farhad Lotfi

University of Belgrade
Faculty of Organizational Sciences
Belgrade, Serbia
farhadlotfi1990@gmail.com

Branka Rodić

College of Health Sciences
Academy for applied studies Belgrade
Belgrade, Serbia
brodic@gmail.com
0000-0003-1965-3899

Zorica Bogdanović

University of Belgrade
Faculty of Organizational Sciences
Belgrade, Serbia
zorica@elab.rs
0000-0003-4799-1588

Abstract— In the modern world, young people face several challenges in their personal life like the workplace, and social life, among which Covid-19 has had an adverse effect on the physical and mental health of young people. On the other hand, with the exhibitive increase in population, the use of traditional methods in the treatment of many diseases such as anxiety no longer seems possible. However, controlling and monitoring patients' anxiety status in the context of intelligent systems can be of higher accuracy, velocity, and quality. In this study, we proposed a system for monitoring and managing anxiety theoretically using machine learning technology. Examining machine learning (ML) techniques have high accuracy, speed, and flexibility. Hence, a pattern was presented, as well as the tools, how to prepare the data collection, and how to obtain the desired output. Highly-accurate detection of anxiety is the first effective step for treatment, for this purpose, supervised learning algorithms have been chosen. Finally, this study has presented a framework to find gaps in this regard

Keywords—.Smart Healthcare, Anxiety, Machine Learning Technology

I. INTRODUCTION

Smart health is a new concept that has attracted a lot of attention in the modern world. Basically, smart health is the use of new technologies in the field of health or healthcare and in the context of the Internet of Things (IoT) to diagnose, control, and treat a lot of diseases [1, 2]. For example, one of the applications of smart health is to detect and monitor stress and anxiety. Wearable technologies with health can be an excellent option for monitoring anxiety. Modern technologies also are more widely accepted among young people [3]. Anxiety is a disease that can be caused by persistent stress and if it persists, it can pose serious risks for individuals. Some illnesses appear in adulthood, but in the case of anxiety, it must be acknowledged that it can occur in childhood and can be dangerous for the people and society [4, 5]. Anxiety can have an adverse effect on as much as a third of the population, according to a survey.

Thus, according to WHO, An estimated 450 million people worldwide suffer from problems such as stress and anxiety [6]. Many factors can cause people to become anxious in the workplace, inability to perform job duties, avoid accepting responsibility in the workplace, and so on [7]. However, the analysis of stress and anxiety data by machine learning techniques have become popular and successful patterns that have been discovered in this field [8]. This study also provides a model for monitoring and detecting anxiety by machine learning technology. For instance, nowadays, academic individuals face many issues such as education and student life, and so on, so that anxiety can have a greater impact on young people. It goes without saying that the Covid-19 pandemic has exacerbated this issue in recent years [9]. For example, in study [10], the factors of formation and exacerbation of anxiety were monitored over a period of 8 months by machine learning techniques, and finally a favourable pattern was extracted for it. It is also stated elsewhere that optimal performance in the academic and industrial fields requires relaxation and a stress-free environment. Machine learning has provided models and patterns that can predict anxiety and stress among the people in real-time [11]. Therefore, it has sometimes been observed that the presence of some diseases can cause anxiety [12]. However, studies have shown that monitoring, controlling, and detecting anxiety in the smart context can have several benefits for the society [13]. Finally, because some important cases were mentioned, and the scope of the data can be very wide, the suggestion of machine learning seems to be a good solution. In this study, a conceptual model for monitoring and detecting anxiety is presented. To collect data through a standard questionnaire via Google Forms and analyse it by machine learning techniques such as supervised learning algorithms have been mentioned. Although, the methods and models of detecting anxiety by artificial intelligence (AI) are varied. In the framework of this research, supervised learning has been selected to analyse anxiety data. Finally, the second part of this study is named background, the third section is called framework, in the fourth chapter of the implementation, and in the 5th part, conclusion is presented.

II. BACKGROUND

A. Smart Healthcare

Technological advances, meta-analysis, and big data in the health industry have led to a revision of the health perspective. The important issue in the healthcare industry is real-time responsiveness to the patients. In fact, the efficiency of intelligent systems in the field of health and treatment is very important because the analysis of big data in health with intelligent systems is possible. Smart health is able to remotely control and manage some diseases, and in this system, the patient's health status is sent to medical centres and physicians, and several patients can receive the desired feedback. On the other hand, electronic devices, wearables, and mobile health with the possibility of monitoring, receiving health data from the patient, and controlling the patient's condition have played a vital role [1, 3]. Hence, smart healthcare has created a new definition for the health industry. However, in this study, a framework for analysing anxiety using machine learning techniques is presented. In general, the use of ML technology on health data like anxiety seems a key methodology [14].

B. Using Wearable Devices To Monitoring The Anxiety

The use of smart devices such as smart mobile phones as well as wearables like smartwatches is constantly increasing. Health data is prepared to analysis by these wearable technologies, using smart mobile phones, tablets, PCs, and so on. In addition, mobile health has also been accepted as one of the most important technologies for monitoring and controlling many diseases [15]. Anxiety is a kind of disease that can be monitored and controlled by these smart wearables. Also, today, AI has been able to play an effective role in promoting smart health through useful programmes [16]. Today, smart health has had a positive impact on many diseases such as anxiety and stress. For example, in the results of the study [3], it has been argued that the use of smart wearables and associated health in medical clinics can significantly reduce the percentage of stress and anxiety of patients.

Smart wearables such as smartwatches and the like are able to send some vital signs such as body temperature, blood pressure, different types of diabetes, heart rate, and so on to mobile health applications for analysis. Therefore, one of the strong ways that people can measure their anxiety today is the same mobile wearables under the health system [3, 17].

Studies have shown that managing anxiety through the use of wearable technologies is very beneficial, but on the other hand, in some cases, its use is prohibited [18].

C. Detecting Anxiety Using Machine Learning

Today, machine learning technology has been able to play an effective role in improving mental health systems, especially in adults, by applying applications [16]. However, analysing anxiety using machine learning techniques is one of the new and reliable methodologies. Analysis of anxiety data in the context of ML has been used to discover good criteria for high-accuracy prediction [19]. However, among machine learning algorithms for detecting anxiety, supervised learning algorithms in most cases have shown a significant and positive effect compared to unsupervised learning algorithms, and so on [20]. Today, machine learning algorithms have the ability to analyse health data such as mental health with the utmost accuracy [21]. For example, in one study with 632 participants (N = 632), anxiety data were analysed with 95% accuracy. In addition, the results showed that participants were more compatible with digital-based therapies [22]. Finally, it should be pointed that today, in order to accurately discover the behavioural patterns of anxiety, deep learning technology has made study easier and more accurate for researchers working in this field [23].

III. FRAMEWORK

A. Data Collection

This study recommends the State-Trait Anxiety Inventory (STAI) and wearable data to measuring anxiety. Twenty questions for state anxiety and twenty questions for trait anxiety, participants also have 4 types of ratings ("Not at all" to "Very much") to answer the questions [24, 25]. Also, for ease of work during data analysis, the answers can be encoded and defined with values (0 to 3), this technique is necessary for data analysis. However, for this purpose, a standard questionnaire form can be prepared via "Google Forms" and distributed among the young people on social media. For instance, a questionnaire form could be sent to a limited number of young people and then distributed widely after the problems were discovered. Some of the information like age, sex, marital status, and educational levels are needed to developing this research. Also, examining wearable data besides anxiety questionnaires can have a positive impact on results. Wearable devices data can be collected using smart devices such as sensors, smartwatches, and so on. Extracting data such as smoking, alcohol consumption, and etc. can also be useful for more accurate analysis.

B. Proposed Pattern

In the previous part, it was mentioned to collect anxiety data and eliminate possible problems, which can be clearly seen in the following pattern. Wearable data can collect from electronic devices, and data cleaning process can be applied to this data.

As shown in Figure 1, the data collection can be shifted to apply machine learning algorithms, and after normalisation, data fusion as the process of integrating multiple data sources to produce more consistent has been presented in this pattern, and then, a comparative analysis between the algorithms can be performed. Finally, a successful decision-making and evaluation can be extracted from the patterns and results obtained. It has been mentioned that this model can be developed in more details and presented. It should also be noted that some data collected from the user, like age, sex, educational levels, smoking rate, and so on., can help complete the evaluation and decision-making.

IV. IMPLEMENTATION

After receiving and classifying the information and extracting the questionnaire diagrams, the data can be prepared for the analysis of machine learning. To this purpose, the data can be analysed using the programming language (Python 3.6) and on the Jupyter platform. Supervised learning algorithms have the most desirable output for analysing anxiety. In Supervised Learning, "Classification" is the task of predicting a discrete class label, and "Regression" is focused on predicting a continuous quantity. Algorithms of classification like "Naive Bayes Classifier", "Decision Trees", "Support Vector Machines", "Random Forest", and "k - Nearest Neighbours" have mentioned in this study. Algorithms of regression such as "Liner Regression", "Neural Network Regression", "Support Vector Regression", and "Decision Tree Regression", "Lasso Regression", and "Ridge Regression" have been proposed to detecting the anxiety [23, 26, 27]. After analysing both data sets by machine learning technology (wearable data & STAI questionnaire), the accuracy of the algorithms for each of the data collection is determined. Finally, the most important cause of anxiety in each branch are determined with the highest accuracy of estimation.

V. CONCLUSION

Studies have shown that the anxiety is more common in elderly people [28]. It is much easier to accept new technologies among the young people and highly-educated. Therefore, it should be pointed that using machine learning technology to monitor and control mental health can have many benefits and also inform them about the many risks ahead. Research findings have shown that the collection of health data like anxiety and analysis of this data using ML algorithms, which have been done in previous studies with high accuracy, can clear the way for further entry and analysis in the branch of deep learning [29]. Successful models can also be used in hospitals and various industries such as robotics, etc. Research findings have shown that models of detecting anxiety among the youth of today with higher impact were presented.

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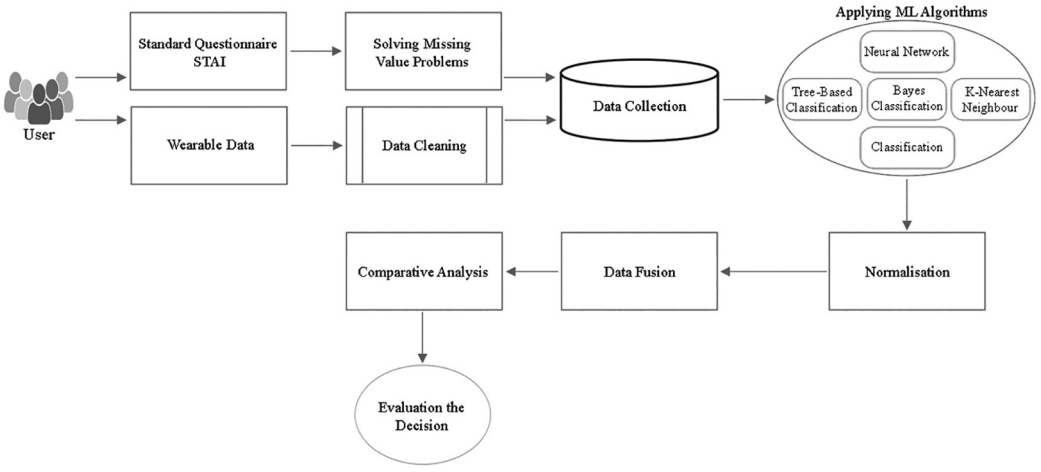

Fig. 1. Proposed pattern to analysing anxiety by machine learning

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EBT 2022

BLOCKCHAIN

Blockchain platform selection with a focus on smart contracts usage

Nikola Matijasevic
University of Belgrade – Faculty of Transport and Traffic Engineering
Belgrade, Serbia
nikola.matijasevic@sf.bg.ac.rs

Marko Đogatovic
University of Belgrade – Faculty of Transport and Traffic Engineering
Belgrade, Serbia
m.djogatovic@sf.bg.ac.rs

Gordana Radivojevic
University of Belgrade – Faculty of ŽTransport and Traffic Engineering
Belgrade, Serbia
g.radivojevic@sf.bg.ac.rs

Abstract - The rise of blockchain technology in recent years has led to the involvement of a large number of entrepreneurs, academics and various other institutions to understand and implement this technology. A special feature of blockchain platforms are smart contracts that make them more useful and interesting for use. Therefore, there is a problem of choosing the best blockchain platform for using smart contracts according to certain criteria. In the paper, this problem is solved by applying the fuzzy PROMETHEE method, and based on PROMETHEE I and PROMETHEE II, partial and complete rank of blockchain platforms are obtained, respectively. By applying these methods, the obtained results show that the Hyperledger Fabric is the best blockchain platform for using smart contracts in relation to other platforms, according to the given criteria.

Keywords - blockchain, smart contract, multi-criteria decision-making, PROMETHEE, fuzzy numbers

I. INTRODUCTION

Blockchain, as a decentralized information transfer technology, has the potential to significantly affect all sectors that rely on intermediaries, in all industries. In 2008, a paper was published describing a peer-to-peer (P2P) version of electronic money, called Bitcoin, which allows direct payments between two parties without the mediation of a financial institution [1]. Bitcoin, as the first blockchain platform to become very successful, has created great interest in areas where building trust, transparency, security and traceability of information and transactions are important. The use of blockchain technology could prove useful in specific applications such as those where there is a requirement for interaction and agreement between multiple unreliable parties. This can be done by using the special functionality of the blockchain platforms, which are called smart contracts. With that in mind, it is important to select the best blockchain platform that supports smart contracts.

This problem can be solver using MCDM (Multi-Criteria Decision-Making) methods. MCDM is a term that describes a set of formal approaches that allow individuals or groups of decision makers to make decisions, taking into account the essentially complex nature of the problem, also all relevant criteria and overcoming all challenges that arise in choosing or creating solutions to problems [2]. Approaches based on fuzzy numbers, in combination with MCDM methods, are commonly used [3]. Linguistic values (such as poor, fair and good) are represented using fuzzy numbers. Linguistic values were mostly used because of the difficulties of finding the exact comparable data. In this paper, PROMETHEE method is proposed because of its flexibility and simplicity for the evaluation of fuzzy data.

This paper is organized as follows: Chapter II deals with understanding and explaining the basics of blockchain technology. Chapter III gives the mathematical background of the fuzzy numbers as well as the proposed fuzzy PROMETHEE method. In Chapter IV, MCDM problem is described and solved using proposed method, and also analysis of the results is given.

II. UNDERSTANDING BLOCKCHAIN TECHNOLOGY

Blockchain technology is a decentralized and distributed database that aims to record all transactions that have ever occurred in the network. The goal of such a database is to create an immutable record of all transactions and their visibility for anyone who monitors or uses the blockchain. In the following, we will present the structure, consensus protocols and working principle of blockchain technology.

A. Structure

It is a structure consisting of blocks interconnected by a chain. The chain of blocks does not exist in the real world, but in the digital one. The essence of the existence of blocks is to store transactions that have occurred in the network, while the chain refers to the cryptographic hash function that connects these blocks and makes the connection "unbreakable". One block consists of the outer header, the header, and the body of the block [4]. The outer block header identifies the blockchain platform and talks about the block size (maximum number of bytes in the block). The most important part is the block header because it contains information about the validation of the block and data about the previous block. The body of the block consists of a counter and a list of transactions.

The block header of each blockchain platform should contain the block version, the parent block hash, the nonce,

the timestamp, the Merkle root, and the hash target [4]. In the process of adding a block to the chain, the most important are the hash of the parent block (the result of a hash function with the header of the previous block as input), a nonce (changed through iterations) and the target hash (fixed hash value in the network).

B. Consensus protocols

The key part in using consensus protocols is determining the node that adds the next block in the chain. As the node does not know the true identities of other nodes in the network, it cannot have the complete trust in them [5]. This protocols serve to replace trust between nodes in the network in order to achieve a common goal. There are two main groups of the consensus protocols, and those are [4] [6]: Proof-of-X (PoX) and Byzantine Fault Tolerant (BFT) algorithms.

PoX algorithms, the first group of consensus protocols, are applied mostly to the public blockchain networks. They use computational calculations to select the node that adds the next block to the chain in a random manner. The main representative of this group is the Proof-of-Work (PoW) algorithm. Here the node can publish the next block through if it solves given cryptographic problem before other nodes. When calculating the solution for this problem, it is necessary to pay attention to the nonce and the target hash. As the target hash is fixed, nonce is the only value that can be influenced in order to reach a solution and to solve a problem. Nonce is incremented through iterations and a new block header hash is computed. This new computed hash is compared with the hash target. If the block header hash is less than or equal to the target hash, it is considered that a solution is found for the cryptographic problem [4]. The main motivation of the nodes to participate in this process of solving a hard cryptographic problem is the reward they receive after successfully adding the block to the chain.

BFT algorithms, the second group of consensus protocols, are based on the protocols of communication. Nodes have equal voices and can go through multiple rounds of communication to reach consensus between them. This group of algorithms is used with private blockchain networks. This is because they are better for networks where there is a smaller number of participants compared to public. Also, they allow faster confirmation of transactions. The main representative is the Practical Byzantine Fault Tolerant (PBFT) algorithm. The main feature of this algorithm is the fact that it does not allow the number of malicious nodes (out of all nodes in the network) to be greater than 1/3 [4]. If the number of malicious nodes in the network exceeds 1/3, consensus cannot be reached.

C. The working principle

As a block is a set of transactions, in order to add a new block in the chain a larger number of new transactions are necessary to occur. Creating and adding a new block to the chain is achieved through the following four steps [4]:

1. *The occurrence of the transaction*: Potentially, if two nodes want to interact with each other and they share the same network, a new transaction can be created (e.g. cryptocurrency transfer).
2. *Transaction propagation*: Propagation in the P2P network is done by the node sending a transaction to all its neighboring nodes. Further, these nodes continue to send that transaction to their neighboring nodes. This process is repeated until each node in the network receives that transaction.
3. *Validation of the (block) transaction*: before placing the transaction in the block, it is necessary to perform its verification by the network nodes. Transaction verification refers to the validation of its cryptographic hash. Upon successful verification, the transaction received approval to be added to the block. Then, it is necessary to find an agreement between the nodes on the validity of the block, that is. the nodes must agree on the order of occurrence of transactions and the calculated hash values of the block using the consensus protocol of the network.
4. *Transaction (block) confirmation*: This represents process of adding the block in the chain. Transaction confirmation occurs when more than a majority of the network agrees that the block (containing the given transaction) is valid and then they publish that block in the chain.

D. Smart contracts

Smart contracts were first proposed in 1994 by Nick Szabo, an American computer scientist who defined them as computerized transaction protocols that execute terms of a contract [7]. Smart contracts are just programs stored in a blockchain that run when predetermined conditions are met. Typically, they are used to automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary being involved. They can also be used to automate processes by triggering the next action when certain conditions are fulfilled.

Withi`e2jem5en a smart contract, there can be as many conditions as needed to satisfy the participants in terms of that the task will be completed according to a deal. When the participants agree upon all of the conditions needed, then the smart contract can be programmed by a developer (although increasingly, organizations that use blockchain for business provide templates, web interfaces, and other online tools to simplify structuring smart contracts) with a goal to implement all of the wanted conditions.

The benefits of using smart contracts [4]:

1. *Speed, efficiency and accuracy*: Once a condition is met, the contract is executed immediately. Because smart contracts are digital and automated, there is no paperwork to process which means there is no time spent on errors that often happen from manually filling in docu-

ments.

2. *Trust and transparency*: Since there is no third party involved, and because encrypted records of transactions are distributed and shared across the network, there is no need to question whether transactions have been altered for personal gain.
3. *Security:* Blockchain transaction records are encrypted, which makes them very hard to hack. Also, because each block is connected to the previous and next block, hackers would have to alter the entire chain to change a single transaction in a block.
4. *Savings:* Smart contracts are used to eliminate the need for mediators to manage transactions and their related time delays and fees.

III. FUZZY MCDM METHOD

The PROMETHEE method (Preference Ranking Organization Method for Enrichment Evaluation) is simple outranking method used in MCDM. This method can be utilized in order to find the best alternative based on an assessment of several specified criteria. Method is consisted of two phases [8]:

- The construction of outranking-relation on finite set of alternatives,
- utilization of this relation in order to give an answer to the multicriteria problem.

At first, an outranking-relation is created using pairwise comparison between alternatives based on a generalized criterion. Preference functions are defined and an outranking table is obtained. Considering for each action a leaving and an entering flow on the outranking table: a partial preorder (PROMETHEE I) or a complete preorder (PROMETHEE II) on the set of possible actions can be proposed in order to solve the decision problem.

In the paper, we will describe PROMETHEE method with the use of trapezoidal fuzzy numbers. Trapezoidal fuzzy numbers are used to express expert's opinion on alternatives regarding each criterion. Also, triangular and crisp numbers can be expressed using trapezoidal fuzzy numbers. The membership function of the trapezoidal fuzzy number can be written as [8][9]:

$$\mu(x) = \begin{cases} 0, & x \le x_l - \alpha \text{ or } x_u + \beta \le x \\ 1 - \dfrac{x_l - x}{\alpha}, & x_l - \alpha < x < x_l \\ 1, & x_l \le x \le x_u \\ 1 - \dfrac{x - x_u}{\beta}, & x_u < x < x_u + \beta \end{cases},$$

where α and β are the left and right spread of the trapezoidal fuzzy number. In the interval $[x_l, x_u]$ values x_l and x_u are the lower and upper boundaries of the numbers that belong with certainty to the set of available values. This trapezoidal fuzzy interval is represented by the following notation, $\tilde{x} = (x_l, x_u, \alpha, \beta)$.. The algebraic operations necessary for the algorithm are defined as follows [8][9]:

$$\tilde{x} + \tilde{y} = (x_l, x_u, \alpha, \beta) + (y_l, y_u, \gamma, \delta) = (x_l + y_l, x_u + y_u, \alpha + \gamma, \beta + \delta),$$

$$-\tilde{x} = -(x_l, x_u, \alpha, \beta) = (-x_u, -x_l, \beta, \alpha),$$

$$\tilde{x} - \tilde{y} = (x_l, x_u, \alpha, \beta) - (y_l, y_u, \gamma, \delta) = (x_l - y_u, x_u - y_l, \alpha + \delta, \beta + \gamma),$$

$$\tilde{x} \cdot \tilde{y} = (x_l, x_u, \alpha, \beta) \cdot (y_l, y_u, \gamma, \delta) \approx (x_l \cdot y_l, x_u \cdot y_l, x_l\gamma + y_l\alpha - \alpha\gamma, x_u\delta + y_u\beta + \beta\delta).$$

The fuzzy PROMETHEE method is defined as [8]:

Step 1. For each criterion f_k it is necessary to define a generalised preference function $p_k(d)$.

Step 2. Also, for all criterions the fuzzy weights are defined

$$\tilde{w}_k = \left(x_l^k, x_u^k, \alpha^k, \beta^k\right), k = 1, \ldots, K.$$

Step 3. For all the alternatives $a_t, a_{t'} \in A$ the fuzzy outranking-relation $\tilde{\pi}$ is defined as:

$$\tilde{\pi}: \begin{cases} A \times A \to [0,1] \\ \tilde{\pi}(a_t, a_{t'}) = \sum_{k=1}^{K} \tilde{w}_k p_k\left(\tilde{d}(a_t, a_{t'})\right), \end{cases}$$

where $\tilde{d}(a_t, a_{t'})$ is fuzzy difference of evaluation between two actions defined as:

$$\tilde{d}(a_t, a_{t'}) = \tilde{f}_k(a_t) - \tilde{f}_k(a_{t'}) = (x_l, x_u, \alpha, \beta) - (y_l, y_u, \gamma, \delta) = (x_l - y_u, x_u - y_l, \alpha + \delta, \beta + \gamma),$$

and where $p_k(\tilde{d}(a_t, a_{t'}))$ is expressed as:

$$p_k(\tilde{d}(a_t, a_{t'})) = \Big(p_k(x_l - y_u), p_k(x_u - y_l), \left(p_k(x_l - y_u) - p_k(x_l - y_u - \alpha + \delta)\right), \left(p_k(x_u - y_l + \beta + \gamma) - p_k(x_u - y_l)\right)\Big).$$

Step 4. Measure of the strength of the alternatives $a_t \in A$, *the fuzzy leaving flow* $\tilde{\Phi}^+(a_t)$ is defined as:

$$\tilde{\Phi}^+(a_t) = \frac{1}{T-1}\sum_{t'=1,t'\neq t}^{T} \tilde{\pi}(a_t, a_{t'}).$$

Step 5. Measure of the weakness of the alternatives $a_t \in A$, the fuzzy entering flow $\tilde{\Phi}^-(a_t)$ is defined by the following expression:

$$\tilde{\Phi}^-(a_t) = \frac{1}{T-1}\sum_{t'=1,t'\neq t}^{T} \tilde{\pi}(a_{t'}, a_t).$$

Step 6. The defuzzification of the fuzzy leaving and entering flow is necessary in order to rank alternatives. The selected defuzzification approach, based on the Centre of Area (COA), is defined as:

$$x_{defuzz} = \frac{\int x\mu(x)dx}{\int \mu(x)dx} = \frac{x_u^2 - x_l^2 + \alpha x_l + \beta x_u + \frac{1}{3}(\beta^2 - \alpha^2)}{\alpha + \beta + 2x_u - 2x_l}.$$

In the following, methods PROMETHEE I and PROMETHEE II will be presented and shortly explained. The essence of the PROMETHEE methods is in determining the preference of each alternative compared to each other (pairwise comparison), according to each of the criteria, using the preference function in order to obtain the rank of alternatives, either partial or complete. The rank of an alternative based on the value of $\Phi^+(a_t)$ usually differs from the rank obtained on the basis of the value of $\Phi^-(a_t)$. PROMETHEE I by crossing the information about the values of these two characteristics, gives a partial ranking of alternatives. Possible relations of alternatives in PROMETHEE I may be preference (P^I), indifference (I^I) and incomparability (R^I) [10]. If it is not enough to get only a partial ranking of alternatives to solve a certain problem, it is necessary to apply the PROMETHEE II method. This method is used to obtain a complete ranking of alternatives. In this case, the net flow of dominance is calculated, which represents the balance between the leaving and entering flow of dominance:

$$\Phi(a_t) = \Phi^+(a_t) - \Phi^-(a_t),$$

and is used to establish a relation between alternatives. Those relations can only be preference (P^{II}) and indifference (I^{II}) [10].

IV. SOLVING MCDM PROBLEM WITH FUZZY PROMETHEE

The procedure based on the proposed algorithm for fuzzy PROMETHEE is demonstrated through the selection of the best blockchain platform for the implementation and use of smart contracts.

A. MCDM problem description

There are a growing number of technological solutions on the market that are based on blockchain technology in which global companies participate. Due to that, blockchain technology becomes very interesting for research. Illustrative example presented in this paper includes choosing a blockchain platform to use for smart contracts functionality.

In the general case, the alternatives (blockchain platforms) to choose from can be written as $A = \{a_t \mid t = 1, \dots, T\}$. In this example, a choice is made between four alternatives ($T = 4$) , and they are: Ethereum, Hyperledger Fabric, Cardano and Waves. Alternatives (blockchain platforms) are marked as a_1 (Ethereum), a_2 (Hyperledger Fabric), a_3 (Cardano), and a_4 (Waves). a_1 (Ethereum) is a decentralized blockchain platform that establishes a peer-to-peer network and it is most commonly known for its native cryptocurrency (ETH) as well as the popularization of smart contracts and Non-Fungible Tokens (NFTs) [11]. a_2 (Hyperledger Fabric), an open source project from the Linux Foundation, is the highly modular and configurable blockchain framework intended as a foundation for developing enterprise-grade applications and industry solutions [12]. a_3 (Cardano) aims to be the most scalable and environmentally sustainable blockchain platform through use of PoS consensus protocol [13], as opposed to the energy-intensive PoW currently used by Bitcoin and Ethereum. a_4 (Waves) is a blockchain platform that focuses on scalability, interoperability, environmental friendliness, and makes it easy to create custom crypto tokens (known as smart assets) and launch smart contracts that power a range of decentralized applications (dApps) [14].

In addition to the mentioned and briefly explained alternatives, it is necessary to state and explain the criteria according to which their comparison will be performed. In the general case, the set of selected criteria can be written as $F = \{f_k \mid k = 1, \dots, K\}$. This example considers fourteen criteria ($K = 14$), including: maturity (f_1), scalability (f_2), decentralization (f_3), transparency (f_4), immutability (f_5), interoperability (f_6), block time (f_7), supporting cooperation and data exchange with other software (f_8), electricity consumption (f_9), number of programming languages (f_{10}), virtual machine testing (f_{11}), standardization and support (f_{12}), costs of use (f_{13}), and migration (f_{14}). The criteria are divided into two groups: characteristics of the blockchain platform and characteristics of the smart contracts. The first 9 criteria belong to the first group, while the remaining 5 criteria belong to the second group. f_1 (maturity) is an assessment of the maturity of the blockchain platform based on years of existence, market share, number of transactions and users, etc. f_2 (scalability) refers to supporting a large number of nodes and transactions in the blockchain network. f_3 (decentralization) describes the transfer of control and decision-making from a centralized entity (individual, organization or group) to a distributed blockchain network. f_4 (transparency) refers to the availability and traceability of data and transactions in the

blockchain to everyone and at any time. f_5 (immutability) is a feature that in the blockchain remains a permanent and unchanged history of all transactions that have taken place. f_6 (interoperability) refers to the ability of different blockchain platforms to exchange and use data with each other. f_7 (block time) represents the mean time required to add a new block to the chain, which means that the transaction is considered to be permanently registered (expresses in seconds). f_8 (supporting cooperation and data exchange with other software) considers collaboration and data exchange across different application programming interfaces (APIs). f_9 (electricity consumption) depends on the consensus protocol used by the blockchain platform (e.g. PoW generates the highest, while the PoS generates the lowest consumption). f_{10} (number of programming languages) represents the number of programming languages that can be used to program smart contracts, where the focus is on the official programming languages of the blockchain platform. f_{11} (virtual machine testing) refers to possibility of running and testing smart contracts in testing environment (essential for developers, not end users). f_{12} (standardization and support) represents the existence of a large community that contributes to the development of smart contracts, the elimination of security problems in code that hackers can exploit, the existence of documentation for learning, understanding, etc. f_{13} (costs of use) refers to the costs of creating, running and using a smart contract in a blockchain network (mostly depends on the size of the smart contract, i.e. the amount of bytecode of the smart contract). f_{14} (migration) represents the possibility of migrating a smart contract from one blockchain platform to another.

Also, in addition to alternatives and criteria, it is necessary to determine the weights for each of the criteria. The set of weights can be written as $\tilde{W} = \{\tilde{w}_k \mid k = 1, \dots, K\}$. For this case, triangular fuzzy numbers were used to represent weights for each criterion. Here, triangular fuzzy numbers are represented as a specific case of trapezoidal fuzzy numbers. The linguistic values and the corresponding triangular fuzzy values for each criterion are given in Table 1.

Table 1. Linguistic values and corresponding fuzzy numbers

Linguistic values	Fuzzy numbers
Very Poor (VP)	(0,0,0,0.15)
Poor (P)	(0.2,0.2,0.1,0.1)
Medium Poor (MP)	(0.3,0.3,0.1,0.1)
Fair (F)	(0.5,0.5,0.2,0.2)
Medium Good (MG)	(0.7,0.7,0.1,0.1)
Good(G)	(0.8,0.8,0.1,0.1)
Very good (VG)	(1,1,0.15,0)

Generally speaking, expert assessments can be used to determine the weights of the criteria, where a set of experts can be written as $E = \{E_i \mid i = 1, \dots, N\}$. Each expert gives his assessment for each of the criteria using linguistic value. We will assume that the significance of each of the experts involved in decision-making process is the same. After that, it is necessary to aggregate expert assessments which gives the final weights ($\tilde{w}_k$) of each of the criteria. This can be achieved by using the following equations:

$$\tilde{w}_k^i = \left(x_{uk}^i, x_{lk}^i, \alpha_k^i, \beta_k^i\right), i = 1, \dots, N,$$

$$\tilde{w}_k = \left(\frac{1}{N}\sum_{i=1}^{N} x_{uk}^i, \frac{1}{N}\sum_{i=1}^{N} x_{lk}^i, \min_i \alpha_k^i, \max_i \beta_k^i\right),$$

where $\tilde{w}_k^i$ are fuzzy numbers that correspond to experts assessments.

For the purposes of the example in this paper, three experts ($N = 3$) gave their assessments for each of the criteria whose aggregation gives the final weights. These values, represented by triangular fuzzy numbers, are given in Table 2.

Table 2. Aggregated weight of the criteria assessed by the experts along with p and q values for preference function

Criteria	Aggregated weight	p	q
f_1	(0.93,0.93,0.23,0.07)	0.10	0.07
f_2	(0.77,0.77,0.17,0.13)	0.11	0.08
f_3	(0.77,0.77,0.17,0.13)	0.04	0.03
f_4	(0.70,0.70,0.10,0.10)	0.05	0.04
f_5	(0.87,0.87,0.17,0.13)	0.04	0.03
f_6	(0.63,0.63,0.33,0.17)	0.06	0.04
f_7	(0.27,0.27,0.17,0.13)	21.08	14.95
f_8	(0.43,0.43,0.23,0.27)	0.10	0.08
f_9	(0.73,0.73,0.13,0.17)	0.11	0.08
f_{10}	(0.50,0.50,0.20,0.20)	0.71	0.50
f_{11}	(0.30,0.30,0.10,0.10)	0.36	0.25
f_{12}	(0.93,0.93,0.23,0.07)	0.08	0.06
f_{13}	(0.80,0.80,0.10,0.10)	0.10	0.07
f_{14}	(0.63,0.63,0.33,0.17)	0.21	0.15

Lastly, before applying the fuzzy PROMETHEE method described in Chapter III, it remains to fill in the decision-making table by entering the values of alternatives according to each of the criteria. Values from decision-making table can be written as $\tilde{X} = \{\tilde{x}_{tk} = \tilde{f}_k(a_t) \mid t = 1, \dots, T;\ k = 1, \dots, K\}$. In this example, the values of the decision-making table are entered through two approaches. The second approach was mostly used in the considered example, as the first approach was used only for f_7, f_{10} and f_{11}. The first approach is to collect values from the relevant literature ([15][16][17][18][19][20]) for all alternatives according to criteria f_7, f_{10} and f_{11}. These values are exact or crisp values. The second approach is to enter the value through the evaluation of each alternative according to certain (remaining) criteria by experts. Evaluation by experts is performed using lin-

guistic values (Table 1). After that, the expert assessments are aggregated to obtain the final values ($\tilde{x}_{kt}$) for the decision-making table using the following equations:

$$\tilde{x}_{kt}^{i} = \left(x_{ukt}^{i}, x_{lkt}^{i}, \alpha_{kt}^{i}, \beta_{kt}^{i}\right), i = 1, \ldots, N,$$
$$\tilde{x}_{kt} = \left(\frac{1}{N}\sum_{i=1}^{N} x_{ukt}^{i}, \frac{1}{N}\sum_{i=1}^{N} x_{lkt}^{i}, \min_{i} \alpha_{kt}^{i}, \max_{i} \beta_{kt}^{i}\right),$$

where $\tilde{x}_{kt}^{i}$ are fuzzy numbers that correspond to experts assessments.

It should be noted that all criteria are maximized, except criterion f_7 which is minimized. Using these two approaches, the final values of the decision-making table for each alternative for each of the criteria were obtained (Table 3).

The decision-making table is complete, i.e. alternatives and criteria have been entered and the weights of criteria and values in the table have been determined. It is now possible to apply the fuzzy PROMETHEE method and perform the analysis of the obtained results. Linear criterion with preference and indifference area is used as the preference function for all criteria in this example. Thresholds of indifference (p) and preference (q) for this criterion are shown in Table 2.

B. Result analysis

By applying the fuzzy PROMETHEE method over the decision-making table, the defuzzified values for entering, leaving and net flow are shown in Table 4.

Table 4. Defuzzified values of the leaving, entering and net flow

	a_1	a_2	a_3	a_4
$\Phi^{-}(a_t)$	3.1265	5.4440	1.6339	1.7525
$\Phi^{+}(a_t)$	2.7314	1.1838	3.4309	3.9934
$\Phi(a_t)$	0.3951	4.2602	-1.7970	-2.2409

Using values from Table 4, it is possible to apply PROMETHEE I and PROMETHEE II methods. Firstly, we will discuss the application of the PROMETHEE I method, which provides a partial rank of alternatives. Basically, the higher the leaving flow (Φ^{+} value) and the lower the entering flow (Φ^{-} value) the blockchain platform is better for using smart contracts. By analyzing the results, the following relation between alternatives can be established $a_2\ P^I\ a_1\ P^I\ a_3\ R^I\ a_4$. In other words, we see that a_2 (Hyperledger Fabric) is the best blockchain platform (preferred over the rest), then a_1 (Ethereum) which is preferred over platforms a_3 (Cardano) and a_4 (Waves), but worse than a_2 (Hyperledger Fabric), and that a_3 (Cardano) and a_4 (Waves) are the worst and incomparable. Secondly, in order to get a clear picture of alternative relations, we use the PROMETHEE II method. This method provides a complete rank of alternatives. The higher the net flow (Φ value) the blockchain platform is better for using smart contracts. By comparing values between alternatives, we get the following relation $a_2\ P^{II}\ a_1\ P^{II}\ a_3\ P^{II}\ a_4$. From this relation, we can see that that a_2 (Hyperledger Fabric) is the best blockchain platform (preferred over the rest), then a_1 (Ethereum) which is preferred over platforms a_3 (Cardano) and (Waves), then (Cardano) and finally a_4 (Waves). a_2 (Hyperledger Fabric) is determined to be the best blockchain platform out of all platforms considered in this paper. Also, it is determined that a_4 (Waves) is the worst platform (Fig. 1).

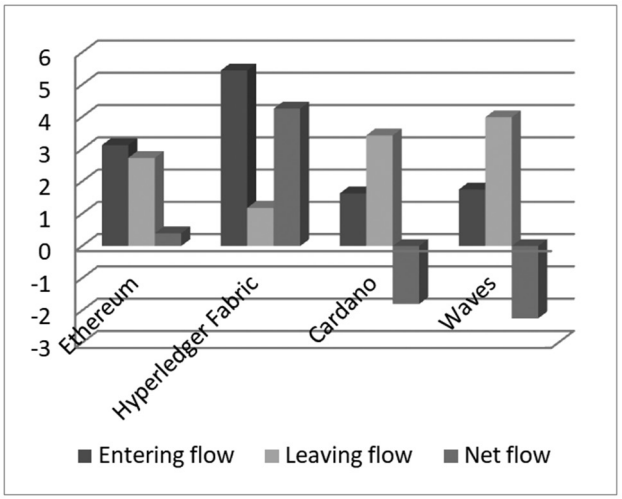

Fig. 1. Fuzzy PROMETHEE I and II partial and complete rank

V. CONCLUSION

Over the years, blockchain technology has become an increasingly relevant for study, testing and implementation attempts. This is mostly because of the smart contracts. Therefore, the number of blockchain platforms offering smart contract functionality has grown significantly. As a result, the goal is to select the best blockchain platform (alternative) for using smart contracts according to selected criteria. To solve this problem, the fuzzy MCDM method has been used. This paper proposes the fuzzy PROMETHEE method based on trapezoidal fuzzy numbers as a possible solution. Using PROMETHEE I and PROMETHEE II methods, partial and complete rank of the blockchain platforms were obtained, respectively. The obtained results of complete rank shows that Hyperledger Fabric is the best ranked alternative. This tells us that this blockchain platform is the most suitable for using and developing smart contracts. This is an important conclusion that may be of use to various companies that want to implement blockchain technology and its functionality of smart contracts, but are not sure which blockchain platform to choose.

Future research may involve considering a higher number of alternatives and/or criteria, a higher number of experts, or the use of other MCDM methods to compare their results.

Table 3.Aggregated values of the decision-making table assessed by the experts

$\tilde{X}$	a_1	a_2	a_3	a_4
$\tilde{f}_1$	(1,1,0.15,0)	(0.80,0.80,0.10,0.10)	(0.37,0.37,0.17,0.33)	(0.63,0.63,0.33,0.17)
$\tilde{f}_2$	(0.50,0.50,0.20,0.20)	(0.87,0.87,0.17,0.13)	(0.77,0.77,0.17,0.13)	(0.73,0.73,0.13,0.17)
$\tilde{f}_3$	(0.87,0.87,0.17,0.13)	(0.83,0.83,0.23,0.17)	(0.87,0.87,0.17,0.13)	(0.93,0.93,0.23,0.07)
$\tilde{f}_4$	(0.77,0.77,0.17,0.13)	(1,1,0.15,0)	(0.73,0.73,0.13,0.17)	(0.77,0.77,0.17,0.13)
$\tilde{f}_5$	(0.77,0.77,0.17,0.13)	(0.87,0.87,0.17,0.13)	(0.93,0.93,0.23,0.07)	(0.73,0.73,0.13,0.17)
$\tilde{f}_6$	(0.80,0.80,0.10,0.10)	(1,1,0.15,0)	(0.77,0.77,0.17,0.13)	(0.80,0.80,0.10,0.10)
$\tilde{f}_7$	(14,14,0,0)	(0.2,0.2,0,0)	(20,20,0,0)	(60,60,0,0)
$\tilde{f}_8$	(0.80,0.80,0.10,0.10)	(0.80,0.80,0.10,0.10)	(0.50,0.50,0.20,0.20)	(0.70,0.70,0.10,0.10)
$\tilde{f}_9$	(0.50,0.50,0.20,0.20)	(0.87,0.87,0.17,0.13)	(0.80,0.80,0.10,0.10)	(0.70,0.70,0.10,0.10)
$\tilde{f}_{10}$	(3,3,0,0)	(2,2,0,0)	(2,2,0,0)	(1,1,0,0)
$\tilde{f}_{11}$	(1,1,0,0)	(1,1,0,0)	(0,0,0,0)	(0,0,0,0)
$\tilde{f}_{12}$	(1,1,0.15,0)	(0.93,0.93,0.23,0.07)	(0.37,0.37,0.17,0.33)	(0.63,0.63,0.33,0.17)
$\tilde{f}_{13}$	(0.57,0.57,0.27,0.23)	(1,1,0.15,0)	(0.77,0.77,0.17,0.13)	(0.87,0.87,0.17,0.13)
$\tilde{f}_{14}$	(1,1,0.15,0)	(0.80,0.80,0.10,0.10)	(0.27,0.27,0.17,0.13)	(0.01,0.01,0.01,0.29)

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Analysis of potential NFT applications

Vukašin Despotović
University of Belgrade
Faculty of Organizationsl Sciences,
Belgrade, Serbia
despotovic@ooxcit.com

Daniel Bjelica
University of Belgrade
Faculty of Organizationsl Sciences,
Belgrade, Serbia
daniel.bjelica@gmail.com

Dušan Barać
University of Belgrade
Faculty of Organizationsl Sciences,
Belgrade, Serbia
dusan@elab.rs

Abstract— The Non-Fungible Token (NFT) market has seen a huge leap in popularity in previous year (2021). Sales of nonfungible tokens have increased from $82 million in 2020 to $17.6 billion in 2021 reflecting a huge spike of interest in the new technology. Over 2.4 million new crypto wallets started trading NFTs in 2021, as compared to only 89,000 in 2020. This sudden increase in popularity has attracted huge attention from industrial and scientific communities. It was widely debated whether NFT ecosystems are the next step in the internet evolution, or they will never find their place in the real world. The non-fungible token technology is in its early stage, and currently it is mostly used in collectibles, arts, and gaming industry. In this paper, we will explore other possible applications of NFT technology in the future.

Keywords - NFT, Ethereum, Blockchain, Smart Contracts, dApps

I. INTRODUCTION

Non-Fungible Token (NFT) is a type of unique and indivisible blockchain-based crypto token, introduced with EIP-721 (Ethereum Improvement Proposals) [1]. As opposed to other, classical cryptocurrencies which are defined by value, NFT's cannot be interchangeable for other tokens as they are defined by their own unique properties [2]. They give us the ability to assign or identify ownership of any unique piece of digital data, trackable by using Ethereum's blockchain as public ledger. Historically, NFTs were mostly used to represent ownership of digital art and collectibles, but they can also be used to represent physical and real-world items such as deeds to a car, tickets to an event, legal documents, signatures etc. One of the earliest examples of a commercial NFT would be a project called Crypto Punks, created by LarvaLabs in 2017. It was a collection of 10,000 uniquely generated 8-bit collectible characters on the blockchain [3]. Even though they are just digital images, they are deemed as an important piece of internet history, and the cheapest Crypto Punk costs over $100,000 today. It is worth mentioning that depending on their properties and rarity, the prices of Crypto Punks differ, most expensive one in the collection (#5822) was sold for roughly $24 million. Another example showing the mind-blowing value of NFTs is the work of a famous digital artist, Beeple, whose art piece called "Everydays-The First 5,000 Days" was sold for $69.5 million in form of an NFT in March 2021 [4]. This craze has attracted attention of media globally, which resulted in influx of millions of new investors. Arts and collectibles have pushed NFTs into the mainstream, and other categories such as gaming have soon followed the lead. Projects like Crypto Kitties and Axie Infinity have spearheaded the growth of gaming NFT's [5][6]. Slowly but surely, the technology is making its way into other industries as well. In the continuation of the paper, we will be looking at the technological innovations which were used as a foundation for NFTs, and we will be discussing possible future application of NFTs in ticketing, medical, entertainment, business, real estate, and finance industry.

II. TECHNOLOGICAL FOUNDATIONS OF NFT

A. Blockchain

The blockchain can be described as a distributed database that maintains a list of all records in blocks of data which are protected and linked to each other using cryptographic protocols. Each transaction is validated by consensus of majority of participants before being grouped into a block and added to the chain. Each block is cryptographically linked to the previous one and replicated across copies of the entire ledger within the network. There is a set of rules established to automatically resolve any possible conflicts. This concept, combined with several other technologies was used by Satoshi Nakamoto in 2008 to propose an idea of peer-to-peer electronic cash, effectively creating Bitcoin [7]. The first of many modern cryptocurrencies. The most widely used blockchain in NFT schemes is Ethereum, while Solana, Binance Smart Chain, Cardano, Algorand and many other blockchains are becoming increasingly popular as well.

B. Ethereum

The idea for Ethereum was first published by Vitalik Buterin in 2014, setting the foundation for its launch in 2015 [8]. Just like bitcoin, it is using blockchain technology, with Ether (ETH) being its main cryptocurrency. As opposed to bitcoin, Ethereum can execute and run programmable code on its network. To put it simply, it is be-

having like a global and decentralized virtual computer, whose state every participant in the network agrees on. This innovation has made Ethereum the foundation for many emerging technologies, such as DeFi (Decentralized Finance), DAOs (Decentralized Autonomous Organizations) and NFTs. Some of the benefits of Ethereum are: Zero Downtime, Privacy, Resistance to Censorship, Complete data integrity, Trustless Computation [9].

1) DeFi (Decentralized Finance)

DeFi is an umbrella term for all financial products and services accessible through Ethereum. With DeFi, there is no centralized authority who can block payments or deny access to anyone. Services like lending, borrowing, token trading and crowdfunding that were previously prone to human errors are now automatic and handled by open-source code that can be inspected and verified by anyone [10].

2) DAO (Decentralized Autonomous Organizations)

DAOs are an effective and safe work to create organizations with unknown parties around the world. Simply put, it is an organization collectively owned and managed by its own members. All decisions and proposals are governed by voting, ensuring every member has a voice. There is no central authority, everything is controlled by a publicly available code [11].

C. Smart Contracts

The concept of smart contracts was first introduced by Nick Szabo in 1996 [12]. Ethereum further developed his idea, applying it onto the blockchain. Essentially, smart contracts are enabling unfamiliar parties to conduct fair exchange and automatically enforce contractual terms of an agreement without need for a third party. In oversimplified terms, as described by Nick Szabo, they can be compared to a vending machine – with the right inputs, a certain output is guaranteed. Just like a vending machine can remove the need for a vendor employee, smart contracts can replace third parties in many different industries.

Anyone can create a smart contract and deploy it on the blockchain, and anyone can interact with the contract if the fee is paid to the network [13]. Ethereum's primary programming language, Solidity, is a Turing complete language, giving a lot of flexibility to developers. Most NFT projects are relying on smart contract-based solutions for implementing sale agreements, verifying ownership, handling transferability, limiting the supply and many other functions.

D. Address and Transaction

A blockchain based address is consisting of a fixed number of alphanumeric characters. It is used as a unique identifier for users to send and receive assets. In order to transfer any assets on the blockchain, including NFTs, the transactor must prove he is in possession of the corresponding private key and sign the transaction with a correct digital signature. Nowadays, this operation is simplified with the rise of popularity of cryptocurrency wallets such as MetaMask, TrustWallet, Trezor, Ledger Nano and others.

III. NFT APPLICATIONS

Figure 1 shows a taxonomy of possible NFT applications, dividing it into physical and digital assets.

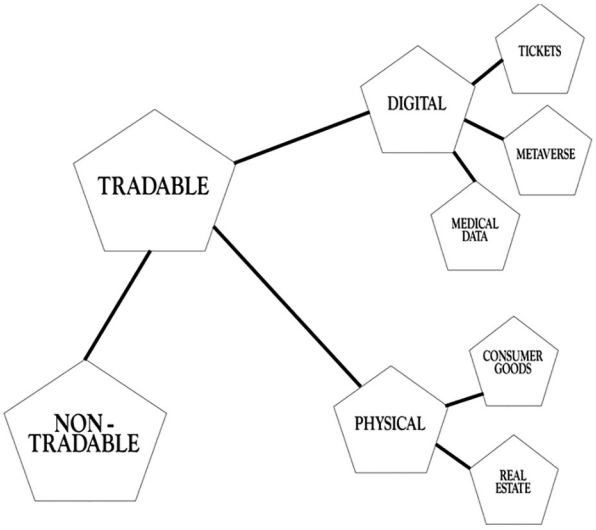

Fig. 1 – Taxonomy of NFT applications

The possibility of identifying ownership of anything on the blockchain is allowing us to trade both digital and physical goods using the NFT technology. This section will explore and discuss possible future applications through several examples. Some of the proposed solutions are already in the works, and some are just theories of what can be done.

A. Ticketing

Digitalization of tickets has pushed the entire industry forward, leaving behind many of the problems which were tied to physical tickets, such as: cost of printing and distributing, possibilities of losing or damaging the ticket before the event and many others. New, digital tickets in form of QR codes got rid of these problems, both for the event goers and organizers, still, a lot more can be done to improve the business. Fraud is still very much present in the ticketing industry, a lot of secondhand ticket buyers are prone to scams, there is no way to know whether a ticket they are buying is real, or fake. On the other hand, the organizers do not earn any additional revenue on secondhand sales, while customers must pay much higher

prices, which is a loss for both sides. These problems can be solved by implementing NFT technology. The transfer of tickets from the initial sale, all the way to secondhand sales would be stored on the blockchain immutably, and all parties could prove the tickets authenticity with ease. As a programmable digital asset, NFTs can have built in rules for royalty splits, which means that everyone participating in organization of an event can receive their part of the earning directly from the smart contract, removing the need for unnecessary third parties. Event after the event, tickets would stay as collectibles in the customers crypto wallet, possibly being re-sold to other collectors with ease.

B. Metaverse

Metaverse is the idea of a perpetual and persistent multiuser virtual environment unifying physical and digital reality. This concept is not necessarily new, in early 2000's, massive multiplayer games such as "Second Life" and "World of Warcraft" were already textbook examples of a Metaverse [14][15]. In case of Second Life, users could create their own content or services and trade with other people. Players could also enjoy many different real-world experiences such as working, partying and even purchasing and renting out virtual properties. The game had its own virtual economy, and virtual currency which could be exchanged with real-world currencies. Even though the idea itself has been around for over 20 years, recent advancements in technologies such as VR (Virtual Reality), AR (Augmented Reality) and MR (Mixed Reality) have brought it to the forefront of tech industry. Rapid development of blockchain technology has created an opportunity to create a new, more appealing type of Metaverse, in which all assets are owned by the players instead of centralized companies. By utilizing NFT technology, ownership of every asset in the virtual world would be easily trackable, and tradable. One of the pioneers a project called Decentraland - it is a virtual reality platform powered by the Ethereum blockchain, in which users can create, experience, and monetize content in applications [16]. Every piece of land in Decentraland is permanently owned by the community through Non-Fungible Tokens acquired by spending an ERC20 token called MANA. Unlike previously mentioned Second Life, Decentraland is not controlled by a centralized organization. No single entity has the power to modify the rules, contents, or economics of their metaverse. A single piece of virtual land in Decentraland currently costs several thousand dollars and is one of the most traded NFTs on OpenSea, with over 185 thousand Ethereum in trade volume (currently worth around 379 million dollars) [17]. Their native token MANA has a market cap of over 2 billion dollars, making it one of the world's top cryptocurrencies [18]. Even though Decentraland is still in early phases of development, based just on the trading volume, it is evident that the idea of a decentralized metaverse is very popular among the public.

C. Real Estate

NFT technology has a huge potential in tokenizing real world assets. Theoretically, owners could issue a token that represents their property, and this token could be sold to interested buyers, completing the process of transferring the ownership with ease. All the information about the property, including when it was built, who was the first owner, how many times it was sold and for what price would be stored on the blockchain without the possibility of tampering. Another benefit of NFTs could be the fractional ownership of real estate. A single expensive property could be split into several tokens and sold to several different investors who would receive percentage of rental income or capital appreciation upon sale through a DAO. Doing this would require no interaction between the investors, there would be no need for a third party, and it would give more people a chance to invest in the real estate market, potentially increasing its overall liquidity. Token being tied to a real-world valuable asset would open more opportunities for decentralized finance as well. Getting loans without ever going to a bank would be possible through various DeFi applications. The property token could be used as a collateral and locked in a pre-defined smart contract until repaying the pre-set amount. Similar concept of decentralized lending already exists through various platforms such as AAVE, with fungible tokens being accepted as collateral [19].

D. Authenticity of products

According to a report by the Organization for Economic Cooperation and Development (OECD), trade of fake merchandise accounts for 3.3% of global trade. Majority of the globally counterfeited merchandise consist of wearing apparel, footwear, clothes [20]. These goods are usually much lower-quality products, and their sales hurt the brand identity and company revenue, but they do not impose as big of a threat as fake pharmaceuticals for example. Counterfeit pharmaceuticals and personal care products can jeopardize customers health and safety, and it is very important to find new solutions to fight this problem. As per WHO's estimates, 1 in 10 medical products in low and middle-income countries is substandard or falsified [21]. Various tests have identified drugs containing unhygienic or dangerous materials like brick dust, sheetrock, and printer ink [22]. Merck KGaA has reported that counterfeit antimalarial drugs alone could be responsible for the deaths of up to 155,000 children annually [23]. Pharmaceutical supply chains usually span across multiple different countries, making it very difficult to track and authenticate genuine product. Implementing NFT technology could become a solution for authentication of genuine products. Blockchain technology could allow us to trace the product from its creation to the final destination, without the possibility of tampering with the information or adding more units. Every unit in the starting pharmaceutical factory can be tokenized on the blockchain, containing necessary information such as: Serial Number, Ownership, Name,

Expiration Date, Active Principle, Company Name, Description etc. Only the creator of the smart contract could change the data, and it would be publicly visible. When the package physically leaves the factory and is distributed to the next point in the chain of supply, the ownership of the NFT will be transferred as well, with the transfer being publicly visible on the ledger. Once the final product is sold to the customer, the NFT ownership will be changed to an address which no one has the control of, burning it, so it cannot be sold again. Applying this method, it would be very easy for the customer to check the authenticity of the product they are buying. If for example, they check the information, and see that the product was produced at Factory A, sent to warehouse B, which sent it to pharmacy C, if they encounter the product in any other pharmacy, they can be sure that it is fake. There would be no way to add additional fake products in the middle of the supply chain, as any additionally created product, would not have a valid ID and history dating back to the production factory. Same system could also be used with different type of products, such as luxury goods, electronics, vehicle parts etc.

E. Medicine

Most medical information is digitized and saved in electronic health records. This data is not used by physicians exclusively, instead, medical researchers and companies are purchasing it in large, anonymized sets as well. While this is very important for the advancements in medical industry, it is also posing an ethical question. Large amounts of sensitive, personal health information are being traded legally, outside of patient's awareness. While the data is anonymized, there is no reason to believe that it cannot be deanonymized using modern computer advancements. According to Kristin Kostick-Quenet, a medical ethicist at Baylor University, the current system is favoring the companies which control access to health records, instead of being centered around the interests of the patients whose data is being used. There is no way for patients to know, if they're data is being sold, how much it is being sold for, or what is it being used for. NFT technology could provide a solution, which would increase the overall transparency and include the patients in the whole process. By tokenizing medical data as an NFT on the blockchain, and by leveraging the possibilities of smart contracts, patients would be able to pre-decide how their data can be used. For example, patients could set a rule, that they are allowing their data to be used for academic research, but not for commercial use. They'd be able to see who requested access to their data, what was it used for, and even get a cut from the sale of their data [24].

IV. CONCLUSION

NFT is a young, emerging technology which could change the future and reshape the market of digital and physical assets. In years ahead of us, there are many challenges standing in the way of mass adoption. Scalability and performance are some of them. Most of NFTs are minted on Layer-1 blockchains such as Ethereum, where high gas fees and high network congestion can be an issue. During peak times, a simple mint execution can cost up to 300$ per NFT. Recently, during the mad rush to mint Otherdeed NFTs, investors have spent approximately $157 million in gas fees to mint only 55,843 tokens [25]. On average, around $2800 was spent on fees per each NFT. In addition, current Proof-Of-Work system employed by Ethereum is known to leave a very high carbon footprint, which is problematic for the environment. A single NFT minting equals to around 100 KgCO2, with every additional transaction adding up. For example, an NFT which was minted and sold several times could equal to 500 + KGCO2 which is comparable to pollution of a 5+ hour long flight [26]. Although it won't solve this problem completely, Ethereum's upcoming switch to Proof-Of-Stake will substantially lower the carbon footprint, lower the gas price, and increase transaction speed [27]. Security is also a very important issue – people all over the globe are getting hacked and scammed daily. Usually, in centralized systems, money can be refunded, stolen items can be given back, and passwords can be changed. In a decentralized system, there is no central authority that could help the aggrieved party. Same people losing their Facebook password in phishing email attacks today, could lose their property deed in the same attack tomorrow if nothing is done about security. Currently, only 25% of U.S. adults are familiar with NFT, while only 7% are active users, that is not a surprise, seeing as how complex participation in the market is at the moment [28]. To reach mass adoption, this space needs to adapt a more user-friendly approach. For now, NFTs have revolutionized digital art market, giving artists around the world a new way to monetize their work without restrictions. Time will show whether this technology will mature enough and revolutionize above mentioned industries as well, or it will burst like a bubble many are expecting it to be.

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Register as a tool to fight utility NFT rug pull

mr Miodrag Šljukić

PhD student Department of e-Business
Faculty of Organizational Sciences
Belgrade, Serbia
miodrag.sljukic@gmail.com

Abstract— Along with the enormous popularity of NFTs (non-fungible tokens) in the last years came scams and frauds. Rug pull happens when originators of a project raise the capital from the sale of tokens and then do not deliver NFT because they never intended to. This paper is a case study of an attempt to fight utility NFT rug pull. It analysis the NFTsReg project and emphasizes the benefits that interested parties gain from such a project. The results show that introducing a register of utility NFTs and verification of the authenticity of the project and project stuff increases the reliability of the project, and hence adds value for all participants in the process. Additional tools promote building long-term relationship between project owners and investors encouraging the quest for quality utility NFT projects. The sources of financing register are membership fee and a fee for additional services provided by the register chargeable to both investors and project owners.

Keywords - scam prevention, utility NFT project verification, utility NFT investor, NFTsReg

I. INTRODUCTION

NFT is first introduced in 2017 and gained huge popularity since then. In 2021. the value of all NFT transactions was $17.6 billion, compared to $82.5 million in 2020. Most of this amount, almost $8.5 billion, was spent on collectibles, while utility NFT made more than $530 million. Some analysts predict that the total value of transactions will go up to $80 billion by 2025 [5].

NFT is unique digital representation of a digital or physical asset [14]. It is not fungible, meaning that every token has its unique value, making it impossible to replace two NFTs with each other. They represent a whole unit and cannot be broken into pieces or combined [7]. Through blockchain technology each NFT is registered in a general ledger which gives the possessor of the NFT a rank of the owner [11]. It is based on ERC-721 standard which extends the common interface to ensure uniqueness and thus tokenization of individual assets. In practice, this provides a lot of ideas on how to employ NFT technology in a variety of use cases. Some of them are tokenization of educational certificates, copyright enforcement, supply chain tracking etc [12]. At the present, NFTs are most often used for presentation of ownership of objects such as art, songs, newspaper articles, videos [2], and collectibles [3]. Despite this kind of prevalence in practice, there are very little peer-reviewed studies in this area [12].

The value of NFT comes from its uniqueness and scarcity. Utility NFT is NFT whose valuation is based on access to some underlying asset and opportunity which they provide to its owner. This means that they have their intrinsic value in addition to the scarcity [13]. Scarcity adds to their attractiveness for collectors and investors [6], while utility part of NFT provides product or service which is of interest to the NFT owner. Scarcity is guaranteed by the Smart Contract algorithm since it can limit the maximum number of tokens available. On the other hand, the connection between token and real asset or service is dependent on trust outside the blockchain [15].

Since the market is not regulated, anybody can create NFT from virtually nothing. Considering the worth of the market, it can be expected that there will be a lot of bad tokens created with the intention of fraud. There are a lot of scam schemes in NFT market: rug pull, pump-and-dump, wash trading, Ponzi scheme, hacking, phishing [4]. This paper deals with rug pull which happens when originator of a NFT project raises the capital from the token sale and then disappears. The important fact is that the originator never had an intention to fulfill their obligation and deliver utility NFT after the project completion. There is simple rug pull, sell rug pull or Smart Contract Trap door rug pull. In reality, in order to execute rug pull several different techniques are executed, usually combined with phishing attacks and pump-and-dump schemes [8].

Investor usually cannot recover his money, nor the fraudster can be caught because these kind of NFT is often anonymous. One such fraud happened in February 2022. when the creators of the Big Daddy Ape Club NFT collection took $1.3 million from investors but delivered no NFT [10]. Another big rug pull happened also in 2022. when creators of Frosties project gone away with $1.1 million of investor's money. It is estimated that the total amount investors lost due to rug pull in 2021. was $2.8 billion [1]. Such development in the market might lead to decrease of the sources of financing and bursting of current bubble, since the investors will abandon risky market. In order to avoid scam, investors must carefully research target projects. Scam project are usually small projects with low

liquidity, small community of overhyped buyers and anonymity of the project ownership [16]. These signs should raise red flag signal for investors. In addition to anonymity, one of the aggravating facts in estimating if the utility NFT project is scam is the lack of the centralized information about issuers of NFT which would make their authentication and validation easier. Because of that, more investigation is required on the side of investor which usually misses important information. Register of utility NFT issuers could reduce validation time and improve the quality of information available to investors [17]. At the same time, the benefits which NFT issuers gain from their projects will increase, since they will be well-suited for investor's requirements.

The remainder of the paper is structured as follows: Methodology section outlines the methodological approach taken in this research and states research questions. Chapter Results and implications describe the features, processes and architecture of the project under examination. Finally, 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

With the respect to the goal and the type of the data collected, this research is descriptive and qualitative. The main goal of the research is to explore the project aimed to raise the level of confidence in legitimacy of utility NFT projects. The project which is the subject of this research is still being developed and is expected to be operational soon. This research covers the basic ideas implemented during the project development.

Preliminary research showed that a centralized register was implemented in some other areas of e-business. Literature review shows that there are ideas on how to employ register with the goal of raising information quality, but no case study which deals with the implementation details of such register was found. This indicated the research gap.

This research aims to answer the following research questions:

1. What is the expected benefit of having register of utility NFT projects?
2. What is the structure of the register and how it works?

In order to answer these questions case study was conducted on the project called NFTsReg[1]. It was analyzed based on publicly available data and insight into the project documentation, which included the feasibility study and software documentation.

[1] NFTsReg is a project aimed to build the register of utility NFT projects found at www.nftsreg.com

III. RESULTS AND IMPLICATIONS

NFTsReg is a register of utility NFT projects whose goal is to raise the level of confidence on investors' side that the project is not fake. This is done by keeping database of records of projects, their owners and team members and their verification. In this process a lot of additional information about NFT is disclosed, which makes investors more confident about the reliability of the project owner and legitimacy of the project.

There are two kinds of stakeholders in the process: project owners and investors. Project owners are interested in registering, disclosing information and being verified because that makes their project more attractive to investors. In order to get verified, project owners are obliged to disclose all information which is relevant to making financial decisions. They are also required to keep that information up to date. This includes the following information:

- project name and description
- project stakeholders
- project roadmap or plan
- links to the project site, Twitter community, and other communities, if they exist
- personal details about project owner and project manager
- personal information, biographies, and even images of the key people engaged in the project
- current status of the project with the obligation to update it whenever important project event happens
- any other information important for the investor to make informed investment decision.

Investors are looking for the opportunity to safely invest their money with profit. In order to do it, they need a lot of information which will remove uncertainty. As a member of the register, investor gets access to the extended set of information of a utility NFT project which is not available to the public. In addition, they can build closer relationship with the project owner and hence obtain insight into project management process.

The purpose of the register is to protect the investors by avoiding anonymity, which is one of the main culprits for rug pull. On the other hand, registered project owners should be able to protect and advance their business interests without disclosing sensitive business and technical information. Investors may obtain such information directly from the project owners, but the register does not participate in that process directly.

In this relation, NFTsReg acts as an independent intermediary whose role is to keep database of records related to the ongoing utility NFT projects, as well as historical record of the owner's performance in the past. Making this information centralized and easily available to the interested parties, NFTsReg adds value in the mediation process. The relationship between three parties included in register is shown in the Fig. 1.

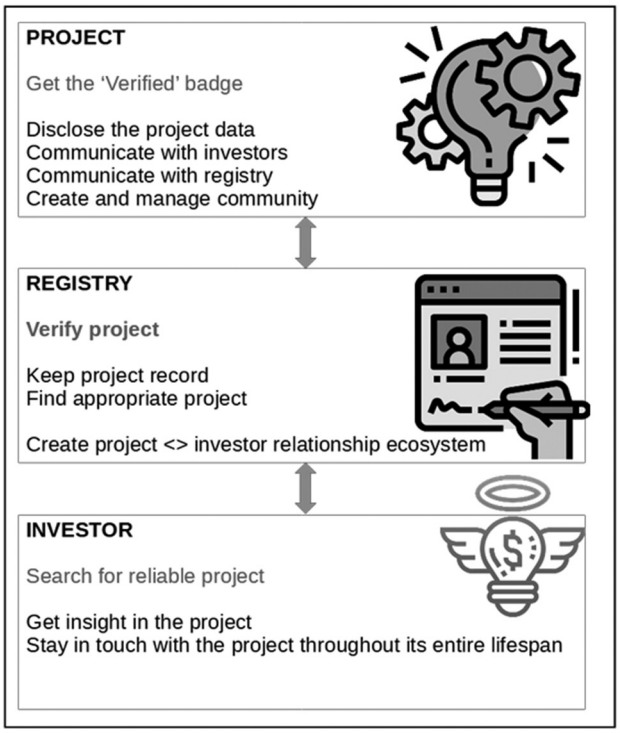

Fig. 1. Processes of NFTsReg register

In the Fig. 1 there are two sides of the process each corresponding to the roles of the register members. The project owner fills in the data about their projects, disclosing all relevant information of the NFT project. This information is available to the investor side of the register through web interface. They can search the projects and make a contact with the selected project owners. Keeping the relationship with project owners enables investors to keep track about progress of the project and gain even deeper insight into the project development, management and its market potential.

Although the centralization of the information produces the value for both parties, the key process which NFTsReg provide is the verification of the project. In addition, NFTsReg makes periodical audits of the information ensuring that the data is up to date. This strengthening of the legitimacy of project is done in several ways:

- contacting project owners in person through video meetings
- verifying facts about the project using machine learning tools and publicly available tools such as Token Sniffer[2], Rug Doctor[3], Etherscan[4], Binance Smart Chain Explorer[5] and others., which help detecting rug pull by doing automatic audit of token by analyzing their smart contract, holders and liquidity in search for common signs of malicious behavior, by maintaining the list of known scams and by enabling tracking of transactions made with token
- analyzing the history record of the project owners if any in the database
- checking if the asset underlying utility NFT really exists
- exploring and analyzing the content and activity of the communities created around the project
- using information about key project personal collected from the investors in the past
- forcing the disclosure of information about the project upon investors request
- using other available information.

Upon successful verification, both project and its stakeholders will get a badge 'Verified' which is the highest status meaning that the project owner is reliable, and the project is a legitimate utility NFT project. Permanent monitoring and periodical checkups made by NFTsReg should contribute to the reliability of the data disclosed. If, during the monitoring process irregularities appear, NFTsReg will inform the interested parties and lower the status of the project or project stakeholders.

From the technical point of view, NFTsReg consists of two software layers. This structure is accompanied by human team responsible for contacting project owners and verifying their information in person. Fig. 2 shows the architecture of NFTsReg.

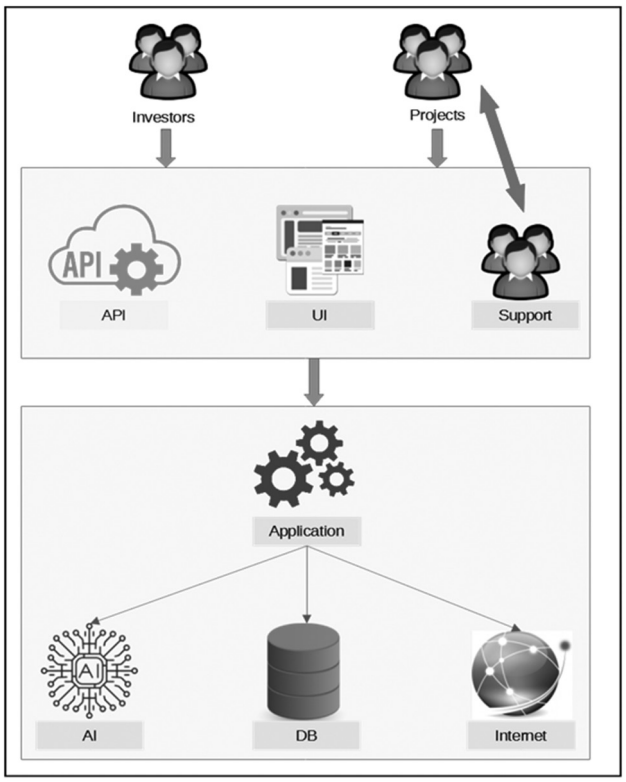

Fig. 2. The architecture of NFTsReg register

Top layer of NFTsReg is responsible for interaction between users and the register. This function is accomplished using standard web technologies which enable users to enter required information and get the search results. Important part of this layer is a subsystem responsible for communication between project owners and investors. Tools for direct communication between two parties are aimed

[2] https://tokensniffer.com
[3] https://rugdoc.io
[4] https://etherscan.io
[5] https://www.bscscan.com

to raise the level of trust between them. Another important component is API through which NFTsReg delivers information to the users and the network of registered project sites as well. This is particularly useful for the delivery of verification badge to the project site. The badge serves as a prove that the project has been verified and the owners are not fake. From the perspective of NFTsReg the badge also offers means for reaching public and thus gaining new utility NFT projects and investors. Investors can subscribe to the services for dispatching news about project updates and upcoming projects. Allowing investors to follow particular person enables them to closely monitor their activity and build long term relationship with the most trusted of them. All of these are aimed at providing investors and project owners with platform which will provide all tools to enjoy the benefits of project-investors ecosystem.

Bottom layer is comprised of software components which enable NFTsReg to deliver the answers to user requests and support the process of verification. Its main parts are application layer and database where the records are stored. Very important part of the application layer is the connection to machine learning services used for validation of project information. These services can provide analysis of the collected data, or some other important information. For example, one such service is Twitter's software which confirms account authenticity.

Special part of the register is a team responsible for manual verification of the data. Although most of the information can be verified from the combination of data obtained from internet and machine learning algorithm, face-to-face interaction between register and project owners can bring key additional value to the register. On the other hand, this puts more responsibility to honest and diligent work of the human component of the register.

Employing human team for verification raises the costs of the register. Looking at the benefits provided, it is reasonable to expect that the members of the registers are willing to pay for its services. That is why NFTsReg plans to earn income from both project owners and investors in the form of:

- membership fee which both sides will pay on the monthly basis
- charge for regular project audit collected from the investors and
- fee for extraordinary information or audit activities required from investors.

IV. DISCUSSION

The goal of the NFTsReg project is to raise the confidence level of investors to the legitimacy of utility NFT project. At the same time, the greater transparency of the projects is achieved, which benefits to the project owners too. Reducing the investor's fear from the fraud will inevitably raise the probabilities for getting finance for new projects and raise the price of the existing ones.

NFTsReg accomplishes these tasks by creating centralized database of utility NFT projects and verifying project owners. The register is built as a platform around the database offering additional services which provide benefits to both sides in the process. In addition to standard functionalities expected from the similar software, NFTsReg offers tools for building relationship between project owners and investors.

The architecture of NFTsReg has two main components. Front-end layer enables interested parties to communicate with the register and with each other. Back-end layer consists of software and human component. Software layer contains database and programs which manage the data, while human components give additional assurance to investors that the data in the database is reliable and up to date. The NFTsReg team is responsible for face-to-face verification of the utility NFT project's stuff, as well as assurance that the underlying asset really exists.

Searching the internet, it is possible to find several similar solutions in other areas aimed at the same goal. One of them is CrypTalk[6] which is built with the idea of preventing fake projects, profiles and communication channels in the area of crypto social messaging. Others like Token Sniffer and Rug Doctor check the blockchain in search for suspicious activity. The tools like Etherscan enable investors to search the blockchain themselves. NFTsReg strives to make the best of these available tools by helping investors to avoid possibly hard and technically demanding task. NFTsReg contributes to research process by providing another layer of audit and, in addition, by providing tools for building long term relationship between investors and project owner.

The main stakeholders and their benefits of using the proposed solution are shown in the table 1 [9].

In addition to the benefits to the stakeholders there are benefits general to the market. Centralized register of utility NFT projects plays stabilizing role on the market. Knowing that there is verified utility NFT project and a mechanism to permanently monitor its development will by itself act discouraging to the scammers. At the same time, it will attract the investors who want safe investment and honest project owners who need investing for their promising idea. This can inspire a new development in the market which otherwise, if lacking confidence and the trust of investors, can vanish under the pressure of fraudsters.

[6] https://www.cryptalk.app

Table 1. Stakeholder benefits

Stakeholder	Benefit
Project owners	Gaining investors' trust
	Easier raising of funds
	Connecting to the investors community built around the register
	Protection of the business
	Creation of greater interest for the project
	Helps building brand identity
Investors	Increase the level of trust to the utility NFT project
	Gain insight into projects in one place
	Get historical information on project owners and team members
	Get independent validation of project owners and team members
	Learn project ratings from the community
	Identify and build long term relationship with prosperous and successful project owners

V. CONCLUSION

The results of this case study suggest that there is a potential for this kind of idea to lower the rate of rug pulls in the utility NFT market. Disclosing information about the projects reduces the chances for fraudsters. Centralization of the information enables potential investors to easily obtain information about their intended investments. Facilitating the relationship between project owners and investors raise the level of trust and stability of the market.

The architecture of the system is flexible and enables creation of different business models. Among others, it is possible to expand the project by adding different modules which will utilize additional functionalities, creating full project-investor ecosystem.

One case study cannot provide definite conclusion on the effects of the proposed validation method. Besides, the NFTsReg project is in its starting phase, so there is no data to prove that this kind of solution can have major influence on reducing the scam rate. More projects like this should be kept track of during the longer period of time in order to generate enough data to make definitive conclusion.

In the future, if the NFT market continues to grow as it did in the last 4 years, we can expect to see new scam schemes together with existing ones. In that scenario, new defensive mechanisms will be needed. In that sense, this research presents one small step in the ongoing struggle. In addition, exploring the full ecosystem for managing project owner - investor relations can contribute to further development of the utility NFTs market.

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EBT 2022

PROJECT-BASED LEARNING AND E-LEARNING

Designing an LMS-ePortfolio Integration and Implementation Model in E-Business Education

Teklehaimanot Embaye

Dept. E-Business, Facultiy of Organizational Sciences,
University of Belgrade
Belgrade, Serbia
teklehaimanot.yemane@gmail.com
https://orcid.org/0000-0002-1306-392X

Abstract—Although Learning Management System (LMS) remains the most useful application for delivering online learning, the overall learning experience can be complemented and enhanced by integrating LMS with a learner-centered personalized learning and reflection environment better known as ePortfolio. This paper presents a comprehensive model for a successful integration and implementation of LMS and ePortfolio systems in an e-business education setting. Three integration strategies namely data-data, API-API, and Integration with Tools and three implementation models namely course level, department level and institution level have been identified. ePortfolio as an assessment tool is briefly discussed. This paper is validated in a lab environment in the department of E-Business, Faculty of Organizational Sciences, University of Belgrade, where one experimental system is installed with Moodle LMS and another with Mahara ePortfolio application. The systems were integrated in three different ways. Based on the review done on variety of related studies and practical experiences, the authors have recommended the API-API integration strategy and to start implementation of ePortfolio at course level and progress towards institutional implementation for institutions new to ePortfolio systems. This paper has contributed to the existing literature by developing an LMS-ePortofolio integration and implementation design model for e-business education.

Keywords— Learning Management System, LMS, ePortfolio, E-Business, E-Education, Personal Learning Environment

I. INTRODUCTION

Learning Management System (LMS) has long assumed an important role in educational institutions and corporations. The main objective of LMS is to enhance the teaching/learning process by using the Internet or Intranet for delivering educational activities. LMSs are specialized systems developed for managing educational activities, which include the distribution of educational content, the synchronous and asynchronous communication with students and the assessment of students' skills based on assignments and tests. The department of E-business in the Faculty of Organizational Sciences, University of Belgrade has a very good experience of using LMS in facilitating the teaching/learning process in the department. Nevertheless, in order to provide an enhanced life-long and personalized learning experience, LMS systems must be effectively integrated with other specialized systems. ePortfolio is one of such Personalized Learning Environment (PLE) systems. Although, there has been a growing interest in using an ePortfolio as an alternative method of assessment in an open distance eLearning environments, the use of an ePortfolio as a complementary solution to LMS in E-Business has not been sufficiently researched. The purpose of this study is therefore to explore how the use of an ePortfolio can enhance and complement LMS and empower personalized life-long learning in E-Business. An ePortfolio platform is a repository management system used to create student ePortfolio profiles, store ePortfolio material, and to evaluate on the basis of ePortfolio data with regard to educational needs. A student ePortfolio profile includes academic papers, essays, projects as well as project reports, assignments, audio and video files, creative design works, code snippets, and any materials regarding personal and professional development related to learning objectives. All these materials are called artifacts. Artifacts are the corner stone of ePortfolio and lifeline for creating personalized learning repository. The components of ePortfolio can be summarized as:

(1)ePortfolio Presentation – which enables celebrating learning, personal planning, transition/entry to courses, employment applications, and professional registration

(2) ePortfolio Tools – which enable capturing and storing evidence, reflecting, giving and receiving feedback, planning and setting goals, sharing and collaborating, and presenting to an audience

(3) ePortfolio Repository – which is a local or remote space to store presentation resources and an archive of evidences created using the tools.

The primary purpose of ePortfolio is to collect evidence for summative assessment, to demonstrate achievement, to record progress and to set learning targets as well as to create professional profile for future employability.

However, the increasing prominence and benefits of ePortfolio platforms as a mean for collecting students' achievements and for evaluating their progress also brings its own challenges. The main issue is integration with oth-

er systems and interoperability with similar platforms. For instance, an integration capability of an ePortfolio system with an LMS would allow artifacts created on ePortfolio to be submited on LMS as part of an assessment. On the other hand it is important that the evidence of students' work does not disappear, or becomes unusable, when they move to another institution or when they graduate from their academic institution. In this regard, interoperability specifications supported by both ePortfolio systems and LMS are crutial. Therefore the main motivations to integrate an ePortfolio system into an LMS are (1) to use it as an assessment tool for creating and sharing artifacts, and (2) to keep the ePortfolio platform independent so that it can be accessibel when the user changes educaitonal institution or get employed in businesess.

The rest of this paper is organized as follows: Section II discusses related work with regard to ePortfolio. In section III, we detail the methodology for the integraton of the ePortfolio with LMS and also outline different implementaion strategies. In the section that follows, we discuss the particular integration and implentation strategies of ePortfolio and LMS Systems in the case of E-Business Education. Finally, we conclude with a summary of the main contributions of this work and a perspective of future research.

II. RELATED WORK

Learning Management Systems (LMSs) have an indispensable role in facilitating the online learning/teaching experience. As defined in [1], LMSs are specialized systems developed for managing the distribution of educational content, the synchronous and asynchronous communication with students and the assessment of students' skills based on assignments and online tests facilities. However, with the advancement of online technologies that promote personal learning experiences, it is inevitable to have some ways of integrating those variety of personal learning tools in to the more mature and widely used LMS systems. The importance of such integration is briefly discussed in [2]. One such very important personal learning tools is the ePortfolio - a repository management system used to create student learning profiles, store personal learning achievements, and to evaluate on the basis of ePortfolio data with regard to educational needs [2]. In this section we briefly discuss a number of related studies with regard to integration of ePortfolio with Learning Management Systems and experiences learned from those studies.

ePortfolio as a student-centered learning has been assessed in [3] to find out the positive and negative characteristics of the system and to ascertain productive approaches to creating e-portfolios. At the same time portfolios' prospects in higher education system has been predicted. It has been shown in [4], that ePortfolio as an assessment tool is more effective than standardized assessment tests. Integrating ePortfolio in the teaching/learning process also empowers self-regulated learning strategies in the digital learning environment. Setting goals and planning effective leaning strategies along with mentor feedback can be enhanced if such initiatives are started with proper orientations on the importance of ePortfolio [5]. In another case study [6], the impact of implementing ePortfolio in a capstone course of an online master's program in health care administration was examined. As their result indicates, students enjoyed the ePortfolio process, critically evaluated their academic work and accomplishments, and valued peer-reviewed feedback offered by their peers.

ePortfolio is also used as an alternative assessment and e-assessment tool in an e-learning environment [7]. However, such attempts are not without challenges. The lack of pedagogical convenience and the lack of students' technological literacy are some of the challenges as discussed in [8] .

Equipping graduates with employability skills can also be achieved by embedding such concepts in the ePortfolio practice as studied in [9]. As noted by the authors, associating learning contents with the workspace skills and motivating learners to keep a record of professional ePortfolio profiles right from beginning can reduce the skills gap between the workspace and academic institutions. In another similar study [10], ePortfolio was used as measure for professional insertion of students so as allowing students to build and enhance academic and extra-academic achievements while being part of a lifelong learning approach. ePortfolio helps students to develop digital visibility by capitalizing their academic achievements and skills obtained elsewhere.

Our approach in this study is quite different in that it focuses in examining LMS-ePortfolio integration methods and then outlining a strategy for implementing personalized learning environment in an E-Business education e-learning settings especially targeted to institutions new to ePortfolio.

III. METHODOLOGY

The research question addressed in this study is: how to design a reliable model for the integration and implementation of ePortfolio with Learning Management Systems and find out how effective an ePortfolio would be as a complementary learning tool in E-Business education setup. To address this research question, the methodological framework employed in this study was action research preceded by extensive technological and literature review along with analysis of related case studies. This approach was deemed appropriate since it relates to the practice of learning, teaching, and researching in the E-Business education and as it relates to the authors. This section is categorized into subsections discussing on (A) ePortfolio integration strategies (B) ePortfolio implementation models, and (C) ePortfolio evaluation Methods. Our lab environment for this study was conducted on Mahara open source ePortfolio system integrated with Moodle learning management system. Moodle is an institution-centered learning management system and Mahara is a learner-centered ePort-

folio system. An LMS and an ePortfolio complement one another in an online learning environment. Their seamless integration results in an effective personalized digital learning environment. Here we discuss the methodologies of Mahara based ePortfolio integration with Moodle and related implementation and evaluation models.

A. ePortfolio Integration Strategies

The most common strategies for integrating an ePortfolio system into an LMS are data–data integration, the API integration and the tool integration strategies.

•Data-data integration – this is the simplest and most widely used, but classic form of integration in digital content management systems. This type of integration uses the import-export features of both the LMS and ePortfolio systems. Both systems must support some common formats in order to successfully integrate resources. These systems support two types of common formats: HTML files (generic) and Leap2A files (specific to ePortfolio). LEAP2A is an XML standard for exchanging learning e-portfolio data. As explained in [11], information in LEAP2A is grouped into items, each represented as an Atom entry. Each item has a LEAP2A type or class, and the type affects which literal attributes, relationships or categories that may be associated with the item. Data formatted in Leap2A can provide domain specific semantic data.

•API Integration – This ePortfolio-LMS integration strategy allows client applications to use directly the functions of a learning management system. These APIs foster client application development through data encapsulation and behavior reuse. This clear separation of interfaces specification from their implementation and data formats allows tool vendors to develop new versions without affecting current clients. Moodle LMS has two such APIs – the Repository API for browsing and retrieving files from external repositories and Portfolio API for exporting Moodle content to external repositories. Both of these API are based on Moodle's FileAPI. File API is a set of core interfaces to allow Moodle to manage access control, store and retrieve files. In order to ensure a bidirectional communication between Moodle and Mahara systems it is required to use both APIs to while creating plugins.

•Tool Integration Strategy – This integration is achieved by Learning Tools Interoperability (LTI) which provides a uniform standards-based extension point in LMS allowing remote tools and content to be integrated into LMSs. The information exchanged between the LMS and the external tool includes course information and user identity – which helps ensure that learners can navigate seamlessly from one learning tool to the other without having to log into each one [12]. There are several benefits from using the LTI integration approach. By adhering to a clearly defined interface between the LMS and the learning tool, academic institutions, LMS vendors and tool providers, can decrease costs, increase options for students and instructors when selecting learning applications and also potentiate the use of software as a service.

By utilizing these sets of integration strategies separately or in combination, it is possible to integrate variety of LMSs with a number ePortfolio systems [2]. However, in this study we integrated Moodle LMS with Mahara ePortfolio using the API integration strategy in a lab environment as illustrated in Figure 1. Both systems are widely used and support API integration out of the box. It is also possible to integrate using data-data integration strategy, but we don't recommend it as it requires manual work and is not user friendly as a result. However, LTI Tool integration is very promising and is currently under fast development to be compatible and applicable with LMSs and ePortfolio systems. By integrating Moodle and Mahara using the API Integration, two key advantages are achieved: (1) Single sign-on, and (2) Assignment submission functionality.

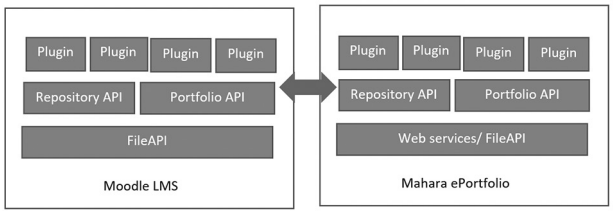

Fig. 1. Mahara – Moodle Integration using API strategy

In the Moodle LMS, the Mahara bidirectional integration support is guaranteed only by the implementation of both Portfolio API and Repository API. The Portfolio API is a core set of interfaces to publish files from Moodle to Mahara repository systems. In this approach, Mahara ePortfolio appears seamlessly as a folder when students want to save content such as a file, snapshots of forums or blogs and assignments.

B. ePortfolio Implementation Models

There are a number of ePortfolio implementation models. However, in this study we have identified three models pertaining to E-Business Education. These are: (1) Implementation at course level, (2) at department level, and (3) implementation at institution or faculty level.

Implementation of ePortfolio at course level is more manageable and its impact and performance can be easily evaluated especially for new institutions. There are a dozen of case studies that implemented ePortfolio at course level. In one case study [13], PebblePad ePortfolio learning was applied to allow students to take ownership of all their learning and achievements throughout a course in a nursing education. This initiative helped students move from didactic model to a student-led focus in their learning experience. In another similar study [14], e-portfolio using Pebble Pad along with Raspberry Pi (RPi), and 3D virtual pathology laboratory was employed in an attempt to improve learning outcomes and increase the chances of employability by aiding in the production of work-ready

graduates in Medical Laboratory Science (MLS) program.

In another case study [15], a strategic plan for digital learning environment was outlined at university level to motivate faculties introduce ePortfolio systems where the culture of using e-learning systems was already there. Such a strategic plan is very helpful in the sense that respective departments or faculties can introduce ePortfolio systems in a gradual manner starting from a pilot project towards full-scale implementation. This shows implementation of ePortfolio at institution level is so complex and may not be effective. However, having a strategic plan inline to the institutions' education goals is very crucial.

This paper introduces a hybrid methodology adopted and modified from the different case studies we reviewed and from the lap environment we setup for this purpose. After outlining the LMS-ePortfolio integration strategy, we followed these six steps to ePortfolio based learning as discussed in [16]:

- Define – First we established the purpose and objectives of the ePortfolio initiative, defined the issues it aims to address, the likely support needs of the learners and the nature of the learning environment. Then we studied which tools, systems or approaches to adopt for the outlined purpose.
- Understand – Clear understanding of what kind of learning outcomes do we require from the ePortfolio initiative and what implications will this have for our practitioners, administrative and technical staff was the second step. Here we make sure, ePortfolio has a great potential as an autonomous and personalized learning environment and provides baseline for life-long learning and future employability.
- Prepare – the third step is to prepare the necessary ground like strategy for access management, ownership of data and identity, assessment of risks and benefits, outlining staff training and support methods, defining accessibility, Intellectual Property Right (IPR), Copyright, and other potential legal issues in relation to ePortfolio usage.
- Engage - Defining an effective strategy for engaging and sustaining the commitment of learners, and those involved in supporting learners' use of e-portfolios is the fourth step. This strategy answers the question, "How are practitioners, personal tutors, administrative, technical and learning support staff, and, potentially, workplace mentors outside the institution engaged in the ePortfolio ecosystem?"
- Implement – Starting implementation of ePortfolio with a lab environment and then with a pilot project is important to take essential lessons. To have an effective ePortfolio implementation, curriculum managers and practitioner teams must be closely involved.
- Review - A range of methodologies to explore the viewpoints of both learners and practitioners should be devised. Creating an evaluation and review methods to show the evidence for the proposed outcomes is the last step in the process of implementing ePortfolio systems.

C.ePortfolio Evaluation Methods

To define effective evaluation methods for ePortfolio, the implementation strategy should always be referenced. The evaluation methods are relative to the purpose and goals of the entity implementing ePortfolio. At the same time it depends on the level of implementation. Be it at course level or institution level, it must have the factors to evaluate the performance of the system in place. In our case, we have designed an evaluation method for both for the course which implemented ePortfolio and the learners' overall practice of utilizing the system efficiently. This evaluation method is explained in detail in the next section in context to E-Business education.

In summary the evaluation method is designed to find out if the ePortfolio implementation is helping in the learning, teaching and assessment process; planning personal/professional goal of users; in transitioning of learners from their institutions to another or from their institutions to the workspaces during job application.

IV. EPORTFOLIO FOR E-BUSINESS EDUCATION

The Department of E-Business, Faculty of Organizational Sciences, University of Belgrade offers a number of business and technology related courses at bachelor, masters and doctorate level. The department has designed and implemented a scalable, reliable and high available private cloud IT infrastructure aimed for scientific work, research and to facilitate technology enhanced teaching/learning process. As a result the department have a long history of using Learning Management System based on Moodle LMS. The courses offered in the department like E-business, Internet Marketing, Internet Technologies, Computer simulation and virtual reality, Cloud Infrastructure and Services, Mobile business technologies, Enterprise networking, E-education, E-government etc. provide an in-depth concepts, principles and practical skills of business and technology. Such multidisciplinary courses have the potential to equip learners with life-long skills and motivate them to continuously learn to remain competitive in their future life.

In this regard an LMS integrated ePortfolio system is highly recommended for the department of E-Business to help learners reflect on their accomplishments, skills and achievements gained throughout their academic journey. Mahara, an open source ePortfolio is a mature systems and have a number of features to create and share variety of artifacts. It is also readily available to be integrated with Moodle LMS at data, API or tool level.

In this study the integration strategy we preferred is the API integration which is supported both by Moodle and Mahara. The implementation model is to start with a lab environment, continue with a pilot project at course level and then to implement a full-scale ePortfolio system at department level which is seamlessly integrated with the existing Moodle LMS in the department of E-Business.

A. Objectives of ePortfolio in E-Business

a) Learning, teaching, and assessment: The first objective is to support the process of learning through reflection, discussion and formative assessment, and providing evidence for summative assessment.

b) Transitioning: The second objective is to provide a richer and more immediate picture of learners' achievements and needs as they progress to a new environment, and supporting them through the process of transition.

c) Personal/Professional development planning: The third objective is support and evidence the pursuit and achievement of personal or professional competences of learners.

d) Applications and Employability: The fourth and final objective in our case is to provide evidence in support of an application for a job or for admission to further study.

B.Evaluation and Feedback Rubric for ePortfolio

An ePortfolio system or combination of tools that supports reflection, collaborative activity and the preparation and presentation of evidence of achievement provides crucial opportunities for learners. However, a reliable evaluation and feedback model should be in place to evaluate students work on ePortfolio. In this study we have modified an ePortfolio rubric adopted from Auburn University [17]. This rubric is used to evaluate learners' performance on creating artifacts and related ePortfolio activities. The key components of the evaluation are as follows:

a) Artifacts - Digital evidence of studnets' learning, experience, achievements and goals [18]. These are the building blocks of everything a student does within the ePortfolio tool. An artifact can be almost any kind of file that describes: academic experiences, Lab or research experiences, Skills or awards, study abroad programs, teaching experiences, internship, work, leadership or volunteer experiences.

b) Design and Arrangements – this evaluates how the student has designed their ePortfolio and arranged their artifact.

c) Reflective Writing Skills – This factor evaluates studnets based on their reflective writng skills

d) Coding/ Technological Skills – This factor evaluates if learners have indepth technological and/or coding skillls.

e) Emotional Intelligence (EQ) – This factor measures, evaluates and gives feedback on the emotional soft skills aspect of leaners.

The above evaluation factors are applied as rating scores: begineer, developing, mature and professional as illustrated in Table 1.

TABLE I. EPORTFOLIO EVALUATION AND FEEDBACK RUBRIC STYLES

Factor	Evaluation Category			
	Beginner	Developing	Mature	Professional
Artifacts				
Arrangements				
Reflective Writing				
Coding/ Technical Skills				
Emotional Quotient (EQ)				

V. CONCLUSION

The indispensable importance of ePortfolio system as an empowering approach in enhancing learners' self-directed learning in the digital learning environment is becoming evident to a number of higher educational institutions [19]. The main challenge is, however, there is no clear strategy for integrating LMS and ePortfolio systems as well as it is quite challenging to implement such integrated systems inline to the goals and objectives of a respective academic institution. This paper assesses a number of case studies and presents a comprehensive model for a successful integration and implementation of LMS and ePortfolio systems in an e-business education setting. The study is validated in a lab environment and the authors have recommended the LMS-ePortfolio API integration strategy and to start implementing at course level and gradually progress from pilot towards institutional deployment. A separate integration and implementation guide is prepared which is not included in this paper. In the future, a course level pilot project will be developed by engaging a selected course.

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Managing students' projects in e-learning

Boris Odalović

University of Belgrade
Faculty of Organizationsl Sciences,
Belgrade, Serbia
borisodalovic@gmail.com

Jelena Mihajlović-Milićević

University of Belgrade
Faculty of Organizationsl Sciences,
Belgrade, Serbia
jm0302@gmail.com

Abstract— This paper's research topic is the improvement of education in the field of student project management through the use of project-based learning. The theoretical basics and concepts of project-based learning are covered in this paper, as well as a review of the concept's practical application in education. The paper aims to suggest a way to improve education in the field of student project management through the use of project-based e-learning. Tools such as Mattermost, OpenProject, and BigBlueButton will be used to communicate, collaborate and organize the work of the teams. The outcomes of the application of this learning concept, as well as a proposal for future work on this topic, will be presented at the end.

Key words— project-based learning, managing projects, e-learning, students' projects

I. INTRODUCTION

The paper's research is on the improvement of education in the field of student project management through the use of project-based learning. The lack of motivation, commitment, and desire for a deeper analysis of the problem being solved is recognized among students. As a result, the main issue that has been identified is how to increase student awareness and engagement so that solving teaching activities is seen as something that will help them in their future development and maturation rather than a duty. When solving any problem, it is critical to inform the participants that their role in the solution is critical, that their opinion is valued, and that it can have a significant impact on the solution's future development. Students get a sense of responsibility for their work as well as the work of other members of the team as a result of project-oriented teaching because the success and results of the entire team are dependent on the performance of each individual. Only then will they be motivated to work hard.

The goal of the Department for e-business at the Faculty of Organizational Sciences was to bring project-based learning closer to the way students work and conduct a simulation of the real environment. In cooperation with professors and associates of the department, a model was designed according to which students from three elective courses will cooperate and form a multidisciplinary team in charge of project implementation and creation of IoT products. Students are tempted to be an independent development team that aims to present a production solution to the problem during one semester, applying the Scrum methodology and learning about its roles. During the implementation of the project, students have at their disposal a group of tools that will help them communicate with each other as efficiently as possible, but also record all the necessary activities and supporting documentation of each part of the project.

II. LITERATURE REVIEW

Mastering Information-Communication Technologies (ICT) is vital since it is the foundational knowledge skill for learners in the twenty-first century. ICT literacy is one element of fundamental knowledge, which includes core content knowledge and cross-disciplinary knowledge. [1] Students' technological understanding is critical, and to achieve ICT literacy, learners might use e-learning. E-learning is anticipated to help trainees understand the newest knowledge and technology while also allowing them to learn without being constrained by place or time. According to the results of a survey on the use of information technology by junior high school science teachers in Indonesia, the usage of ICT in the teaching process is low. As a result, we require a learning approach that enables learners to gain ICT literacy.[2]

Based on the findings of several studies, project-based learning combined with e-learning can provide students with the opportunity to broaden their knowledge and develop skills based on problem-solving and investigation. Learners can search for and share information more widely using e-learning, which supports differentiation and diversity, empowers learners to personalize the learning process, and provides an opportunity for learners to master it.[3]

In recent years, higher education institutions have attempted to provide students with both hard and soft skills, such as cognitive knowledge and professional abilities, such as problem-solving and teamwork. These skill-related objectives, however, are difficult to attain since traditional learning has dominated, with professors acting as "the transmitter of knowledge" and students acting as "the receiver of information." As a result, students may find it difficult to completely engage in instructional processes, resulting in a superficial understanding of discipline knowledge.[4]

Universities place a greater emphasis on developing students' research talents than on professional or transferable skills. As a result, there may be a gap between what students learn at university and what they require in the business. To improve this scenario, students should be allowed to participate in real-world problem-solving and knowledge construction in actual professional settings. Project-based learning is one appealing technique to accomplish this goal.[4]

In project-based learning, students engage in groups to solve real-world, curriculum-based, and frequently interdisciplinary problems. Learners select which activities to pursue and how to tackle an issue. They collect data from many sources, synthesize it, analyze it, and derive knowledge from it. Their education is intrinsically meaningful because it is grounded in reality and encompasses abilities like teamwork and contemplation. Students exhibit their newly gained knowledge at the end and are graded on how much they learned and how well they express it. Rather than directing and managing student work, the teacher's responsibility is to guide and advise them throughout this process.[5]

Project-based learning, as one of the self-organized learning variations, focuses on a project that serves a temporary purpose and allows students to work on a concrete goal while gaining experience. Additionally, students can offer their skills and desires. Last but not least, project-based learning aligns with some key teaching principles:[6]

- Situation relatedness: Contents are arranged according to concrete current or future situations.
- Action relatedness: Contents offer assistance and orientation for concrete actions.
- Science relatedness: Contents are oriented both by the level of knowledge as well as by the topics and methods of the respective scientific discipline.
- By example: Contents were selected so that the wealth of knowledge is depicted by a few typical cases (which are representative of similar issues).
- Structure: Contents transport also structural knowledge such as basic ideas, elements of theories, models, schemes of explanations, etc.

The real-world focus of Project-based learning (PBL) activities is central to the process. Students are driven to work hard when they understand that their effort is ultimately meant as a solution to a real problem or a project that will have an impact on others.[5] When students propose projects, their motivation is high. A group of students at the University of Applied Sciences - Technikum Wien has been working on a sophisticated system of robots playing soccer for several years. The initiative is one of the university's most intriguing PBL projects. Students from a variety of academic programs are involved. The project's outcomes are outstanding. Three years in a row, the squad reached the RoboCup quarterfinals in the F180 league. [6]

PBL is a student-centered method of instruction founded on three constructivist principles: learning is context-specific, learners participate actively in the learning process, and they attain their objectives through social interactions and knowledge and understanding sharing. [7] Because students can document the entire process and quickly share their products in a digital format, modern digital technology is a big enabler for students to comfortably engage with the process of planning and developing their projects.[8] In the PBL context, effective use of technology as an integrated part of instructional processes has been found to assist both weakly and strongly performing students develop knowledge.[9]

According to John Larmer and John R. Mergendoller, seven essentials for project-based learning are:[10]

1. A Need to Know - Teachers can effectively stimulate students' desire to learn content by starting a project with an "entrance event" that captures the attention their attention and prompts them to ask questions.
2. A Driving Question - A excellent driving question expresses the project's essence in simple, compelling language, giving students a sense of purpose and challenge.
3. Student Voice and Choice - In terms of making a project feel meaningful to students, the more voice and choice, the better.
4. 21st Century Skills - Collaboration, communication, critical thinking, and the use of technology
5. Inquiry and Innovation - Students find project work more interesting when they do true investigation, which does not entail gathering information from books or the Internet and pasting it onto a poster.
6. Feedback and Revision - Formalizing a process for feedback and revision during a project makes learning meaningful because it emphasizes that creating high-quality products and performances is an important purpose of the endeavor.
7. A Publicly Presented Product – Presenting a product to a real audience makes students care more about its quality.

The impacts of project-based learning and direct instruction by teachers on students' educational achievements in elementary, secondary, and tertiary education were compared in one of the reviews. In this study, PBL refers to a learning approach in which students are involved in real-world projects and product development. PBL had a more favorable influence on students' academic progress than direct instruction, according to the findings. However, only 20% (6 out of 30) of the studies assessed were undertaken in higher education.[4]

Reis et al. [11] conducted a review of PBL in engineering education studies using bibliometrics (e.g., keyword analysis) and categorizing research techniques. The top three keywords used, according to bibliometric statistics, were project-based learning, engineering education, and problem-based learning. The classification results revealed that over 70% of studies focused on undergraduates, with case studies being the most popular research method.

III. AN APPROACH TO MANAGING STUDENTS' PROJECTS

In the cooperation between professors and associates of the Department for e-business at the Faculty of Organizational Sciences, a model of project-based e-learning was designed in which students from three elective courses will have the opportunity to develop software products in multidisciplinary teams. In the first part of the teaching activities, students have the opportunity to get acquainted with the theoretical foundations and concepts of both project-based learning and Scrum methodology. After getting acquainted with the necessary theoretical work, students have the opportunity to apply what they have learned in mutual discussions to work with professors and associates to well determine the concepts of Scrum methodology and product development techniques previously heard in class. The next step is to choose topics. Everyone has the opportunity to choose between the offered topic or to make a proposal for a new topic that can be processed following the objectives of the courses.

Students from the elective courses E-business risk management, Internet Marketing, and Internet of things are participating in the realization of the project. Depending on which course students attend, they will have different roles by Scrum during the implementation of the project. Each team consists of the following roles:

1. Product owner - Represents a person who defines the requirements of the project, accepts or rejects the results of work, and performs a time estimate for the required activities. This role during the realization of the project was given to either a professor or an associate of the department.
2. Scrum master - represents the person who leads the project, manages and assists the development team, and enables cooperation between all roles and functions in the organization. This role during the implementation of the project was given to a student from the elective course E-business risk management.
3. Member of the development team - The person responsible for the implementation of specific activities. This role during the realization of the project is given to the student from the elective course Internet Marketing and/or Internet of things

After choosing the topic and forming the team, the Scrum Master is obliged to arrange a kick-off meeting with the Product Owner, where the presence of all team members is mandatory. At the kick-off meeting, it is necessary to define the goals that the team wants to achieve with their product and get all the necessary information from their Product Owner which will be important to them for further realization. After the initial meeting, the Scrum Master, together with the development team, plans sprints and further distributes activities to members. The development team is not obliged to fully comply with Scrum's daily meetings due to other obligations they have at the faculty, but the proposed number of meetings for one week is two.

During the implementation of the project, students have at their disposal various tools that will help them communicate with each other as efficiently as possible, but also record all the necessary activities and supporting documentation of each part of the project. The tools available for use are Mattermost, OpenProject, and BigBlueButton. These are channels for a formal form of communication. Each team is free to use, in addition to the mentioned benefits, any other channels for informal communication that it considers suitable and efficient during development.

A. Mattermost

Mattermost is an open-source platform for secure communication, collaboration, and orchestration of teamwork and tools. Mattermost is made especially for software development and engineering use cases. Each student receives their account on the mentioned platform and has access to their team and appropriate channels within it. By applying this tool, we want to bring students closer to what communication looks like in a real business environment. It is necessary that the team members record within the appropriate channels all the necessary information that may mean to other members, but also in this way document their work on the project. In addition to the basic functionalities, the Mattermost Boards option is also used, which is a tool for recording and distributing activities to members, as well as setting deadlines and prioritizing tasks.

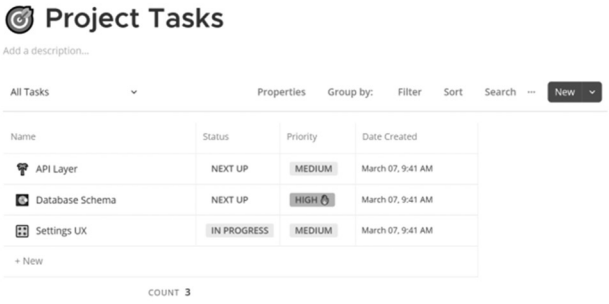

Fig. 1. Mattermost Board

B. BigBlueButton

BigBlueButton is a tool integrated within the Mattermost platform and used by the team as a tool for online meetings so that they can communicate as easily and quickly as possible due to problems, but also for conducting daily activities.

C. OpenProject

OpenProject is an open-source platform used for efficient project management and administration. Within the project on the platform, participants have the opportunity to see the plan of future work, what activities are assigned to them, what is the deadline for their implementation, the Gantt chart, and milestones that need to be achieved. In addition to all the options related to the individual, this tool

provides the opportunity to organize a meeting, conduct various discussions on the project, record the necessary documentation, estimate costs, etc.

Fig. 2 OpenProject Work packages board

IV. ANALYSIS OF RESULTS

In the previous two years, over 40 projects were successfully implemented, in which more than 100 students from the courses E-business risk management and Internet of Things collaborated. Students completed their activities and passed the course during the current school year. After the realized projects, in the conversation with the students, we managed to collect praise for the innovative way of working, as well as their criticism, but also space for improvement. What stood out the most in the conversation with the students was that this was a real opportunity for them to experience what it is like to work in a team, use tools that are used in the development of real projects, and participate in creating software products in today's fastest-growing industry.

The third year of project-based learning within the elective courses of the Department for e-business is underway. The new year brought with it an expansion of the number of students on projects because we recognized that there is interest in the same, but also an increased motivation among students when they participate in creating something practical instead of preparing only a theoretical exam.

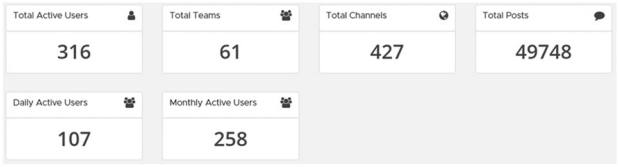

Fig. 3. Mattermost System Statistics

As can be seen in the picture above, there are over 300 active users who are assigned to multidisciplinary teams that also represent the number of active projects. Currently, the teams are actively working on over 60 projects that can be internal, involving professors and associates of departments, and external, projects that students implement as part of teaching activities in accordance with the project-based learning model. Within teams, students and other participants are allowed to create channels that cover a particular topic for discussion when developing a particular product. So there are a total of 427 channels created within the project. Also, based on the daily and monthly number of active users, it can be concluded that each team on a daily or monthly level meets the necessary number of users to adequately monitor the current state of the project.

The total number of posts on the system is currently almost 50,000, and looking at the diagram in the picture below, it can be concluded that the goal of active communication among students within the Mattermost platform was achieved based on the number of users who posted on a given day in all teams on the system.

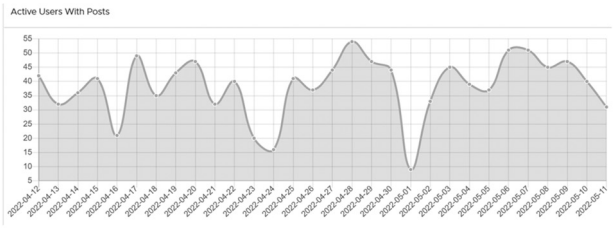

Fig. 4. Active Users With Posts

V. CONCLUSION

Students benefit greatly from project-based learning in computer science, but it requires careful planning. Many times, project ideas offered by students turn out to be successful. This is most likely due to the high amount of drive that students have in such situations. Surprisingly, these types of initiatives do not receive as positive feedback as projects set by faculty members. This phenomenon could be caused by several factors. The complicated arrangement of projects in computer science is one potential factor. Students who propose an idea are also in charge of determining project objectives. However, due to a lack of experience in creating such project goals, these targets are often unattainable. Even if the project's results in terms of grades are bad, the learning outcome is excellent in such instances.

The plan for the future development of this way of learning is to achieve cooperation with companies that are ready to engage students in the implementation of real projects in agreement with the faculty and thus provide students with an even more realistic picture of the business world. This way of project-based learning has great potential because, in addition to increasing the motivation of students, it will help them to get a job and contribute to the growth of the industry.

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Project based learning for DevOps: School of Computing experiences

Miloš Radenković

School of Computing
Union University
Belgrade, Serbia
mradenkovic@raf.edu.rs
0000-0002-1708-9799

Snežana Popović

School of Computing
Union University
Belgrade, Serbia
spopovic@raf.edu.rs
0000-0002-6774-670X

Svetlana Mitrović

Faculty of Project and Innovation Management
EDUCONS University
Belgrade, Serbia
svmitrovic@mts.rs

Abstract— The subject of this paper is the implementation of DevOps practices in an academic environment, specifically at the School of Computing. The goal is to offer insights into the implementation process alongside the chief challenges that needed to be overcome. DevOps approach to software development is quickly becoming an industry standard, besides its technological aspects such as tools and pipelines, DevOps also brought changes in culture necessitating tight collaboration from team members. Despite it being an industry standard, most universities are yet to include DevOps practices in their curriculums. For this purpose we propose a model for incorporating DevOps practices in universities based on the advances made at the fourth year of studies at the School of Computing, where students were introduced to some CI/CD aspects during the course of a semester long project. We offer some insights into potential ways to better facilitate student collaboration, and ways to guide them towards best practices already realized in the industry for bridging the gap between the academic and corporate environments.

Keywords— project-based learning, DevOps, software engineering.

I. INTRODUCTION

Business demands for scalability, availability and rapid development of applications is constantly on the rise. To meet these rising business demands, new methoologies and tools are needed. One of the most popular approaches today that seeks to meet these rising demands is DevOps[1]. DevOps is a way of improving the software development process through the concepts of continuous development, integration, testing, delivery and monitoring[2].

Despite the popularity of DevOps in the business environments, the concepts that it relies upon are often overlooked in university education[3]. This problem manifests itself in the ever rising demands for new software developers who are capable of working in DevOps environments, but the universitiy curriculums are falling behind and leaving the gap between academic and business environments ever larger. While there are many attempts to implement devops in education[4][5], there hasn't been a global shift in educational pririties.

In order to overcome these problems new technologies and concepts must be introduced into the educational process[6]. But the knowledge gap is not the only problem with the educatinal process, DevOps environments heavily rely on collaboative culture as a cornerstone of problem solving. To overcome this problem a pedagogical shift must occur, where individual problem solving must be directed towards problems encountered in the idustry and complex problems overcome through teamwork and sophisticated tools.

In this paper we present an approach for introducing DevOps principles in senior years of university education. The approach was evaluated at the School of Computing. In order to better show the required changes to the educational process we will highlight the way the course was organized and the tools which were used to guide students through CI/CD (continious integration and continious delivery) and facilitate the change in student collaborative culture.

II. DEVOPS CONCEPTS FOR SOFTWARE ENGINEERING EDUCATION

The term DevOps stands for combination of development(Dev) and IT operations(Ops). By combining these two segments which were traditionally kept separate allows for higher levels of collaboration and removes some of the most common problems that arise when teams are not aware how the other performs their tasks[7]. This paradigm shift means that teams are becoming multifunctional and are made up of members with different qualifications. While this change in culture is critical its impact would fall flat if it was not assisted by the various tools that better facilitate this collaboration and in optimal cases even automate it[8]. This high level of automation is in fact something that is most associated with DevOps, but without changes in culture that facilitate the use of these automation tools, their effect would be somewhat limited[9].

These automation tools and changes in culture are not the only things that are required for a successful DevOps implementation. In order to fully realize DevOps projects, they need to be based on current technologies that allow

for applications, in the form of services[10][11], to be packaged into containers for ease of testing and deployment[12]. These containers rather than source code are the building blocks of DevOps projects and allow for such high levels of automation and make deployment and scaling of applications a standardized process. Likewise to fully capitalize on the automation aspects and the scalability aspects, it is preferable to use microservice architectures, where each microservice can be built, containerized, tested and deployed in an automated manner.

The usual DevOps lifecycle is made up of eight distinct phases: planning, coding, building, testing, release, deployment and monitoring[13]. In an ideal environment all the activities besides planning and coding can be automated or at least made to work with minimal human guidance. While DevOps is not in the strictest sense a project management methodology, it relies on the project being managed in an agile manner such as SCRUM where rapid iterations where automation can be fully leveraged[14][15].

III. PROJECT-BASED LEARNING BASED ON DEVOPS

The DevOps approach was evaluated at the School of Computing, at the fourth year of studies on the subject of "Software Engineering". The course had approximately 100 students enrolled which were further divided into four teams, of 25 students each. These teams were formed with the idea of tackling a single project during the course of the semester, the performance on this project would play the main role in their grade and participation was mandatory. Since student teams were relatively large in size, detailed coordination by the professors would be difficult, for this reason students were required to self-organize and were provided with considerable autonomy. Projects themselves were open-ended in the sense that the students were provided with a topic such as "Banking", "Insurance", "Hospital", "Accounting". The only restrictions to the projects were technical in nature and mostly dealt with technologies, frameworks and system architectures. Students were encouraged to form smaller teams to fulfill more specialized roles, and most teams settled into the traditional teams of: Backend team, Frontend team, Specification team.

Students were divided into four roles:

Project Manager were tasked with keeping track of the project itself. All the communication with professors was through the managers, necessitating that student teams filter up any necessary information to manager level. Managers were tasked with keeping detailed accounts on the activities of individual team members with the help of team leaders. In keeping with the autonomous nature of teams, managers would also grade their team members, and these grades would be used as the main component in the students grade. Given their ability to directly influence someone's grade, managers were to play the a direct role in the success of the project.

Assistant Managers were necessary due to the overwhelming nature of the role of Project managers, their task was to assist their manager with any required tasks, and were given many powers to do so. The chief distinction between managers and assistant managers was that only the project manager could assign grades and communicate directly with professors. Assistant managers also primarily dealt with scheduling of meetings and other purely organizational tasks.

Team leaders were tasked with running teams of between 5-10 team members. Seeing as most teams dealt strictly with programming, the main role of team leaders was to assign tasks to individual members, and to review their code once the tasks were complete. Team leaders rarely programmed themselves, and were usually more experienced programmers that guided their team members and helped them in their various tasks. Team leaders were also tasked with informing managers on the state of their tasks, and the activities of their team members.

Team members were tasked with completing their tasks within the assigned deadlines, and were encouraged to participate in as many meetings as possible.

A simplified view of the main interactions within the framework can be seen on figure 1.

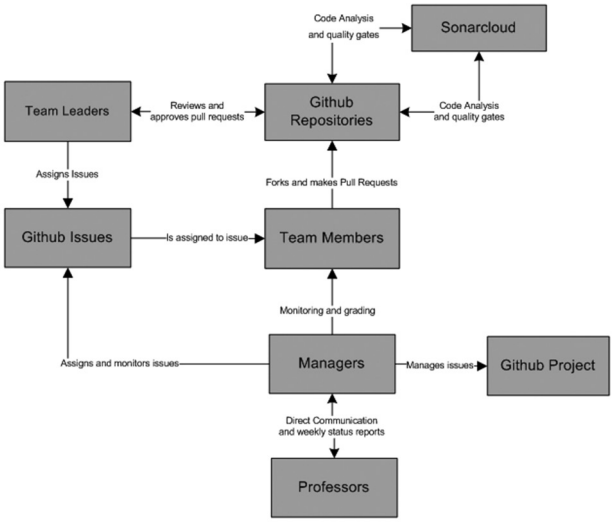

Figure 1. A simplified view of main interactions between roles

Since to goal of such organization was to facilitate autonomous organization and close collaboration within teams, students were free to manage their projects as they saw fit. With the topics provided it was up to the students to research how such systems functioned and to provide their own specifications for them. These gathered specifications were presented to the professors at regular intervals for approval in order to maintain the required complexity of the projects as well as to maintain that the systems were faithfully represented. Students were free to use any project management methodologies that they

saw fit, but all teams settled on agile methods, incorporating most SCRUM good practices in their projects, such as one week sprints and regular short-length meetings. In order to better capitalize on the agile nature of their projects, regular control points of their projects were organized. Each week every team would present their progress to the professors, and any potential issues within the teams would be addressed and questions answered. In addition to the weekly control points, there were deliverable control points where students had to present their code and applications, in order to gain points which are to be allocated to their project as a whole. The points allocated in such a way were at the project managers disposal for further allocation to individual team members based on their effort up to that point. In addition to the usual deliverables that were made for 25%, 50% and 100% of project completion, students were also encouraged to tackle additional tasks (mostly dealing with CI/CD) which would likewise increase their collective points.

In order to teach the students more about DevOps workflows and organization. Teams had many tools at their disposal and were taught and encouraged to incorporate them into their projects as much as possible. Some of these tools include:

Mattermost – was used as the primary means of communication within the project, and only mattermost communication was considered to be “official” by the teaching staff. Channels were formed around individual teams(for example Backend), likewise channels were made for cross team collaboration such as (back/front, back/spec, etc..). Mattermost was also used for all official announcements by the professors, and managers were also encouraged to use mattermost for any official announcements. An example of team channels for one of the project groups can be seen of figure 2.

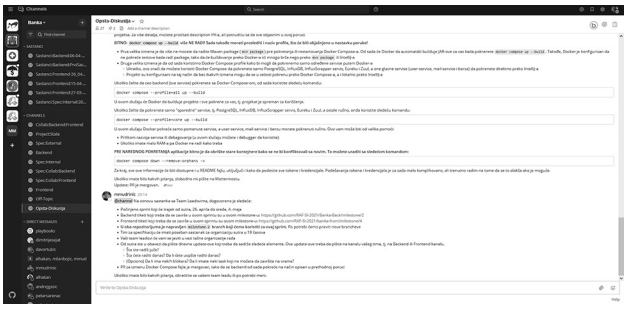

Figure 2. Team chat with its relevant channels

BigBlueButton – is a video conferencing software, and was used to facilitate student meetings. All student meetings were made through BigBlueButton and were saved by the platform for later viewing by either students who could not make it to the meeting, or the professors. Bigbluebutton was further integrated with mattermost, where each bigbluebutton meeting would be assigned its own mattermost channel, where the access link could be found, and the recording to the meeting. By integrating these two tools, we have made sure that all project communication was transparent to all those involved, and hopefully minimized any problems that could arise due to access. An example of integration between BigBlueButton and Mattermost can be seen on figure 3.

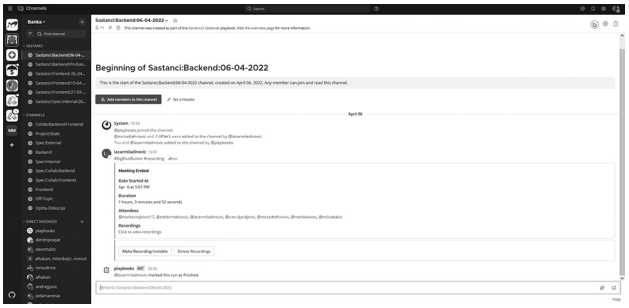

Figure 3. Mattermost-BigBlueButton integration

Google Calendar – In order to ovecome scheduling conflicts that come with such large groups, all students had to keep their google calendars up to date. Google calendars were the primary means of sharing invites for Bigbluebutton meetings and were critical in ensuring that timeslot could be found where everyone was available.

Github – every project had two separate repositories, one for frontend and the other for backend development. Only the project managers and team leaders had to permissions to create, merge and push to branches. All other team members had to use forks and pull requests in order to submit code for potential addition to a branch. A system based on pull reqests meant that team leaders could play the role of code reviewers before accepting any pull requests that were of sufficient quality. Additionally these pull requests were usually made by a single team member, resulting in a highly transparent system where the contributions of individual team members could be clearly measured.

Github project and github issues – students were encouraged to use github issues as project activities that could be assigned to any individual team member. Then as pull requests were made by those team members, they could be tied to those issues. Github project was used as an alternative to conventional project management applications such as openproject. The use of github issues with github project allowed for a very fine grained approach to project tracking. Likewise, being hosted on github allowed these github projects to be viewable by both the professors and other team members, keeping the state of the project public for all. One of the student github projects with its active tickets can be seen on figure 4.

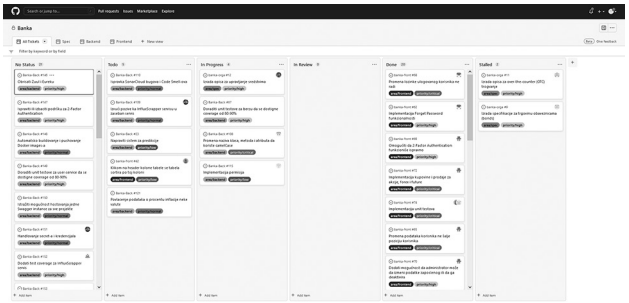

Figure 4. Github project from one of the student teams

Docker – In order to achieve continuous delivery, all microservices within their projects had to be containerized. For development purposes docker and docker-compose tools were used. Docker-compose allowed the students to live test their applications, where whole microservice stack could be rapidly initialized on any machine. Docker-compose was also used for live demonstrations of projects during classes.

Kubernetes – Since docker-compose was used for development environments, docker images were already developed and uploaded to docker repositories such as dockerhub. The existence of these docker images made it easy to integrate them inside a Kubernetes cluster where production environments could be simulated, and continuous delivery workflows integrated. All projects were provided with their own kubernetes cluster made up of several nodes hosted on the private cloud.

Sonarcloud – in order to better facilitate continuous integration, testing and code quality was partially automated by integrating Sonarcloud service with github repositories. This integration allowed each pull request to be analyzed by sonarcloud, to highlight bugs, failed tests, errors, and bad quality code. Sonarcloud reports have proven to be an invaluable tool for team leaders that needed to review and approve pull requests.

IV. ANALYSIS AND CONCLUSION

As of the writing of this paper the projects are still ongoing, but as projects are organized around smaller deliverables it was possible to analyze them as seperate lifecycles in order to improve and further adapt the approach for the coming iterations. Some of the main takeaways from the projects are the following:

Students had limited knowledge on how software should be tested and were averse to writing tests. After additional effort was made to ensure that all team members were educated on writing tests for their own forks they are starting to realize how important testing is to the the project lifecycle. Team leaders have further embraced testing as a way of ensuring that the code they are reviewing is properly tested before it is submitted to them. In order to further reinforce the newly established testing practices a requirement for 80% test coverage for all new microservices was established.

If suitable infrastructure is provided in the form of mattermost and bigbluebutton. Students will utilize this infrastructure to its fullest. Additionally, transparency in the form of recordings of their meetings plays a large factor in their use of the platforms. Likewise github in the form of issues/project can be used for barebones project management purposes, and has proven to be more than up to this task especially when its close integration with repositories is considered. Overall up to now, at the 50% project progress students have made 153 BigBlueButton video conferences with an average duration of 1 hour. A short overview of mattermost activity for one of the teams can be seen on figure 5.

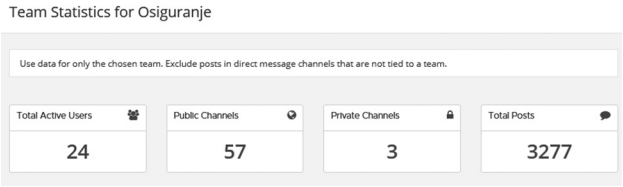

Figure 5. Team statistics for one of the four teams

The project should have many deliverables, which encourages the students to be even more agile in their tasks. In particular the deadline for the first deliverable should be within the first two weeks of the course. This first deliverable should be centered around common task such as user management, the goal of this first deliverable is to ensure that backend and frontend development do not wait too long for the first specificactions from the specifications teams to arrive. By the time they are done with user-management services, they will have established the necessary workflows and knowledge of tools in order to tackle the more difficult tasks in the specifications.

There is a large disparity in both aptitude and knowledge when backend and frontend tasks are concerned. All students were interested in being a part of backend team while interest in frontend development was lacking. When left to choose their own teams, backend team members outnumbered the frontend members at a factor of 2:1. After the first deliberable this problem became evident to the project management, and team „rebalancing“ took place. After the rebalancing took place, the new frontend team members had to be taught by the frontend team in order to become productive team members. This disparity in both aptitude and knowledge should be addressed as soon as possible, so that „training“ can be done in the earliest iterations so as not to endanger the capablities of the frontend teams.

By using docker and containerizing their microservices, students can truly view the rest of the project as a black box into which the microservice they are developing can be plugged in. No matter the size of the application, all developers can run it through docker-compose and run integration tests with other services. For this reason it is important that students start containerizing their services from the start of their projects.

By having such large teams of 25 people collaboration becomes more difficult, but it also reinforces the idea that good collaboration is critical to the success of the project, and student teams will often see this for themselves and will seek to improve their collaboration as time goes by. Having such large teams also means that there is a large disparity in knowledge and experience between students. Since collaboration is critical to the success of the projects the students have taken upon themselves to teach each other the necessary technologies and good practices. This knowledge transfer is further aided by bigbluebutton and the fact that all meetings are recorded and can be accessed

at any time.

Since collaboration is critical to the success of the projects, naturally teams where team members know each other are naturally performing better than teams where there is little prior knowledge among team members. Some teams have recognized this problem and have started the practice of team building in order to improve collaboration and make communication between team members easier.

While the managers have the means of negatively influencing someones grade, this mechanism was often not utilized, and when it was utilized it often had a negative effect on the team morale. For this reason teams have realised that they need to focus on improving their own collaboration in the form of better detection of delays and misunderstandings. This has resulted in iterations becoming shorter and tasks becoming more manegable and less dependant on each other.

Collaboration between frontend and backend teams broke down in periods of high activity in proximity to the deadlines. In order to counteract this problem students have realised the importance of documenenting their services and have started using tools such as swagger. Additionally regular meetings between frontend and backend teams have been established as the norm, where backend teams present the developed services, and frontend details how they would wish their data to be delvered.

By highlighting the most common issues faced by large project teams and the solutions to these problems we hope to provide any future implemenetations of DevOps in education with a suitable framework upon which they can build their own courses. Likewise we presented a set of tools which were made at the students disposal and have proven critical to the success of the project teams. Our experiences at the school of computing at the senior year also show that when presented with suitable tools and the knowledge on how to use them, students were able to quickly adapt developing within CI/CD and working within large teams in order to complete complex projects.

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Data streaming architecture based on Apache Kafka and GitHub for tracking students' activity in higher education software development courses

Milan Miloradović

Department for e-business
The University of Belgrade, Faculty of organizational sciences
Belgrade, Serbia
mm20213510@student.fon.bg.ac.rs
https://orcid.org/0000-0003-4101-2350

Ana Milovanović

Department for e-business
The University of Belgrade, Faculty of organizational sciences
Belgrade, Serbia
am20205027@student.fon.bg.ac.rs
https://orcid.org/0000-0001-5282-881

Abstract — Data streaming architecture can be used to collect data and gain insights into the dynamics of individual or collaborative software development activity that takes place in higher education courses. There is a place to further investigate streaming architecture in a given context. The code versioning platforms, such as GitHub, serving as data sources in the existing implementations of data streaming architecture are lacking in practice. The goal of this paper is to investigate the implementation of a custom data streaming architecture that could be used to track real-time students' analytics in higher education software development courses. The solution is based on Apache Kafka and GitHub platforms. Also, the architecture developed in the paper could be considered when planning on integrating LMS (Learning Management System) as a visual web interface for students' analytics.

Keywords — data streaming architecture, Apache Kafka, GitHub, higher education, software development, Learning Management System (LMS)

I. INTRODUCTION

Data streaming architecture is based on the concept of events [1]. Event Streaming Platforms, which are based on the data streaming architecture, provide the infrastructure that enables software to react in real-time to the given events [1]. Apache Kafka is an open-source streaming platform that can make use of producers which are applications that are sending messages to the Kafka broker [2]. Kafka Broker stores messages that are later accessed by consumers [2].

Git represents a system that enables tracking changes to the user files and it is considered a Version Control System (VCS) [3]. GitHub platform relies on git and its' commands to perform version control of user files.

The aim of this paper is to provide a possible solution to the data steaming architecture that would be used to collect and process data on students' activity that takes place on version control platforms in higher education software development courses.

Upon considering different use cases of implementing data streaming architecture and taking good architectural practices into account, possible architecture is formed. The purpose of this paper is to investigate the integration of the version control platform (GitHub platform) with the data streaming platforms such as Kafka to process events generated while conducting higher education software engineering courses. This use case is lacking in practice and could be beneficial for further related work as far as higher education is concerned.

The solution gives a presentation of a data streaming architecture based on Apache Kafka and the GitHub platform. Besides, GitHub webhook concept is described, as well as the flow of communication between Kafka producer and Kafka consumer. In the proposed solution, the communication between Kafka producer and Kafka consumer starts with a GitHub webhook event.

Kafka producer and Kafka consumer are implemented using the Java Spring Boot framework. Java Spring Boot is an open-source, microservice-based Java web framework [4]. The microservice architecture provides developers with a fully enclosed application, including embedded application servers [4].

The question of integrating Learning Management systems (LMS) such as Moodle LMS into the architecture for a unified dashboard preview of students' analytics is also considered.

II. LITERATURE REVIEW

As the authors state in [5], the GitHub platform provides insights into social coding activities. Apart from the popular usage of the GitHub platform in the software development industry, this is also the reason to consider using GitHub as a collaborative software development platform [6] in higher education setup and as a data source in data streaming architecture.

GitHub data analysis done in [7] demonstrates the possibilities of data generated through events on the GitHub platform. Different analytics are considered including the number of commits per contributor and SNA (Social Network Analysis) analysis [7]. Those analytics could also be considered when implementing Kafka consumer.

Some of the research papers that are dealing with the integration of code versioning platforms into the curriculum of the software development university courses have relied on the GitHub platform and its' functionality to gain insight into students' activities [8][9][10]. However, using GitHub as a data source provider to deal with real-time stream processing and analytics in an educational environment is lacking in practice.

New streaming technologies that are available today handle stream data with high performance with a message throughput of millions of messages per second [2]. Data platforms handle data from different sources and stream data to different consumers [2].

Events in the Kafka ecosystem are assigned to topics [11]. Those topics are holding different numbers of logs (shards or partitions). The number of shards is configurable, thus scalability in the Kafka ecosystem is provided [11].

The use cases of deploying data streaming architecture are quite diverse in education. In [12] authors have developed a cloud-based e-learning platform to provide educational content for the agricultural community. The streaming analysis here is employed in real-time using Apache Kafka and Apache Spark to provide high-quality video content to users and to control server resources.

A popular area to employ streaming platforms is certainly IoT (Internet of Things). In the research presented in [13], the authors developed a course that is called Network-of-Things Engineering Lab (NoteLab). The course combines IoT, edge and cloud computing and is dealing with the implementation of interfaces and protocols that connect the entire system (MQTT, COAP and HTTP) [13]. Kafka is used as a connector, consisting of a Kafka broker among other components, using publish/subscribe protocol to connect with Kafka producers and Kafka-Firebase connector to connect to Firebase real-time database [13].

Machine learning is another popular area to take into consideration when investigating the usage of streaming platforms. In [14] Apache Kafka is utilized to implement a stream processing system based on a publish-subscribe pattern. The system developed in [14] deals with vehicle detection based on its' attributes such as color, speed and type. There are two main steps, the first being getting the vehicle information from a video, and the second step is streaming that information to subscribers.

In [15] by making use of DevOps and cloud computing "continuous quality assurance approach" is facilitated [15]. The prototype of the solution consisted of detecting problems that are likely to happen when the new versions of the microservices are being in building state, deployed, or targeted with requests [15]. The data crawler observes all microservice containers that are running, collects the relevant data and sends the data to the Apache Kafka cluster. Data is further being fetched and indexed in Elasticsearch [15].

Another usage of data streaming is implemented in CERN HSE (occupational Health & Safety and Environmental protection) Unit [16] which deals with the implementation of the CERN Safety Policy. Researchers developed REMUS (Radiation and Environmental Unified Supervision) system that is using an open-source Apache Kafka streaming platform to stream real-time data to their Web Interfaces and Data Visualization Tools [16].

III. METHODOLOGY

In order to create custom data streaming architecture based on Apache Kafka and GitHub for tracking students' activity, GitHub webhook, Kafka producer and consumer are used.

It is necessary to identify components of the data streaming architecture. Identified components are as follows (Table 1):

- GitHub users
- GitHub webhook
- Kafka producer
- Kafka cluster
- Kafka consumer

Kafka producer and consumer are implemented using the Java Spring Boot framework.

Table 1. Identified Components

No.	Data streaming architecture	
	Components	*Example*
1.	GitHub user	Student working on GitHub repository (push event).
2.	GitHub webhook	Mechanism integrated into GitHub organization of higher education institution (elab).
3.	Kafka producer	The application that broadcasts messages.
4.	Kafka cluster	Its' task is to process and organize the data.
5.	Kafka consumer	The application that receives messages.

The first part of the architecture is the GitHub platform. As already stated, it is a platform for version control and is usually used for various social coding [5] activities. In this particular case, the GitHub platform serves to broadcast events that are created within the GitHub organization. Some of the event types that should be considered are: push, pull request, merge, view, commit, etc.

GitHub users, in this particular example, are students within the GitHub organization, which generate events over their repositories. When one of these events happens, the GitHub webhook [17] is triggered as shown in Fig. 1.

After that, the GitHub webhook forwards the POST request to the Kafka producer, which further determines to which topic to send the event.

The second part of the architecture is the Apache Kafka (Fig. 1). Apache Kafka consists of a Kafka cluster, Zookeeper server, as well as producer and consumer. Kafka producer and Kafka consumer are applications where one application broadcasts (producer) messages and the other one receives messages from the broadcaster (consumer) [18].

Kafka cluster's task is to process and organize the data that is passed to it. Each Kafka cluster contains a list of topics, where incoming messages are redirected. A topic is made up of one or more partitions, and each partition is an edited, immutable sequence to which new records are constantly added [18].

Based on the GitHub event type that is being processed by the Kafka producer, messages could be passed to a different topic. For example, for each commit event being processed, the Kafka producer sends a message to the topic Topic 1 (Fig. 1). For each pull event, the Kafka producer can be configured to send a message to the topic Topic 2 (Fig. 1) and for each merge event to the topic Topic 3 (Fig. 1).

Identified topics are also given in the table (Table 2):

Table 2. Identified Topics

No.	Kafka topics	
	Topics	*Example*
1.	Topic 1	Topic which contains only commit events.
2.	Topic 2	Topic which contains only pull events.
3.	Topic 3	Topic which contains only merge events.

Kafka broker is an instance of a Kafka cluster. It receives messages from the producer, assigns an offset to each message, and then stores those messages on a disk [18].

Zookeeper is a site management and performance monitoring tool in the Kafka cluster [18].

In the end, the Kafka consumer application reads data from the topic and students' activity analytics are calculated. Later these analytics could be presented in some web interface such as dashboard preview.

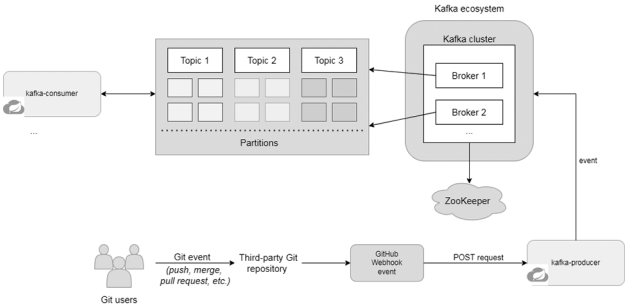

Fig. 1. Proposed Data streaming architecture diagram

An example (TABLE I) of an event, which is triggered from a GitHub webhook, is shown in the figure (Fig. 2).


```
{
  "id": "123",
  "type": "PushEvent",
  "actor": {
    "id": 123,
    "login": "student",
    "avatar_url": "https://avatar.url"
  },
  "repo": {
    "id": 123,
    "url": "https://api.github.com/repos/elab/iteh"
  },
  "org": {
    "id": 123,
    "login": "elab",
    "url": "https://api.github.com/orgs/elab",
    "avatar_url": "https://avatar.url"
  },
  "created_at": "2022-04-21 19:55:46"
}
```


Fig. 2. Push event

Push event (Fig. 2) contains data about event id, type, actor (in this case the student who generated the event), repository (repo), GitHub organization (org), and date (created_at) when the event is created.

Kafka's producer's task is to forward push events to a certain topic (event_topic) as shown in Fig. 3. Once the data arrives at the topic, the Kafka consumer reads the data. It is possible that the consumer application, upon reading the data, performs analytics and presents the data through the web interface. The web interface could be integrated with Moodle LMS, but this option needs to be investigated further.

```
package com.kafka.producer.broker.producer;

import com.fasterxml.jackson.core.JsonProcessingException;
import com.fasterxml.jackson.databind.ObjectMapper;
import com.kafka.producer.model.Event;
import lombok.extern.slf4j.Slf4j;
import org.springframework.kafka.core.KafkaTemplate;
import org.springframework.stereotype.Service;

@Service
@Slf4j
public class EventProducer {

    private KafkaTemplate<String, String> kafkaTemplate;
    private ObjectMapper objectMapper;

    public EventProducer(KafkaTemplate kafkaTemplate, ObjectMapper objectMapper) {
        this.kafkaTemplate = kafkaTemplate;
        this.objectMapper = objectMapper;
    }

    public void sendMessage(Event event) {
        String json = null;
        try {
            json = objectMapper.writeValueAsString(event);
            kafkaTemplate.send("event_topic", event.getType().toLowerCase().substring(0, event.getType().toLowerCase().indexOf("event")), json);
            log.info("Producer was sent a message {}", json);
        } catch (JsonProcessingException e) {
            e.printStackTrace();
        }
    }

}
```

Fig. 3. Kafka producer implementation

Fig. 4 and Fig. 5 show the web interface. Fig. 4 shows the profile of GitHub organization, as well as a list of its repositories. Besides that, the figure also shows repository search by date.

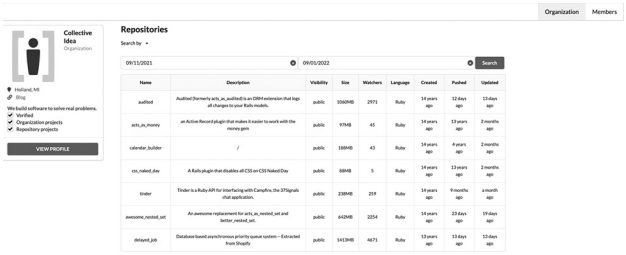

Fig. 4. Repository search by date

Fig. 5 shows the review of a member's profile within GitHub organization. Some of the data are: number of followers, number of public repositories, location, email, company, etc.

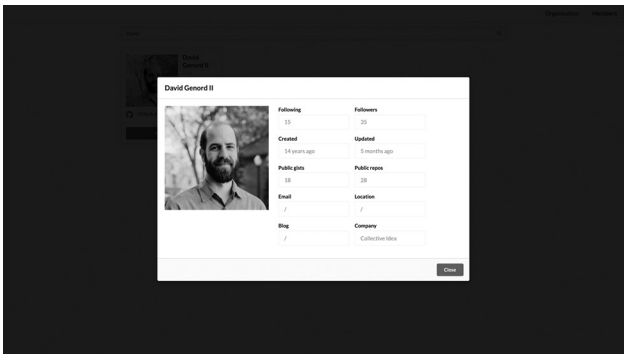

Fig. 5. Review of a member's profile within GitHub organization

IV. CONCLUSION AND IMPLICATIONS

In conclusion, it is important to state that there is a possible way to implement data streaming architecture which is based on Apache Kafka and GitHub platform for tracking students' activity in higher education software development courses.

GitHub webhook mechanism is used to integrate the GitHub platform and Kafka producer application. Students are working on their individual or collaborative GitHub repositories and thus are generating events. GitHub webhook is triggered by some event types that are defined when creating a webhook. Upon certain GitHub events happening, the webhook is sending the POST requests to the Kafka producer. The producer further determines to which topic to send the event. In the end, the Kafka consumer reads the data from the topic and calculates analytics based on students' activity.

The given solution could be used as a starting point for further consideration of this idea. The main goal of implementing an architecture that relies on Apache Kafka is to obtain the necessary analytics on students' activity generated on the GitHub platform. The advantage of this solution is in the speed of message processing and in the number of messages that are processed. This provides teachers with the latest information on students' activities in real-time.

What could be further investigated is the question of integrating LMS (Learning Management System) such as Moodle with the Kafka consumer application. This would allow real-time web presentation of data that is analytically processed before. The dashboard presented in the LMS solution could provide different analytics and previews customized to LMS user that has access to it. Different dashboard data could be presented to the students and to the teachers depending on the role that is given to them.

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Project Based Learning in Vocational Studies

Miloš Mijić

Academy of Applied Studies Šabac, Department of Studies for Educators and Nurses - Educators
Šabac, Serbia
mijic.milos3@gmail.com

Branko Ćebić

Academy of Applied Studies Western Serbia, Valjevo Department
Užice, Serbia
branko.cebic@vipos.edu.rs

Abstract— The paper will give an example of project learning in the subject Computer Graphics and Multimedia, which is performed in the study program Business Informatics and Programming, in basic vocational studies. The aim of the course is to understand the role of computer graphics and multimedia in modern business and communication and to master the basic techniques of creating graphic and multimedia content. For the needs of the proposed project learning, students should first get acquainted with the theoretical foundations of creating raster documents: techniques of processing raster objects (tool palette, layering, selection, transformation, coloring, lighting, filters, actions, text input and editing…), creating content for the Web, preparing for printing and publishing. The proposed example will be implemented through the following phases: selection of the topic - defining the problem to be worked on, project preparation and work plan development, project flow, presentation of project results and evaluation. The focus is on recording, analyzing and processing images on a given topic. It is expected that it will give an example of project learning that can be implemented in primary vocational education as a method for educating students in Computer Graphics and Multimedia, that students will achieve better exam results and that this method of work will be gladly accepted by students.

Keywords— project-based learning, higher education, computer graphics and multimedia, raster object processing

I. INTRODUCTION

Continuous improvement and improvement of the knowledge transfer process aims at more efficient production of professionals who will be able to respond to the future challenges of their profession, and to take responsibility for their decisions [1]. In modern didactics, the largest number of criticisms refers to frontal work which is aimed at satisfying the needs of only average students. This way of working is based on the transfer of ready-made knowledge where students are passive participants. In order to overcome these problems, it is necessary to modernize the teaching process by developing and using new methods of work [2] that would put students in the forefront as active participants in the learning process. One such form of active learning is project-based learning [2].

II. REVIEW OF LITERATURE

Project-Based Learning is a comprehensive approach to teaching and learning in the classroom designed to involve students in research on authentic issues [3]. It is a form of learning that trains students in real-world challenges they may face in future professional career [4]. Project-based learning enables students to learn by working and applying their ideas, to deal with real, meaningful problems that are similar to the activities of adult professionals [5]. Through this type of learning, students are given the opportunity to research, ask questions, suggest hypotheses and explanations, discuss their ideas, challenge the ideas of others and try new ideas. Research has shown that students who learn teaching content organized through meaningful problems, show better results than students who study in the traditional way [6, 7, 8]. Project-based learning has long been used in higher education as a method for educating students with the help of realistic problem tasks [9, 10]. These tasks usually require initiative and independence from the student. They need a lot of time to complete, result in the production of the final product (eg reports or presentations) and use educators in an advisory role [3,11,12]. Projects can often involve students working in groups with the aim of encouraging collaboration and developing interpersonal competencies. This approach has already been implemented as a good practice in bioinformatics training [13]. PBL - Project Based Learning allows students to learn organized in groups in which they work together to solve specific problems and finally present the final result of their work-projects in the form of a multimedia presentation, written report, website or constructed product [2].

Project-based learning (PBL) is an active form of student-centered learning. It is characterized by student autonomy, constructive research, goal setting, cooperation, communication and reflection in real world practice. Research conducted in different contexts at different stages of schooling, from primary to higher education, could not determine with certainty the causal link between PBL and the positive results of both students [14].

Experiential learning is a key factor in acquiring knowledge through experiencing things. The basic idea of project-based learning is to connect students' experi-

ences with school life and to provoke serious thinking as students acquire new knowledge. Through experiential learning, and especially through PBL, a connection with real-world problems is made [15].

In his paper, Dimmitt [16] analyzes the extent to which project-based learning (PBL) contributes to learning efficiency and the extent to which it provokes critical thinking among first-year university students. The results of his analysis showed that the PBL method can learn students effective techniques for increasing self-confidence and independent, critical thinking that are necessary for students to be successful in their academic endeavors. Sulaiman and colleagues [17] investigated the effectiveness of involving students in environmental projects. The results of the research showed that the greatest impact on the students had projects that required them to make pleasant and unusual final products such as a documentary, a campaign throughout the school and an environmental exhibition throughout the school. This result indicates that PBL can be implemented with few resources, within the school building and in the time allotted for processing the topic.

Branch [18] conducted a study to determine the effects of project-based learning on student achievement in mathematics. The study examined differences in student achievement in two charter schools in Chicago. In one school, the traditional way of learning was applied, and in the other, project-based learning. The results revealed that there are statistically significant differences in student achievement between schools that used project-based learning as a learning approach and schools that used a traditional learning approach.

The interdisciplinary field of mechatronics encompasses a coherent interactive design process that facilitates, innovates and develops desired skills by adopting experiential approaches to learning. Mechatronic educational and experimental systems have been developed to facilitate experiential learning and improve the learning process in order to stimulate thinking skills in undergraduate students. Developed educational and experimental systems of Mechatronics are designed, implemented, programmed, tested and successfully used by students within the designed laboratory. Developed systems have their own learning indicators where students acquire knowledge and learn certain skills. Knowledge is acquired through engagement, practical experience focused on students inspired by collaborative participation, reflection and interactive discussion. The integration of learning outcomes related to the developed educational and experimental systems of Mechatronics, combined with the project-based learning approach, has given the desired results that indicate the improvement of the learning process. The effectiveness of the developed experimental systems has been demonstrated through an experimental laboratory and through project-based learning at Sanio_Onoda City University, Yamaguchi, Japan, and the American University in Cairo [19].

Numerous studies have investigated the effectiveness of learning based on examining the effectiveness of the application of the PBL method in the education of engineers in various countries. For example, Ruikar and Demian [20] found that there was a link between learning success and engaging industry partners through multimedia podcasting in the UK. Industry partners provide real-world cases that put them in the context of theoretical content.). Multimedia content podcasting also addresses the issue of student engagement. They can adapt to different ways in which students learn (eg VARK - video, audio, reading / writing and kinesthetic sensory learning modalities). The paper describes a case study of the application of podcasting in the final year design module at Loughborough University. The students were assigned a master planning project on which to work. An industry partner was hired to record an audio-visual session in which he gave a report on key design considerations and rationale for the master planning project. Later, in a dedicated lecture module, an audio-visual podcast was released. Students were briefly introduced to the scope of the podcast's content. The survey found that the student showed very good results on the test and gave a very high grade to the podcast in the questionnaire that asked for their subjective reaction to the experience.

Hassan et al. [21] have adopted an integrated, multidisciplinary, project-based learning methodology in e-engineering in Spain. Fernandes et al. [22] also applied a project-driven education model developed by Powell and Weenk (2003), and applied it as a learning model to students at the University of Portugal.

Another study looked at project-based language learning. They used the theory of activities in the university language program in Ireland. This study showed mixed results in learning outcomes for study participants. Such results are a consequence of contradictions identified in the system of activities (unequal division of labor, lack of time due to community obligations or opposition to the rules governing activity in modules). [23].

III. EXAMPLE OF PROJECT LEARNING ON THE SUBJECT OF COMPUTER GRAPHICS AND MULTIMEDIA

Basic information about the project: Project learning is extremely suitable for learning in the IT group of subjects through which, in addition to theoretical knowledge, some organizational skills are acquired, communication skills, creativity, ability to take responsibility and ability to work in a team. From the group of informatics subjects that are studied at the basic vocational studies is the subject Computer Graphics and Multimedia. From the curriculum of the subject Computer Graphics and Multimedia, a certain unit has been singled out, which refers to the processing of photography. Through lectures in higher education, on the processing of photography, teachers convey important theoretical information. Exercise classes work on the practical improvement of theoretical knowledge by applying creative methods of work on selected content. Learning can be organized as a project research

task. Students are engaged in processing the photo so that it is convincing enough for the observer. Editing and processing a photo can be extremely interesting because its quality can be improved, and even top quality photos can be obtained. The project would be organized over three weeks (6 school hours). Students are divided into groups of 5. The groups are heterogeneous. Each group has a full task.

A. Preparatory phase

Project topic: Creating raster documents: techniques of processing raster objects (tool palette, layering, selection, transformation, coloring, lighting, filters, actions, text input and editing…).

Project objectives: General objective: to understand the roles of computer graphics and multimedia in modern business and communication and to master the basic techniques of creating graphic and multimedia content.

Specific objectives: to improve the levels of information literacy by collecting and selecting information; to develop and improve communication skills; to develop more efficient and effective collaborations-cooperation of an individual in a group in order to achieve a common goal; to form critical thinking (ability to distance oneself from one's own beliefs and prejudices in order to come to well-founded and logical conclusions about what to believe and what to do); to develop ICT skills needed to work with computer and communication devices, software, applications ...; to establish cooperation between the two Academies of Vocational Studies in Sabac and Valjevo.

Project outcomes: Students' ability to: organize and see the project (acquire the ability to learn, research and search, select and use information, develop social skills, collaborate, acquire practical and managerial skills ...); self-creation of posters, flyers, brochures or similar graphic solutions; self-creation of a logo or illustration on a given topic; taking and processing a photo on a given topic / need.

Holders of activities: Students, teacher. A cooperative relationship is formed between them to solve the problem. This attitude contributes to the development of self-initiative, greater freedom in work and encourages the responsibility of students to take the initiative in finding solutions.

Methods of work: Individual and group method, Method of oral presentation (description, explanation, reporting), Method of conversation (discussion, brainstorming), Method of reading and working on the text, Method of writing, Active and interactive methods of work (Activity encouraged by teaching technique, content or teacher instructions, Interactive methods have the task to transfer the activity from teacher to student, to help students learn together, solve tasks and evaluate work.).

Forms of work: Team work (projects) - Working in a team motivates the student better than working in a group. There must be a willingness, knowledge and ability among the members of the group to make a full contribution to the achievement of a common goal according to their abilities and role. Group form of work: The composition of the group is determined by agreement between teachers and students. According to the tasks, all groups do the same task.

B. Project planning

Explanation of the project topic: An image is an artifact that displays or records visual perception [24]. An image can be defined as a two-dimensional function f (x, y) where x and y are spatial coordinates, and the value of the function represents the intensity at a certain point in space. Given that about 90-95% of the information about the world around us is obtained through the visual system as visual effects, quality images must be convincing enough to leave a good impression on the viewer. Regardless of how the photo was created and whether it is product of an amateur or a professional, for high quality, it sometimes needs to be subjected to beautification - digital processing with the help of digital computers. Digital processing is performed to improve the visual characteristics of the image in order to achieve a satisfactory image perception by the observer.

The Chinese proverb "A picture is worth a thousand words" confirms that our mind prefers to work with visual elements than to use words. We can describe reality in words, but we can directly show reality in pictures. And if we prefer to use visual thinking as an important aspect of information processing, unfortunately, in the field of education, graphic methods are mostly neglected and knowledge transfer is most often done verbally. In the middle of the last century, a new concept of "visual thinking" emerged as a pedagogical approach that advocates the view that the ideal way to create, share, develop and manipulate ideas is to present in a visual sense. We process images much faster than any information in text or oral form. Visual information leaves a deeper impression on us than what we read or what they tell us. It is clear that language, as written, so is the oral, very sophisticated and useful means of conveying ideas, however, this means of conveying concepts has no immediacy or closeness to the image. Example: it is much easier to learn what an apple is if seen in a photograph or in real life than if we remember its definitions [25].

Preparation for the selected topic: Students and the teacher jointly define the main topic and plan activities and contents, evaluate the learning process and their results, generate and choose possible options. All team members should be equally engaged. Members agree with each other. Upon completion, each team prepares a report on the results of the project.

Each team was given the same task, to download an image from the Internet and approach the development of an image processing plan with a specific tool.

The teacher suggests tools that I can use: Adobe Photoshop and Adobe Lightroom. Adobe Photoshop is selected.

Reason for choice: Adobe Photoshop (Photoshop) is the market leader among professional programs in the field of digital image processing and creation [26].

Choice of information sources: scripts from lectures and exercises, PowerPoint presentations, materials from the Internet, tutorials.

Choice of required resources: Computer, Software and image processing application. Instructions-tutorials available on Youtube can be used to use some tools. Take into account what was presented in the theoretical classes. Focus on the levels and phases of digital image processing.

IV. PROJECT IMPLEMENTATION

Implementation and materialization of ideas. Monitoring the work plan, documenting the implementation of the project (notes, pictures...). Possible example of concretization of the project topic - opening the project.

A. Task 1: Turn a photo into a drawing.

Fig. 1. Example of concretization of a project topic (Initial photo) [17]

Step 1: Launch Photoshop and upload the import photo via the “Open” option.

Step 2: To get a black and white drawing, remove the color from the photo. Menu bar- find the Image > Adjustments > Desaturate option. Now color of the photo becomes "black and white".

Step 3: Duplicate a layer of "black and white" photo. The Layers palette shows all the layers of the photo stacked on top of each other. Right-click, select the layer and select the Duplicate Layer option in the context menu and then select the OK option. A new layer appears on the palette above the "Background layer” called "Background copy".

Step 4: Convert the "Background copy" layer to photonegative. Select it if it is not selected (the active layer is colored blue) and use the Image > Adjustments > Invert option.

Step 5: Work on the layer continues - return to the layers and mix colors. Use one of Mod's merges on the Layers palette to mix the colors of two photos. Select the Color Dodge option from the drop-down menu. Turn the white surface into a drawing using a Gaussian Blur filter. The Gaussian Blur filter is located on the menu line Filter> Blur> Gaussian Blur. Select Gaussian blur and make adjustments (value ranges between 1 and 10 pixels), 10 pixels were used for work purposes.

Step 6: You need to “glue” the layers by selecting the "Background copy" layer, and right-click to select the Merge Visible option. Only one layer is visible on the Layers palette now. Then the photo editing was successfully completed.

Step 7: After converting the photo into a drawing, add the text to the photo. Select The Horizontal Type Tool. Use font settings (Brush Script MT, Italic) and font size (57 pt,strong) to add text.

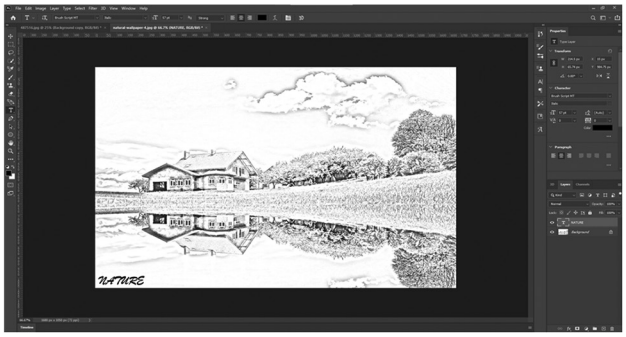

Fig. 2. Example of concretization of the project topic (Final photo after editing)

B. Task 2: Photo retouching. In Adobe Photoshop, retouch the original photo. Remove irregularities and make corrections on the skin and face and make a uniform tonality

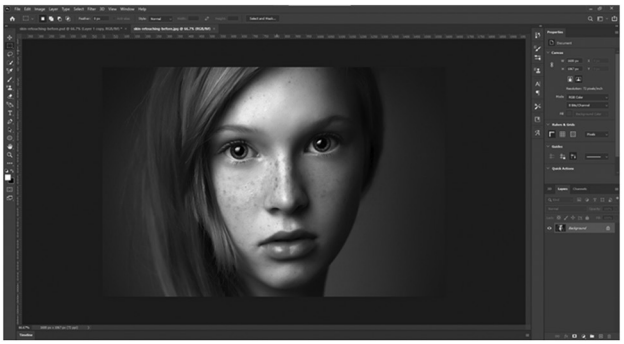

Fig. 3. Example of concretization of a project topic (Initial photo) [18]

Step 1: Open the original photo and duplicate that layer (Layer > Duplicate Layer).

Step 2: Select the Spot Healing Brush Tool from the Toolbox. By applying this tool, irregularities on the skin are eliminated.

Step 3: Select the copy of layer and again make a duplicate of it (Layer > Duplicate Layer), and then apply the "Dust & Scratches" filter (Filter > Noise > Dust & Scratches) to that layer.

Step 4: On the same layer, apply a "Gaussian Blur" filter (Filter > Blur > Gaussian Blur) with a radius of 2 px, in order to obtain a soft skin tone.

Step 5: To get a more natural look, add a "Noise" filter (Filter > Noise > Add Noise).

Step 6: Add a mask to this layer via the icon on the Layers palette. Fill the mask layer with black (keyboard shortcut D, X then ALT + DELETE). Then invert the color of the foreground and the background so that the color of the foreground becomes white (X on the keyboard), select the paint brush (B) and use the brush to "paint the skin" in the necessary places.

Fig. 4. Example of concretization of the project topic (Final photo after retouching)

V. PROJECT PRESENTATION

Presentation in Word and PowerPoint presentation with a description of the work process supported by photographs documenting each step. Various tutorials contain instructions for making presentations. The presentation of the project results is done in front of the teacher for 10 minutes. If necessary, the presentation time can be extended, but not longer than 20 minutes, because a longer presentation reduces the attention of the listeners. The questions are short and are asked at the end of the presentation. Question time - no longer than 15 min.

VI. EVALUATION

Since the presentation of project results is done in front of the teacher, it can be more extensive in the form of conversations between teachers and students and based on feedback, an assessment can be given. The survey technique was chosen in this project. The project implementation is being evaluated. Students should give their opinion in order to find out their position on the implemented project. The example of the questionnaire for students is arranged according to the survey, ie. Evaluation sheet for students [29] with certain modifications:

1. Do you like the way you work on the project?

YES - NO - PARTIALLY - I DON'T KNOW

2. Are you satisfied with the team way of working on the project?

YES - NO - PARTIALLY - I DON'T KNOW

3. Are you satisfied with the working conditions on the project?

YES - NO - PARTIALLY - I DON'T KNOW

4. Are you satisfied with the coordination of teachers' work on the project?

YES - NO - PARTIALLY - I DON'T KNOW

5. Do you better understand the essence of the content through classroom lectures or project teaching?

YES - NO - PARTIALLY - I DON'T KNOW

6. Would you prefer team work, project teaching and research tasks to be more represented in regular classes?

YES - NO - PARTIALLY - I DON'T KNOW

In addition to the evaluation of the project, future research may also evaluate the work of teachers, the work of group leaders and the work of each student individually, the evaluation of available literature and the evaluation of evaluation. In addition to evaluation in further research, the effects of the application of project-based learning in higher education can be examined.

VII.CONCLUSION

The subject Computer Graphics and Multimedia is a subject that is taken at the basic vocational studies of the first degree. The set goal of the course implies that students at the end of the learning process should understand the role of computer graphics and multimedia in modern business and communication and master the basic techniques of creating graphic and multimedia content. The competencies that are provided in the Curriculum of the course are expressed through the outcomes of the course and must be in accordance with the requirements of the profession. Through the envisaged competencies in this subject, which represent knowledge and skills, students should be trained for a job in the profession for which they are studying. Research has shown that project-based learning significantly contributes to better student outcomes and performance. Project learning can be designed and implemented in most subjects. The main disadvantage of such learning is the limited time frame for the material, which is extensive. This kind of learning requires more times than classical learning [30]. Excessive material and a condensed schedule burden students. Because they may be uninterested in work that additionally burdens them and takes away their free time. The problem can also arise because students have different places of residence, so there is a problem

of organizing meetings outside of school. The advantage of the method is that real life contexts and high technology tools can be introduced into subject curricula through project learning. In this way, students are encouraged to work independently, develop critical thinking and lifelong learning skills.

The proposed example of project learning could be implemented in learning in which students and the teacher would try to organize learning so that the set task is done together in order to reach the set goal. For successful implementation of such learning, not only certain experience is needed, but also good organizational skills of teachers, but also the will to step out of the beaten path of classical learning, to accept the challenge and to be more engaged in creating higher levels of student education. It is expected that he will give an example of project learning that can be implemented in primary vocational education as a method for educating students in Computer Graphics and Multimedia, that students will achieve better exam results and that this method of work will be gladly accepted by students.

According to the Australian College of Teachers' Code of Ethics: "Teachers have an obligation to keep pace with learning achievements and with theories and strategies of teaching... They are responsible for what they teach and for the way they build relationships with students" (F. Haynes).

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Comparison of learning outcomes in the traditional and e-learning model in higher education

Srđan Barzut

Academy of Applied Technical Studies Belgrade
Belgrade, Republic of Serbia
sbarzut@tehnikum.edu.rs
https://orcid.org/0000-0002-8283-8100

Ana Petrović

Academy of Applied Technical Studies Belgrade
Belgrade, Republic of Serbia
apetrovic@tehnikum.edu.rs

Abstract— E-learning was a matter of personal choice, in line with individual preferences, commitments, and leisure, until two years ago. We found ourselves in a scenario where we all had to start working remotely, which had a significant impact on education as one of society's foundations. We were compelled to adopt two teaching models because of health restrictions: online and a blended hybrid model that mixes periodic face-to-face education with e-learning. Therefore, it is now critical to assess the outcomes. This paper addresses this topic, restricting its scope to the students' results and experiences. A survey is performed to assess students' perceptions of being taught online and in a hybrid model, as opposed to face-to-face, and to determine which type of learning they prefer. We investigated why two groups of students at different levels of study had such disparate survey results. The outcomes of students' midterm exams over the previous four years are analyzed to confirm the successful transformation of the traditional curriculum into an e-learning model.

Keywords— e-learning, e-teaching, distance learning, learning outcomes, higher education

I. INTRODUCTION

Higher education in Serbia has experienced numerous challenges and significant transformations in the previous 15 years. European standards have been implemented in education as a result of the Bologna Process, with the goal of reforming higher education to make it student-centered learning, to balance competencies, and to promote student mobility. At the same time, a formal model of e-learning in higher education was introduced. An institution that implements a distance learning model must ensure that this method of education provides the same levels of knowledge and skills as traditional education. For that purpose, the Republic of Serbia's National Council for Higher Education developed the standards that higher education institutions must achieve during the accreditation process for this method of learning. Simultaneously, the institutions must meet the necessary ICT and software requirements to deliver this model of education. According to the data from the National Entity for Accreditation and Quality Assurance in Higher Education in 2019, only 18 out of 270 higher education institutions (170 state-funded and private faculties and 80 schools of applied studies) have at least one accredited distance learning study program [1]. The latest report from this institution reveals that currently there are only 13 institutions with at least one accredited distance learning study programs [2]. In the evolution of higher education, there has been an increasing need for short and accelerated programs that are different from formal traditional academic programs. The implementation of the dual education system in higher education reflects the latest improvements in the education system in Serbia. Combining it with e-learning could make it more efficient.

The delivery of learning, training or education program electronically is called e-learning. According to some, it is a subset of electronic business technology i.e., a form of technology used to increase an organization's efficiency, decrease expenses, or expands market reach using the Internet. The application of these technologies achieves many advantages over the traditional ones:

- Ubiquity: Elimination of physical or time constraints;
- Global coverage: Geographic, temporal, and national restrictions have been erased thanks to the Internet, resulting in a potential market for the entire world's population;
- Universal standards: the standards and protocols on which e-business technology is based are universal and provide interoperability at the global level;
- Information wealth: Global market data can be obtained easily, inexpensively, and fast with high precision;
- Interactivity: Information technologies used in e-business technology are interactive and enable quality two-way communication, which provides useful feedback and adaptability;
- Personalization: User-specific content can be generated and supplied based on his preferences, needs, or other factors, which results in an individual's tailored environment (interface) that feels more comfortable.

Due to a health crisis, we found ourselves in a situation where working remotely was no longer a choice, but a necessity. Depending on the sort of employment, remote work is possible in some circumstances, but not in others, such as production facilities, construction, etc. The same path was followed in the education sector, where the e-learning model has taken on a substantially main role. People's mobility was limited by restrictions, but remote working, e-learning, and online collaboration platforms, as well as online leisure options such as gaming and video streaming, began to grow. These new circumstances have

underlined the Internet's critical role. As a result, Internet traffic volume has increased by roughly 40%, often at the expense of download performance, raising concerns about the Internet's robustness [3] [4].

Education is one of the pillars of every society, and it has experienced substantial disruption in recent years. Professors and students alike were pushed to reconsider how they used available technology to both provide and receive academic resources. However, whether or not this forced change was effective, it is time to examine the results of this period. Based on observations and experiences from higher education, in the next sections of this paper a critical analysis of e-learning issues will be presented, as well as results on students' preferences regarding preferred learning method. To confirm successful transformation of one traditional curriculum into an e-learning course, we conducted a comparative analysis of learning outcomes in each teaching model. Our hypothesis is that the transformation is effective if the results are consistent, regardless of the applied learning model.

II. TRADITIONAL AND E-LEARNING MODEL

In the previous period, there were many discussions and research on the topic of e-education. The influence of modern technologies on the process of learning and education has greatly changed the traditional approach to education. The usual sage on stage approach is less and less dominant in education. Sage on the stage is a teaching approach where a professor lectures their students to impart knowledge. With little feedback, students are expected to take notes, learn, and repeat this information when asked. Students passively absorb the knowledge that the teacher presents to them. To meet the needs of new generations, lectures had to undergo a modernization process, which included the addition of interactive multimedia content to keep up with other social content and the environment. The discussion surrounding the employment of digital technologies in higher education is primarily focused on student learning rather than professor lecturing and their lack of adequate digital literacy [5]. Utilizing new technologies in education requires teachers to assume new responsibilities, develop a range of new skills, and undertake a long list of new roles. This is an ongoing research topic, which aims to find different instruments for measuring digital competence in teaching. For instance, the European Framework for the Digital Competence of Educators (DigCompEdu) [6] summarizes a teacher's digital competence in six areas, which are divided into 22 specific competencies, as shown in Fig. 1. Area 1 is focused with at the greater professional environment, i.e., educators' use of digital technology in professional contacts with colleagues, students, parents, and for their own career advancement. Area 2 examines the skills required to utilize, develop, and distribute digital learning resources effectively. Area 3 is responsible for overseeing and managing the use of digital technology in learning and teaching. The use of digital techniques to improve assessment is addressed in Area 4. The potential of digital technology for learner-centered teaching and learning practices is the emphasis of Area 5. The specific pedagogic abilities necessary to enhance students' digital competence are detailed in Area 6.

Students are constantly on social networks and text messaging, and they use a number of online platforms to express themselves. Young students are frequently described as having a natural affinity to digital technologies for everyday use. However, the main concern in terms of education is if they are capable of learning independently and with the same dedication in e-learning model. As a result, the guide on the side approach is becoming particularly crucial in the distant learning model. An educator who empowers students to study a subject area autonomously or through mutual interaction while providing them with learning resources, occasional guidance, assistance, and correction. Also, it is not enough for students to know how to utilize the various mobile devices and software that are available at a given time throughout their studies at a higher education institution. Given the quick rate of technology advancement, they must also be able to adapt to new digital settings and create habits that foster the continual mastery of new digital abilities [5] [7].

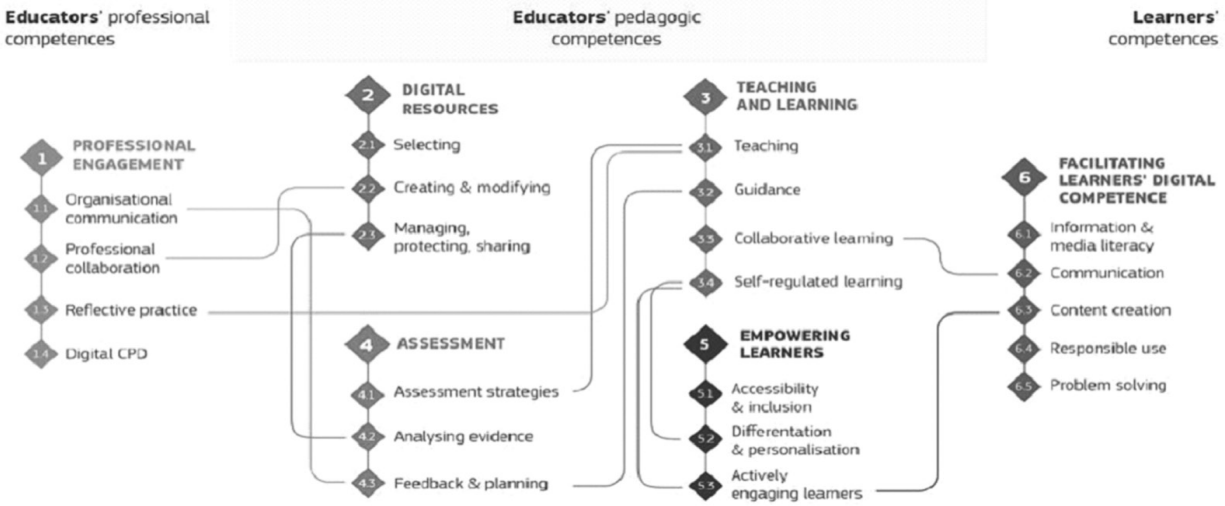

Fig. 1.The European framework for the digital competence of educators. Source: [6]

Professors who teach intensively online have been reported in multiple studies to have a higher rate of burnout than professors who do not teach online [7]. Intellectual property concerns are addressed as losing intellectual property rights to teacher's course materials that may include original approaches and creative concepts. Enforcing copyright and fair use of educational materials available online presents numerous challenges. It's not unusual to come across a simple link to another teacher's online materials within an online course. Are appropriate references sufficient for satisfaction, given the time and effort invested in creating course materials?

Learning to conduct courses using digital resources has an overall positive impact on online teaching approaches in higher education [8]. Due to health restrictions, during last two years, we used two models of teaching: online and a blended learning hybrid model. Hybrid learning model combines face-to-face education with online attendance. Lecturers have been given new roles in these models, compared to traditional education. On the other hand, students were given additional responsibility for conducting learning and successfully mastering the material with much less teacher's assistance. Higher education institutions that never had an e-learning model before were forced to completely change their teaching methods, and teachers were forced to adapt their courses and materials to an acceptable digital form in a very short period of time, without the support of course designers, computer experts, or graphic production staff. In addition to their professional competencies, teachers are tasked with mastering the skills of using digital distance learning platforms in a short period of time. Those who could not adapt so quickly, kept in the usual sage on the stage approach, conducting traditional lectures using well-known collaboration tools like MS Teams, Zoom, Slack, etc. However, at the time of global insecurity and health concerns, enormous effort has been invested by all teachers, and that is something that society must honor in some way.

It is important to measure student satisfaction, dedication, and achieved results, and dropout rate. The next section of this paper addresses this topic, restricting its scope to the students' results and experiences. We explore how students evaluate being taught online and in hybrid model, compared to face-to-face, and ultimately which model of learning they prefer on undergraduate and master's programs in the field of applied technical studies.

III. FINDINGS AND DISCUSSION

A. Preferred teaching model

During the current semester, a group of students in the first and second year of undergraduate applied studies were being polled, and an online survey was carried out with a group of students in the first year of master's applied studies. The aim of the survey was to find out which learning model students prefer. A total of 150 students were surveyed, corresponding to 67.57 percent of the total number of students who were eligible to participate. The poll was open to students who were enrolled for the first time in the specified year of study. The survey findings are presented in Table 1. Averages of 87 percent of undergraduates, regardless of the year of study, have a strong desire to participate in traditional classes. As expressed during the available discussion, the most common reasons for traditional learning model are foremost the social aspect, followed by a better understanding of the lessons and learning consistency. The students stated that it suits them better when they come to a higher education institution, make personal contact with teachers and colleagues, exchange opinions, study in a group, socialize at the same time and spend extra time together after classes. They admitted that having a set class schedule fits them considerably better than having to plan their own time. They attain substantially better learning continuity this way. A completely different choice of learning approach is noticeable among master's students, with 90 percent preferring the hybrid model. The majority of students in this group is employed or live outside of the higher institution's city, which are the primary reasons for their choice.

TABLE I. A SURVAY ON PREFERRED TEACHING MODEL

Students	Preferred teaching model		Polled
	Hybrid	Traditional	
1st year undergraduate	12.20%	87.80%	65.08%
2nd year undergraduate	13.56%	86.44%	72.84%
1st year master's graduate	90.00%	10.00%	64.10%

B. The success of transforming traditional curriculum into an e-learning model evaluation

The authors of this paper are teachers in the course Informatics, which is mandatory in the second year of all study programs in our department. A comparison of students' performance and activity in the online, hybrid, and traditional learning models is conducted by analyzing the results achieved in this course in the last four years. This course comprises one class of theoretical teaching and three classes of laboratory exercises per week. Because of the greater focus on practical teaching, transforming this segment of the curriculum into an online model posed a challenge, especially considering that in 2020, after just two weeks of the semester, the decision was made to transfer from a traditional to an online model. Creating study materials for online teaching is a difficult and time-consuming task. Although it is commonly assumed that young

people have a natural predisposition for digital technologies, our main concern was whether the generated online materials would be attractive enough for them to sustain their attention and approach learning with the same dedication. To meet the needs of new generations, the lectures are designed to include as much interactive multimedia content as possible, in order to remain coherent with other social networks' content and the environment to which students are accustomed. Complete teaching materials were uploaded on the well-known distance learning platform Moodle. This platform was chosen because it supports all guides on the side approach criteria necessary for conducting laboratory exercises, especially in light of novel circumstances. It was crucial to empower students to exercise autonomously with provided learning resources, enabling their mutual interaction using the platform's chat capabilities, and ensuring students monitoring, guidance, assistance, and correction. All laboratory exercises were covered by extensive video tutorials. MS Teams, a synchronic groupware solution for online meetings, is used for the theoretical parts of the course and consultations. Asynchronous groupware tools like e-mail and chat were used as additional communication channels. To ensure continuity in the hybrid teaching model, students were given lectures in electronic form for the entire curriculum, regardless of whether some lessons were conducted face-to-face. Although that is beyond the scope of this paper, it is interesting to note that we have encountered mentioned issues such as work overload, burnout, and intellectual property concerns.

In order to analyze the success of the implemented transformation of the traditional curriculum into the model of e-learning, we reviewed the available data on the outcomes gained by students in the preceding four years at midterm exams. A midterm grades are a snapshot indicating how a student is performing academically in the course. Classes were held traditionally in 2018 and 2019, so these statistics serve as a baseline for comparison with the outcomes attained in 2020 when classes were delivered online and in 2021 when a hybrid approach was used. Average outcomes gained by students are presented in Fig. 2. Regardless of the applied model of education, the outcomes from both midterms are uniform in all four years evaluated; even a slight improvement in the hybrid model of teaching is noticeable. From the foregoing, it can be inferred that the process of transforming a traditional curriculum into an e-learning model has been done effectively. It is worth mentioning that the students expressed great pleasure with the manner and quality of available lessons, to our great satisfaction.

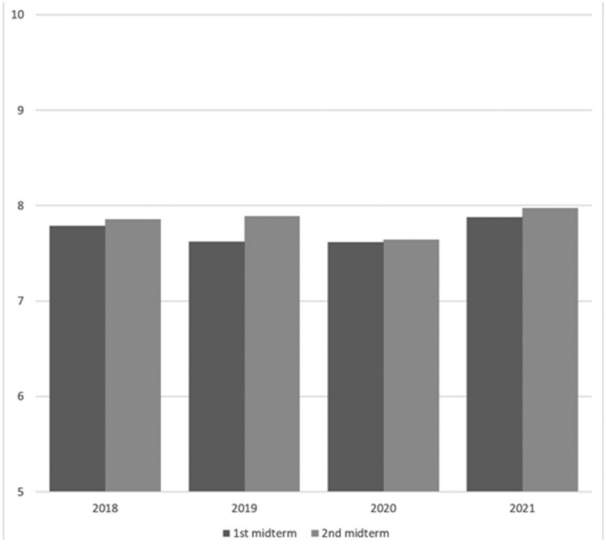

Fig. 2 Average outcomes in the preceding four years at midterm exams

A summary of similar research was given in [9], all of which concluded that in terms of knowledge transfer, it is possible to achieve the same learning outcomes by applying distance learning or traditional education. However, concerns regarding generalizability need to be taken into account in terms of the scientific fields to which the research relates. This study focused solely on non-STEM (Science, Technology, Engineering, and Mathematics) courses. These results may not translate into the comparable performance of students in STEM courses that require a laboratory-based component. However, a few promising studies in the field of science report the effective transfer of traditional undergraduate biology courses to online learning [10], as well as the conclusion that hybrid learning in an embryology course had no difference in overall student performance [11]. Our research supports these findings, demonstrating that in the field of computer science, transforming a traditional curriculum to an e-learning model can be carried out efficiently, achieving the same learning outcomes.

IV. CONCLUSIONS

When considering the e-learning model, all relevant criteria must be considered from the perspectives of students and institutions. From the students' point of view, the advantages are that they allow a certain group of people, usually employed students, to learn at their own pace and at a time that suits them. Simultaneously, it helps to save time for students who live outside of the institutions' city, as well as reducing the expenditures of travelling and accommodation during their studies. On the other hand, e-learning must be a personal choice based on individual desires, abilities, and preferences. The benefits of this model were acknowledged by older and more mature students, mostly due to their other engagements, according to research conducted on students who were compelled to study online or in a hybrid model. Young people, on the

other hand, are concerned about receiving the same quality of education as in the traditional approach. The social aspect of conventional education is very essential in terms of developing social and professional life. Student organizations organize forums, lectures, sports competitions, student parties, tourist vacations and excursions, humanitarian initiatives, and other activities. All these activities and benefits are significantly reduced in distance learning. Nonetheless, based on the presented research, we may conclude that e-learning matches traditional education in terms of knowledge transfer.

The advantage of e-education, from the perspective of educational institutions in Serbia, is shown in the ability to extend market reach and the total number of students, bearing in mind that accreditation requirements for physical resources and number of active teachers are lower than in traditional. Significant investments in ICT equipment, as well as the hiring of IT experts, who are now the most expensive work power in the market, are required. Much more teacher engagement and collaboration with assistants, editors, course designers, computer experts, and graphic staff members are required for well-prepared lecturing. As a result, the number of accredited study programs based on the distance education model at Serbian higher education institutions has decreased. However, after being forced to use this model of learning for the past two years, it is anticipated that interest in this model of learning will grow, resulting in a rise in the number of newly accredited study programs. The combination of a dual education model and short study programs offered via distance learning could be the next great advancement in higher education.

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Analysing the similarity of students' programming assignments

Tatjana Stojanovic

Department of software engineering,
Faculty of organizational sciences
University of Belgrade
Belgrade, Serbia
tatjana.stojanovic@fon.bg.ac.rs,
0000-0001-7191-6444

Sasa D. Lazarevic

Department of software engineering,
Faculty of organizational sciences
University of Belgrade
Belgrade, Serbia
sasa.lazarevic@fon.bg.ac.rs

Abstract— Having many assignments teachers tend to use automated grading systems to make the grading process more efficient. One of the problems while using such systems is detecting plagiarism. Many tools for detecting plagiarism have been developed and are still being improved. These tools can detect the percentage of program similarity, but cannot determine if the similarity is a product of plagiarism or not. In this paper, it is shown that high similarities between implementations are not always a product of plagiarism. Functions which may have a high similarity percentage among students are those for which solution was provided during the course, coding style used during the course, and small functions with a small number of possible solutions. For these functions, it is not possible to determine whether the code was plagiarized only by detecting code similarity.

Keywords— plagiarism, plagiarism detection, code similarity, automated grading systems

I. INTRODUCTION

The outbreak of the COVID-19 pandemic forced many faculties to change their courses in order to better adapt to the new circumstances. This pushed e-learning to become the dominant mean of teaching in a situation where physical contact is meant to be restricted. In recent years, many faculties had to adapt their courses to be online and the popularity of online courses is rapidly growing. The sudden increase in the volume of usage of e-learning platforms also brought new problems which teaching staff had to consider when conducting the faculty curriculums. One of the mentioned problems refers to the large number of exams which had to be reviewed and graded. In order to assess many students' programming assignments, teachers tend to use automated grading systems. One of the main problems with automated assessment is detecting plagiarism among the students' assignments.

Oxford University defines plagiarism as "presenting someone else's work or ideas as your own, with or without their consent, by incorporating it into your work without full acknowledgement".[4] It is important for the issue considered in this paper to emphasize that plagiarism refers not only to physical materials, but also to those in electronic form, as well as the fact that plagiarism can be intentional, but also unintentional. In the context of programming assignments, students are prone to take others' code and incorporate it into their assignments, often without changing even a single line and without fully understanding it. This can be especially problematic in exams which are meant to test students' problem-solving skills and their programming proficiency.

Tools for automated grading of programming assignments usually impose certain restrictions on the possible implementation of the students' solutions. These rules are most often concerning function prototypes, class names etc. Regarding strict rules when taking a test, several issues can be observed. Students must follow pre-determined blueprints while implementing the functions, which leaves them with little space to use their problem-solving skills. Types of automated tools which use static analysis usually expect a student to implement one of the model solutions and can be too restrictive [3], while tools which are test-based can be too strict while grading because they is unable to grade code which has any error.[6] It is important to estimate how strict the restrictions imposed on students should be, in order to be able to detect plagiarism correctly.

To detect plagiarism, many tools for detecting the similarity of programs have been developed. Some of the popular tools are MOSS, JPlag, Plaggie and others.[2][5][1] These tools compare all submissions against each other and usually provide a report containing the most similar programs. As stated, these tools only provide information about the similarity of programs, without determining why the programs are similar.

Here will be analyzed how the similarity of programs depends on the given assignments. Some functions are common in programming or there is a limited number of ways to implement them. Also, in the course, students are taught to implement a function usually in one manner. When students are required to implement such functions in an exam, it is likely for programs to be more similar. These functions will be referred to as common functions. When students are required to use their problem-solving skills and solve more complex problems which may differ

considerably from those lectured during the course, it is expected that students will have more different solutions. These functions, which can have multiple implementations, will be referred to as non-common functions. In this work similarity of programs containing common functions as well as those containing non-common functions will be analyzed, in order to ascertain how assignments affect the usage of these tools and to prevent misusage of plagiarism tools. By knowing to what extent this alters results, it will be possible to determine which similarity percentage is abnormal and probably a result of plagiarism.

II. METHODOLOGY

Analysis of students' programming assignments was performed with assignments from an introductory programming course in C. Assignments are consisted of several functions to be implemented. Due to usage of automated grading tool, students were given prototypes of these functions and type definitions for structures. Some functions (i. e. printing array, matrix, finding a member in an array or a list...) are as same or similar to those shown during the course, while other functions are not provided in the course materials.

The similarity of assignments are analysed in four ways:

1. whole programs containing all functions,
2. only functions which are considered common or simple functions for which similarity is predicted to be high,
3. only functions which are considered non-common, functions which haven't been explained during the course and can have multiple solutions, thus lower percentage of similarity is predicted,
4. each function separately, which allows determining what kind of function had higher similarity and which had a lower percentage of similarity.

All analysed assignments were implemented by students at one exam. The exam was conducted at the faculty, while students were monitored by teachers. Nevertheless, the problem analyzed here can also be applied to situations where exams are conducted fully online. The assignment consisted of seven functions which students had to implement. Two of seven functions are considered common (i.e. print an array, find a node in the list etc.). Three of them are considered non-common, meaning that solutions to these or similar functions were not provided in the materials for the course. While two remaining functions cannot be grouped in either of the two.

JPlag tool was used for determining program similarity analysis because the report shows a number of matches grouped by the percentage of similarity, which allows for determining the average percentage. In Fig. 1, a screenshot of JPlag's report is shown. When comparing all submissions with this tool, sensitivity must be determined. Sensitivity represents the minimum number of tokens required to be counted as a matching section, and smaller values might lead to more false positives.[4] The sensitivity value cannot exceed the maximum number of tokens. Sensitivity for the whole assignments and files with more functions was set to the default value of 12 tokens. For files containing only one function sensitivity value of 4 tokens was used, because some functions were short and sensitivity above 4 token did not successfully determine similar parts of code.

In order to assess the similarity of these programs, for each student program were generated four types of files – a file containing all functions, a file containing only functions which are considered common or simple, a file containing only those which are non-common and a separate file for each function.

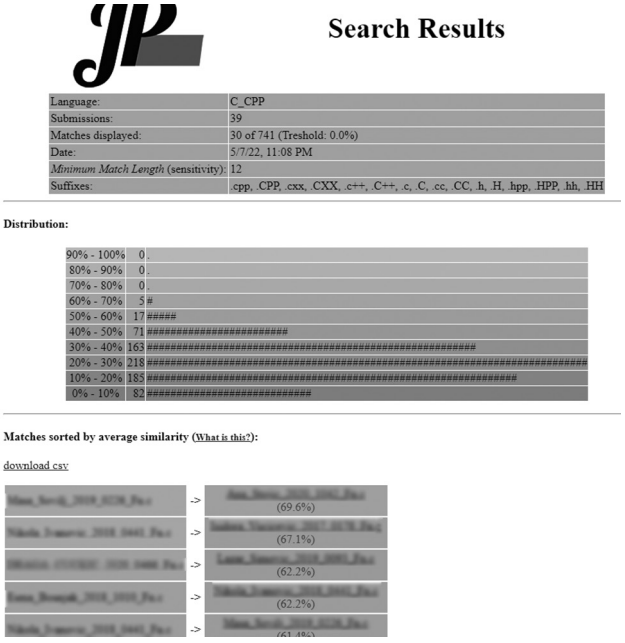

Fig. 1. JPlag report

III. RESULTS

Before the analysis, students' assignments were separated into the files as stated above. The total number of performed analyses is ten:

- 1 for the whole assignment containing 7 functions which students were asked to implement. Other auxiliary functions which students may have implemented were excluded,
- 1 for functions which are expected to be similar (common),
- 1 for functions which were not expected to be similar (non-common),
- 7, one for each function.

At Fig. 2 the vertical axis shows a percentage of total matches done, while the horizontal axis represents a group of similarity. For example, almost 40% of matches done with files which contained only common functions, have between 40 and 50% of similarity. In Table I, number of comparisons in each similarity group is shown, but results were separated in five groups instead of default ten. As it

can be seen from Fig. 2 and Table 1, the similarity tends to be over 50%. For non-common functions, the similarity tends to be lower than 20%. Overall similarity tends to be lower than 30%. Meaning if the assignment consisted only of functions for which solutions are provided in materials or during the course, a higher similarity percentage can be expected. This similarity, however, is not necessarily the consequence of plagiarism since the common functions can be implemented in a limited number of ways (as explained before), so it is not possible to determine whether the code was plagiarised or not at all. This may affect the ability to use tools for determining plagiarism. On the other hand, assignments which require better understanding and problem-solving skills and for which many different solutions can be constructed make preventing and detecting plagiarism much easier, but also can lead to a higher number of failed assignments, since the non-common functions tend to be more difficult for students. It is also observed that a lower number of students have implemented these functions.

Similarity for whole assignments shows that for this particular exam plagiarised assignments can easily be observed, with a high percentage of similarity. But if the assignment contained only common functions, plagiarised assignments would not be easily detected.

TABLE I. ASSIGMENTS SIMILARITY REPORT

Similarity %	Assignments comparisons					
	Expected to be similar		Expected not to be similar		Whole assignments	
	Number	Percentage	Number	Percentage	Number	Percentage
0%–20%	70	9%	504	72%	267	36%
20%–40%	73	9%	178	25%	381	51%
40%–60%	357	46%	20	3%	88	12%
60%–80%	116	15%	1	0%	5	1%
80%–100%	70	9%	0	0%	0	0%

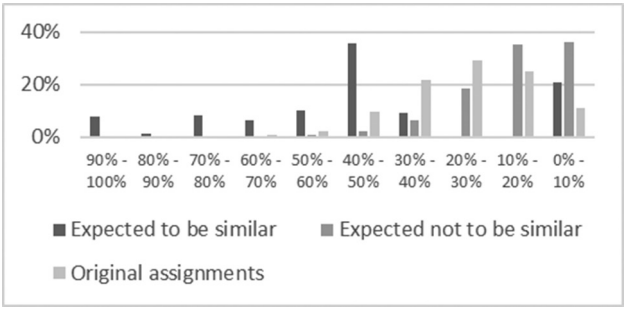

Fig. 2. Similarity report between files with all functions, files only with functions which are expected to be similar and between files only with functions which are not expected to be similar

In Fig. 3 and in Table II, the percentage for two functions which are expected to be similar is shown. The percentage of comparisons for each similarity level is shown. Functions names are:

- F1 and F2 – common functions (e. g. printMatrix, addNewNode…),
- F4, F5, F6 – non-common functions, functions previously unfamiliar to students (e. g. startGame, addMove, transformList…)
- F3, F7 – cannot be grouped in one of the previous two groups.

As it can be seen, the average percentage tends to be higher among common functions. For example, almost 90% of matches had a 90% of similarity of function for printing matrix (F1). For function F2, over 75% of total matches have similarities over 60%. For functions F4, F5, and F6, it can be observed that none of the functions has a high percentage of similarity matches (over 60%). Some of the functions like F5 and F4 have over 78% and over 40% of matches below 40% of similarity, where half of the comparisons for function F5 have similarity below 20%.

TABLE II. ASSIGMENTS SIMILARITY REPORT FOR EACH FUNCTION (%)

Similarity %	Comparisons of functions (%)						
	F1	F2	F3	F4	F5	F6	F7
0%–20%	0%	4%	9%	15%	50%	4%	23%
20%–40%	0%	10%	27%	38%	29%	17%	12%
40%–60%	1%	8%	26%	26%	16%	31%	26%
60%–80%	0%	30%	21%	19%	5%	30%	20%
80%–100%	99%	48%	17%	3%	0%	6%	18%

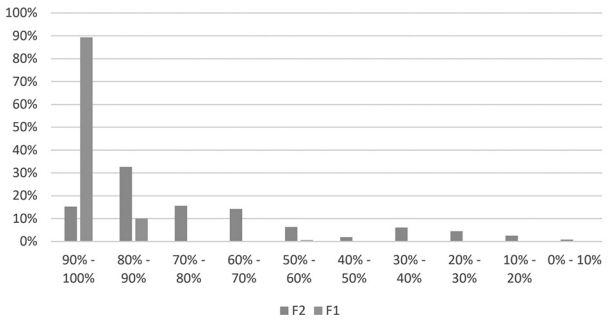

Fig. 3. Similarity between common functions

In Fig. 4, the number of percentages for three of the non-common functions is shown. As it can be seen, one of the functions is not similar at all to other implementations in almost 40% of the comparisons.

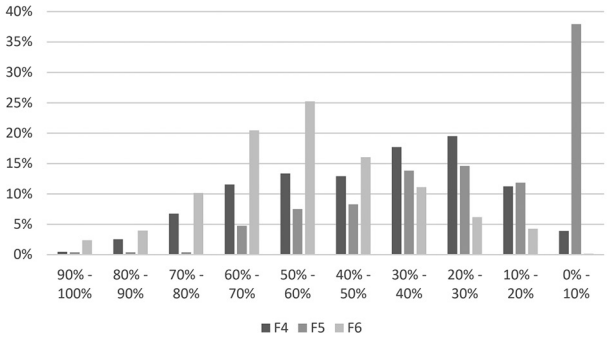

Fig. 4. Similarity between non-common functions

IV. DISCUSSION

When given functions for which solutions were given in materials or explained during the course, or similar, a higher percentage of similarity is expected. Also, for functions which have a limited number of possible implementations, we can expect the similarity to be higher. In this case, the high percentage of similarity does not necessarily mean that there had been plagiarism among the students' works. Plagiarism is harder to detect in this case.

With functions for which can be given more than one solution and for which there is not a solution provided during the course, a lower percentage of similarity is expected. For these kinds of functions, it is easier to determine whether implementations were a result of plagiarism. In this case, a high percentage of similarity between students' works usually means that they had plagiarised.

When a number of submissions are compared it is obvious that those new functions, which are not common, have a lower number of submissions. Also, implementing common functions like printing or reading from standard input cannot be avoided, same as simple functions for which students may give similar solutions. Teachers should be aware that the percentage of similarity depends on the earlier students' experience of solving those functions. When functions are the same as those presented during the course, a higher similarity is observed and it is hard to determine if this similarity is the consequence of plagiarism or the student's familiarity with the problem being solved.

In the mentioned tools, there is a possibility of excluding such common parts of the programs from the report, but when the programs mainly consist of simple or already familiar functions, the usability of these tools is questionable.

When given an assignment containing several functions which are familiar and several which could be considered non-common, tools for detecting plagiarism are effective in determining the assignments which contain plagiarism to a large degree, but smaller functions or partially plagiarized code may remain undetected.

Some tools for plagiarism detection such as MOSS, have ways to avoid grading common functions or shared code as plagiarism. MOSS enables the declaration of base files which e. g. could be provided by teachers. In addition, MOSS enables declaring a maximum number of assignments before declaring a part of code as common. For number n, if a code appears in n or more assignments, that part of the code isn't considered as part of plagiarized code. One of the cons of using MOSS is that it is an online-only tool which generates HTML response which isn't considered safe in terms of students' privacy. For this research, MOSS doesn't provide an aggregated report, making it troublesome to assess a normal percentage of similarity and its distribution.

V. CONCLUSION AND FUTURE WORK

In this paper, it has been shown how a previous knowledge of possible implementations for functions can result in similarly implemented solutions among the students. But also, using common functions is often necessary while implementing programs, and can't be avoided. With using programs such as JPlag, assignments which contain plagiarized code should be obvious, depending mainly on assignment requests.

Plagiarism tools and tools for automated grading are being used for a long time and improved through the years. While automated grading brings many benefits to the process of grading, it also limits the number of possible solutions for the assignments, making it harder to determine whether a similar code is a result of plagiarism or a coincidence.

When designing the assignments, teachers should have in mind not only the functions for which solutions are shown during the course, but should also consider how the complexity of the function affects the same issue. The simpler the function, the higher similarity should be expected, because a limited number of solutions are possible, while students are not motivated to implement the most creative solution, but only a working solution. But if functions are too complex, automated test tools could be too strict in terms of grading, not being able to partially grade code.

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EBT 2022

ЭЛЕКТРОННЫЙ БИЗНЕС И ЦИФРОВАЯ ЭКОНОМИКА

Влияние интернета и цифровой экономики на развитие конкуренции: что мы можем сказать о Сербии

Райко М. Буквич

Нижегородский инженерно-экономический университет
Княгинино, Россия
r.bukvic@mail.ru

Аннотация: С ростом применения ИКТ технологий и развитием цифровой экономики в конце прошлого и начале нового столетия вопросы конкуренции, её природы и роли в экономике появились в новом свете и с новой силой. Исходя из положений известной теории пяти сил Майкла Портера многие ожидали, что применение интернета приведёт к росту конкуренции, оказав огромное воздействие как на стороне предложения, так особенно на стороне спроса. Некоторые исследования казалось бы подтверждали такие надежды. Но, другие эмпирические данные и соответствующие исследования показали, что это не совсем так, и что подтверждается альтернативная теория «Победитель забирает всё», согласно которой конкуренция развивается в направлении монополистической конкуренции. Ситуация в Сербии, оказавшейся в некоторых исследованиях в группе стран зарождающихся лидеров в области ИКТ, пока не ясна. Основы использования ИКТ уже положены, но электронный бизнес пока не столь развит. Эмпирических исследований влияния интернета и ИКТ на конкуренцию нет, но быстрое развитие этих отраслей внушает, что конкуренция пока достаточно сильна. Это особенно можно сказать про самый сектор ИКТ, который является самой быстро развивающейся отрасли в сербской экономике.

Ключевые слова: цифровая экономика, интернет, конкуренция, концепция пяти сил, теория «Победитель забирает всё», ИКТ, Сербия

I. ВВЕДЕНИЕ

В ранних 1960х гг. в деловых кругах развитых стран началось применение компьютеров, и это считается началом новой, цифровой революции, характеризующей в более широком смысле слова переход от третьей к четвёртой промышленной революции. Её основными характеристиками являются технологии, развивающиеся исключительно быстро, изменяя при этом не только экономику и экономические отношения, но и весь обыкновенны уклад жизни людей. При этом самые крупные перемены произошли именно в экономике: различные инновационные технологии принесли многие новинки в традиционный бизнес, так что он становится почти неузнаваемым. Среди них особенное внимание уделяется развитию интернета и мобильных коммуникаций, с последствиями видимыми даже непрофессионалам. Конечно, все эти перемены с течением времени расширялись по всему миру, хотя и неравномерно, как это впрочем бывало и с другими инновациями и в другие времена.

Действительно, в последние несколько десятилетий во всей мировой экономике происходят процессы перехода к глобальному использованию электронных средств для обмена информацией и совершения транзакций. Современное развитие торговли как на местном так и на мировом уровнях предполагает именно применение средств быстрого и надёжного переноса информаций, а такими в первую очередь являются электронные носители информации – компьютеры и сотовые телефоны и технологии связанные с ними. Стремительное развитие ИКТ технологий подготовило почву не только для электронной торговли, но и электронного бизнеса в целом.

В этих новых условиях и проблемы конкуренции, как один из крупнейших вопросов создания эффективной экономики, появляются на повестке дня с новой силой. Новые технологии несомненно расширяют возможности участников на рынке, но кроме очевидного действия на рынке труда, в направлении увеличения спроса на высококвалифицированные рабочие места, остальные воздействия показываются не так ясными. Ожидания многих исследователей сначала были, что интернет и вообще цифровые технологии приведут к усилению конкуренции, в результате крупных перемен в целой экономике. Некоторые исследования, казалось бы, подтверждали такие ожидания. Но, появились и противоположные положения: некоторые эмпирические исследования ставили такие оценки под сомнение, подтверждая альтернативную теорию, согласно которой конкуренция движется в направлении создания монополий. Вопросы соотношения цифровой экономики и конкуренции пока ещё далёки от окончательного ответа, но тем более они заслуживают пристального анализа и постоянных исследований.

В этом докладе мы попробуем сделать обзор на влияние применения современных ИКТ технологий, т.е. в более общем смысле цифровой экономики на развитие конкуренции, обращая особенное внимание

на ситуацию в Сербии. Основой для нашей работы является текст [3], подготовленный для недавней конференции в Нижнем Новгороде, посвящённой подобной тематике.

II. ЧТО МЕНЯЕТ ЦИФРОВАЯ ЭКОНОМИКА

Цифровизация и развитие цифровой экономики, как экономики основанной на цифровых технологиях, принесли значительные перемены во всей экономике, проявляющиеся в ином создавании продуктов и их характере, иной организации предприятия, иной трактовке труда и способе создания стоимостей. Эти перемены сильно отражаются как на стороне предложения так и на стороне спроса, а этому в большей степени вклад приносит переход с унифицированного массового производства к производству приспособленному индивидуальному потребителю [20: 207].

На стороне предложения эти перемены проявляются в появлении новых форм продуктов и услуг, специфического характера и назначения, равно как и новых, цифровых продуктов и услуг. Всё это сопровождается новым характером и способом презентации и дистрибуции, также и потребления. Ричард Познер выделяет три главные индустрии, т. е. три рынков цифровой экономики: 1) производство софтвера, 2) интернет компании, 3) компьютерные коммуникационные услуги, которым давался дизайн с назначением поддержания двух предыдущих рынков [24]. Портер подчёркивает, что интернет создал новые отрасли (такие как торги в режиме онлайн и виртуальные магазины), но всё-таки выделяет как его главное воздействие изменение условий функционирования действующих отраслей за счёт снижения информационных, коммуникационных и трансакционных издержек [23].

Именно перемены издержек представлают ключевое понятие, связанное с функционированием цифровой экономики, как это подчёркивают Голдфарб и Такер [18]. Согласно этой статье для понимания эффектов цифровой технологии нам не нужна новая экономическая теория, что противоречит некоторым другим авторам. Голдфарб и Такер выдвигают издержки, как отличительную черту в понимании этих эффектов, а цифровая экономика должна объяснять, как меняются стандартные экономические модели, когда какие-то издержки существенно падают, и даже стремятся к нулю. Эти сдвиги издержек можно, согласно ним, группировать в пять типов: 1) более низкие издержки поиска, 2) более низкие издержки репликации, 3) более низкие издержки транспорта, 4) более низкие издержки наблюдения, и 5) более низкие издержки верификации.

Все эти перемены сопровождались в то же время процессами специализации и концентрации. Они, конечно, не являются новыми, они характеризовали и традиционную экономику, но в цифровое время они охватили все сегменты информационных технологий и экономики, обоснованной на их. Равно как и в традиционной экономике специализация служит предприятиям, что бы они увеличили свою конкурентоспособность. Таким способом в каждом сегменте осуществляется высокая степень концентрации, и значимыми становятся только несколько участников на рынке. Именно тогда наступает другой процесс, т. е. заключительный этап – занимание всем [20: 208], в котором большие, уже владеющие сетью, теперь желают на этой сети продать всё. В этом стремлении они поглощают другие компании, их идеи и технологии, фактически повторяя похожие процессы концентрации и централизации из времён начальных этап капитализма [5: 639 и дальше].

На стороне спроса цифровая экономика привела к в полности новому рынку – цифровому рынку, которого составляют виртуальные покупатели, индивиды и компании. Этот рынок увеличивался в последнее время ежегодно на новые 200 миллионов пользователей [20: 208], теперь можем сказать и больше, а этому во всяком случае надо прибавить и рост объёма рынка в рамках существующих потребителей.

Цифровизация принесла и значительные перемены в посреднических деятельностях и в каналах продаж [20: 77, 208], потом в способах оплачивания, в организации, наконец привела и к сдвигу в структуре секторов в хозяйстве и к релятивизации классических экономических аггрегатов, акцентируя потребность новой системы национальных счётов [25].

Все приведенные, как и другие, перемены, о которых в литературе уже достаточно написано, принесли ключевые трансформации в почти все сегменты рынка. Рынок новой, цифровой экономики отодвигается от обыкновенных пониманий и определений. В отличие от традиционного рынка, который ограничен по различным основам (административно, географически) и детерминирован видом товара, продающимся и покупающимся на нему, цифровой рынок в полном смысле слова является глобальным. Это в первую очередь результат расширения интернета, что создаёт технологическую платформу сетевой, т. е. глобальной экономики. Последствия создания сетевой экономики широко рассматривались в литературе. Среди них выдвигается по своему значению факт, что товар в цифровой экономике не является редким, откуда происходт и то, что отношение предложения и спроса не является важным, как это было в традиционной экономике. Это конкретно означает, что предложение и спрос приведенны в иное взаимное отношение, ввиду чего цены не образуются как отношение предложения и спроса.

Ещё Ромер [26] в 1990 году показал, что в экономике состоящей из обмениваемых информационных товаров несовершенная конкуренция становится нормой. В дальнейшем оказалось, как утверждал Мейсон [6:

173], что своего «равновесного положения экономика, основанная на информационных технологиях, достигает тогда, когда доминируют монополии, а люди имеют неравный доступ к информации».

В условиях экономики сплетённой в сеть и предприятия и индивиды находятся в иной позиции в отношении к традиционной экономике, и имеют другие возможности и ограничения. О положении и возможностях индивида в этой экономике см. например [12]. С другой стороны, те иные, и увеличенные возможности и предприятий и особенно индивидов должны были привести, по предположению, к более высокой конкурентоспособности, т. е. должны были создать более конкурентные индустрии и рынок. Большие надежды в этом смысле возлагались в первую очередь на интернет, доступность и возможности которого в последние десятилетия драматически увеличились, как в мире в целом так и отдельных странах, между прочим и в Сербии, см. например [2]. О основных показателях касающихся индивидуальной доступности и использования интернета в Сербии см. Рис. 3 в этой работе.

III. ДВЕ АЛЬТЕРНАТИВНЫЕ ТЕОРИИ

Интернет несомненно представляет конкурентное преимущество предприятий, см. [7]. Иногда даже сам электронный бизнес отождествляется только с применением сети Интернет. Такой подход, конечно, можно оценивать слишком узким, но он со своей стороны показывает значение интернета в понимании современной экономики. О других подходах к исследованию типологии электронного бизнеса см. например [4]. Тут в частности приведены три подхода. В соответствии с первым, электронный бизнес трактуется как предпринимательская деятельность, осуществляемая только с применением сети Интернет. Другой подход является более универсальным, он считает электронным бизнесом современные бизнес-процессы, осуществляемые с использованием ИКТ технологий. Наконец, третий подходне делает акцент на средствах и технологиях ведения бизнеса, согласно ему электронный бизнес – это «... совокупность электронный коммерции, бизнес-аналитики, управления взаимодействием с потребителями, управления логистикой и сбытом, а также информационной системой планирования (ERP – Enterprise Resource Planning)» [4: 4073]. На теперешнем этапе экономического развития на мировом уровне можно выделить следующие направления использования интернет-средств в предпринимательстве (рис. 1)

Рис. 1 - Основные направления использования интернет-средств в предпринимательстве

Источник: [4]

Что касается влияния интернета и современных ИКТ на конкуренцию, пока существуют две конкурирующие теории. Согласно первой из них, в большинстве теоретических рассматриваниях с самого начала преобладали положения, что интернет интенсифицирует конкуренцию. Основы этого теоретического подхода разработал ещё в 1979 [22] Майкл Портер. Его известная схема пяти сил конкуренции охватывает следующие силы: угроза появления товаров-заменителей, угроза вступающих на рынок фирм, рыночная власть поставщиков, рыночная власть потребителей, внутриотраслевая конкуренция (см. рис. 2).

Рис. 2 – Модель «Пять сил» Портера

Источник: Яндекс картинки, согласно [22].

Согласно Портеру, значение каждой из этих сил меняется от бизнеса к бизнесу и предопределяет, в конечном счете, прибыльность бизнеса, а в рамках действия этих сил должны позиционировать себя компании. Надо подчеркнуть, что эта модель не охватывает такого крупного игрока, каким является правительство (государство), и это часто определяется как её крупный недостаток, хотя сам Портер обяснял почему правительство, равно как и некоторые другие факторы не могут представлять самостоятельные силы. Кроме того, этому нужно прибавить и

следующее. Теория Портера возникла на переходе к восьмидесятим годам прошлого столетия, и конечно она носит отпечаток условий характеризующих это время: сильная конкуренция, периодические изменения конъюнктуры и относительно устойчивые рыночные структуры [11]. Но, как подчёркивает этот автор, в современных условиях представляется невозможным этой моделью объяснить и проанализировать те динамические изменения, которые преобразуют целые отрасли промышленности, эти современные условия идентифицируют три новые силы, которые требуют новой стратегической структуры и разработки ряда других аналитических и бизнес инструментов, какими являются: цифровизация, глобализация и дерегуляция [11: 78].

В более поздней работе [23] Портер рассматривает стратегические положения своей теории в связи с развитием и применением интернета. Подчёркивая несомненные влияния интернета, Портер не ставит вопросы нужно ли применение интернета, компании такого выбора не имеют. Проблема состоит в том, как его применять, поскольку он имеет и позитивные и негативные тенденции. Среди первых выделяются, например, ослабление рыночной власти каналов сбыта продукции за счёт обеспечения прямого выхода к потребителям, расширение масштабов рынка отрасли за счёт укрепления её позиций по отношению к традиционным субститутам её продукции. Большинство последствий, всё-таки, проявляется в виде негативных тенденций. Такими являются: усиление позиции покупателя за счёт облегчения доступа к информации о продуктах и поставщиках; низкие входные барьеры вследствие существенного снижения необходимости серьёзных вложений в отдел продаж и обеспечения доступа к каналам сбыта; предоставление новых возможностеё получения знания о заменителях продукта или сервиса, что существенно увеличивает их количество. С аспекта темы интересующей нас в этой статье, особенно важными являются следующие тенденции, также классифицированные Портером как негативные: интенсификация конкуренции из-за усложнения сохранения компанией принадлежащих ей особенностей предложения (т.е. отличия от других) и расширения географических границ рынка, и стимулирование разрушительной ценовой конкуренции в результате снижения уровня дифференциации продукции (услуг), изменения структуры затрат в пользу постоянных издержек, ввиду чего прибыльность в целом по отрасли существенно снижается. Портер рассматривает проблему с аспекта компании и её стратегии, оттуда оказывается очевидным, что если посмотреть из угла отрасли, или даже всей экономики, то и выводы о позитивных и негативных тенденциях должны быть иными.

Рис. 3 – Кривая «Длинный хвост» Криса Андерсона

Источник: [1]

Многие исследователи приняли специфический подход Портера, сосредоточив анализ на цены и качество, и подобно ему пришли к выводу, что интернет приводит к эффективному и конкурентному рынку, см. например [28]. Сонг и Захеди проверяли модель с двумя стратегиями (чистая и смешанная) на выборке 419 фирм и пришли к выводу, что интернет стратегии предприятий тесно связаны с политиками цен. Одно из исследований, касающихся области услуг, относится к страхованию, и охватывает ранний период использования интернета [13]. Здесь тоже показано позитивное влияние применения интернета на движение цен, подтверждая косвенно усиление конкуренции.

Основы противоположной теории ставили Фрэнк и Кук в известной книге The Winner-Take-All Society [16]. Их аргументы (см. таблицу 1) пытались в новейшее время проверить и подтвердить также многие исследователи, или пользовались ею, что бы объяснить асиметрию в распределении прибыли между интернет предприятиями и их аггресивными маркетинговыми затратами, см. например [21]. В этом русле Анита Эльберс [15] поддержала эту теорию через теорию длинного хвоста [1], в частности через эффект супервёзды [27]. В отличие от всем известного правила Парето, которое применительно к массовой экономике (т. е. к массовой продаже) может звучать примерно как «20 процентов товаров приносят 80 процентов прибыли», правило «длинного хвоста» (сначала Правило 98%) сформулированное Андерсоном доказывает совсем обратное: маловостребованные товары — те самые 80 процентов — способны дать прибыль, в сотни раз превышающую прибыль от продажи товаров-хитов. Когда Андерсон опубликовал статью «Длинный хвост» в журнале Wired в октябре 2004 года, она сразу стала самой цитируемой из когда-либо опубликованных статьей в журнале [1: 28].

Правило длинного хвоста, ставшее новым стратегическим подходом для экономики XXI века, наглядно показывает различия торговли новыми

Таблица 1 - Конкурентные теории и объяснения эффектов интернета на отраслевую конкуренцию

Теории	Ключевые понятия	Эффекты интернета на отраслевую конкурентную структуру
Пять сил Портера	Интернет интенсифицирует соперничество между конкурентами, принося большее число компаний в конкуренцию, и перенося конкуренцию к ценам.	Более конкурентная структура
Побелитель забирает всё	Поскольку быстрая коммуникация созидает схождение потребителей в их вкусах и покупательских навыках, малые преимущества перед конкурентами могут быть награждены большими рыночными долями. Интернет помогает усилению конкурентной позиции выбранных групп победителей и уменьшают конкурентную силу маленьких и/или слабых фирм.	Менее конкурентная структура

товарами от торговли в традиционных (розничных) продуктовых магазинах. Андерсон показал, что традиционная экономика из-за большой затратности дистрибуции и физической ограниченности товарного представления (на полках в обычных магазинах) основывалась на самых продаваемых товарах, пока в эпоху цифровой экономики на хиты приходится всего лишь 2% продаж, а 98% на нишевые продукты. Они и представляют «длинный хвост» товаров (см. рис. 3). Разгадка очевидно простая: вместо ограниченного пространства магазина (даже и супермаркета), теперь перед покупателем огромный непрерывный континуум товаров, требующий от него только компьютер, т. е. интернет.

Всё-таки, эмпирия в значительной степени оказалась не согласной с теоретическими предпосылками о положительной роли интернета в развитии конкуренции, даже ставила под вопрос такие ожидания. Конечно, эмпирических исследований пока всё-таки недостаточно для окончательных оценок, особенно учитывая взрывное развитие интернета и цифровой экономики. Так, например, Ванг и Жанг [31] показали на основе COMPUSTAT North America data-base для всех предприятий США в 1997, 2006, 2010 и 2011 гг., между прочим, что существует значительно позитивное отношение между пользованием интернетом (значит, цифровой экономикой) и конкуренцией (концентрацией), измеряемой обыкновенным индексом Хиршмана-Херфиндаля. Их результаты внушают, что вместо увеличения конкурентности использование интернета приводит к менее конкурентным рыночным структурам.

Это, конечно, противоречит тому, что утверждали Портер [22] и другие, говорящие именно, что интернет интенсифицирует конкуренцию. Если бы Портер и другие имели в виду ценовую конкуренцию, как это утверждается например в [20: 231], тогда данного противоречия не было бы, поскольку эмпирически подтвержденно, что цены на интернете более низкие чем при классическом сбыте. Конечно, интернет конкуренция не исчерпывается ценовой конкуренцией, и в этом смысле Ванг и Жанг не пренебрегают факта, что Портер внушает, что предприятия в интернет окружении не могут опираться на оперативную эффективность как конкурентную силу, но должны направляться на особое стратегическое позиционирование [23], [31].

На основе этого анализа Ванг и Жанг в своём исследовании пришли к выводу, что вместо конкуренции интернет создаёт систему выигришных компаний, интернет изменяет вид кривой спроса в пользу прицеливанных продуктов. Это должно означать, что эффект суперзвезды [27] доминирует над эффектом длинного хвоста [1]. Итак, согласно этим авторам анализ подтвердил теорию «Победитель забирает всё» [16], и интернет приводит к менее конкурентным рынкам. Хотя у интернета и какие-то позитивные тенденции, такие как увеличение величины рынка и улучшение позиции продукта в отношении к стандартным субститутам, всё-таки отрицательные тенденции преобладают.

Какими являются последствия развития конкуренции в новых условиях и какие рекомендации можно следать для предприятий, потребителей и конечно государственных органов. Что касается антимонопольных учреждений, эти проблемы начали серьёзно рассматриваться ещё более двух десятилетий тому назад, см. например [14], [24]. В эпоху всеобщей дерегуляции они как юы не стали особенно популярным. Но, конечно, это в общем-то является особой, к тому жу сложной, темой и для её рассматривания у нас здесь нет возможностей.

Рис. 4 – Доступ интернету, индивидуальное использование сотовых телефонов и широкополосное подключение домашних хозяйств к интернету (в %) в Сербии (без Косова и Метохии) 2006–2021

Источник: [10], [30]

IV. ЦИФРОВАЯ ЭКОНОМИКА И КОНКУРЕНЦИЯ В СЕРБИИ

Возможно ли и как, в свете всего написанного, оценить актуальную ситуацию в Сербии? Как это показывает рис. 4 основные предпосылки для функционирования цифровой экономики в Сербии на стороне потребителей уже практически созданы. Учитывая и другие моменты, Сербия даже в различных исследованиях оценивается совсем положительно. Так Костин и Березовская, считая Люксембург и Канаду лидерами по объёмам использования электронного бизнеса в мире, к лидерам по странам с переходной экономикой, использующим электронный бизнес, относят Сербию и Македонию [4]. Также, в исследовании проведенном Столяровой [8: 70] Сербия оказалась в группе стран зарождающихся лидеров, вместе с десятью других европейских стран. Все их характеризует следующее: это догоняющие страны с высокими темпами прироста экспорта ИТ-услуг, достаточно высоким объёмом экспорта ИТ-услуг, относительно высоким вкладом данного экспорта в экономику отдельных стран и относительно низкой эффективностью экспорта ИТ-услуг – большая часть ИТ-услуг связана с аутсорсингом. Таким образом, Сербия классифицирована между самыми перспективными странами Центральной и Восточной Европы. Конечно, некоторые другие исследования не совсем согласными с такими утверждениями, см. например [19], также [29] но общая оценка всё-таки как бы должна остаться положительной.

Рис. 5 – Доля предприятий с собственным веб-сайтом и продажей через интернет (в %) в Сербии (без Косова и Метохии) 2015–2021

Источник: [10], [30]

Между тем, уже рис. 5 показывает несколько иную картину. Сначала скажем, что по результатам исследований [10], [30] все опрошенные предприятия имеют доступ интернету, при этом с широкополосны подключением. Доля предприятий с собственным веб-сайтом также достаточно велика, но продажу посредством интернета осуществляет только понемногу более одной четверти предприятий, несмотря на то, что собственный веб-сайт имеет более четыре пятых среди них. Наконец, данные о доле нижней квартили (1–24 %) в совокупной продаже осуществленной через интернет представляют своеобразный показатель того, что такой сбыт товаров пока ещё не является чем-то, скажем так, нормальным. Всё-таки, мы должны обратить внимание на то, что эта доля с исключением

2020 г. уже несколько лет уменьшалась, а это во всяком случае было обнадеживающим и указывало на не так уж и малое продвижение. Но, что в самом деле случилось в 2020 г. нам кажется неясным, несмотря на возможное влияние пандемии. У нас нет сведений о причинах таких, не совсем хороших результатах, касающихся положения электронной торговли, но всё-таки мы здесь не можем не упомянуть доверие потребителей, по видимому находящееся на низком уровне. Очевидно, здесь есть ещё много простора для исследований, конечно и для будущего продвижения.

На рис. 6 показаны направления использования интернета в предприятиях Сербии (без Косова и Метохии) в 2020 и 2021 гг. Представлены следующие цели предприятий, т. е. использованные возможности, предоставленные предприятиям: 1) описание товара или услуги, прейскурант; 2) содержание на веб-сайте, приспособленное очередным посетителям; 3) возможность посетителей познакомиться с продуктами или осмыслить их; 4) линки предприятия к социальным сетям (Facebook, Twitter); 5) On-line заказы или резервирование продукта/гслуги; 6) прослеживание или статус заказа. Рисунок показывает выраженную ассиметрию, меннее софистицированные цели оказываются далеко наиболее присущим. Это ещё раз свидетельствует о нехорошей развитости электронной торговли и вообще электронного бизнеса в экономике Сербии.

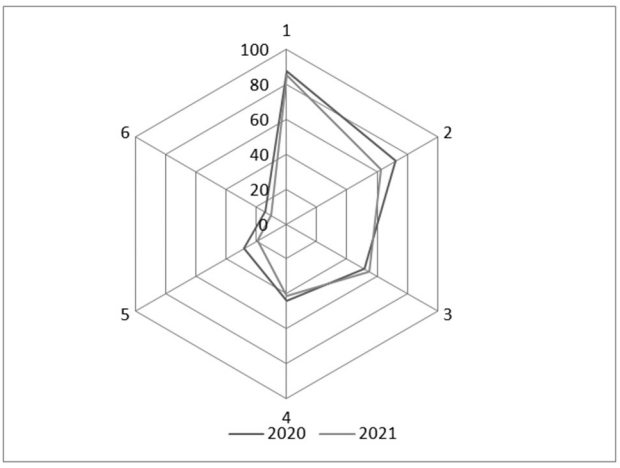

Рис. 6 – Направления использования интернета в предприятиях Сербии (без Косова и Метохии) в 2020 и 2021 гг. (в %)

Источник: [30]

Если мы говорим о самом секторе ИКТ в Сербии, как уже подчеркнуто в соответствующих документах, см. [2], он оказался в закончившемя и в начале нового десятилетия самым быстрорастущим в экономике Сербии. Основное его достоинство состоит в том, что он употребителен во всех других секторах, являяст таким образом инфраструктурным в целой экономике, даже вообще в обществе. Поэтому и нужно особое внимание посвящать именно ему.

Сразу надо сказать, что результаты хозяйственной деятельности в области информационно-коммуникационных услуг и информационного общества (производство компьютеров, электронных и оптических продуктов, почтовые активности, телекоммуникации, компьютерное програмирование, консалтинговые и с этим связанные деятельности, информационные сервисные деятельности и азартные игры) по числу занятых, заработным платам, внешнеторговому обмену, прямым иностранным инвестициям и конечно числу (новых) предприятий являются для Сербии очень хорошим и обнадеживающим.

Мы здесь воспользуемся данными Стратегии [9] и Экономической палаты Сербии и вкратце рассмотрим основные показатели: число занятых, заработные платы, внешнеторговый обмен, прямые иностранные инвестиции этого сектора. В четвёртом квартале 2018 и 2019 гг. в этой сфере было занято всего 82 535 и 88 544 человек, что составляло 4,0 и 4,2 % от совокупного числа занятых в Сербии (без Косова и Метохии), а в третьем квартале 2020 94 105, или 4,4 % совокупной занятости. Итак, рост более чем очевиден. В январе 2019 и 2020 гг. средние зарплаты занятых в рассматриваемой деятельности составляли 64 102 и 68 582 динаров, при обменном курсе равном 1€=118,0416 дин. (январь 2019 г.) и 1€=117,5643 (январь 2020 г.). В 2020 г. экспорт телекоммуникационных, компьютерских, информационных и почтовых услуг принёс 1,5 миллиардов евро дохода (столько же было осуществлено и в 2019 г.), а даже 91,4 % от этого относится на компьютерные услуги На стороне импорта совокупная стоимость телекоммуникационных, компьютерских, информационных и почтовых услуг была в том же 2020 г. 540,6 мил. евро. В целом был осуществлён суфицит на 909,4 мил. евро (к 2019 г. он вырос на 14,2 %). В 2019 г. эта деятельность имела нетто приток прямых иностранных инвестиций от 163,3 мил. евро (4,3 % совокупного нетто притока прямых иностранных инвестиций в Республику Сербию), а в 2020 г. 41,8 (в целом 3 014,2 мил. евро).

Согласно данным приведенным в Стратегии [9] в 2018 г. в Сербии были активны 2 349 предприятий в этой сфере. К 2011 г., когда началось действие предыдущей Стратегии, это составляет рост на почти 700 предприятий. Среди этих предприятий преобладают програмистские (1 483, или 63 %), которые представляют самую динамичную отрасль сербской экономики, с около 200 новых предприятий в год. Но, среди самых больших предприятий в целом ИКТ секторе почти половина находится в собственности иностранцев, что само по себе не совсем хорошо.

Занятость и экспорт сектора информирование и телекоммуникации в Сербии показаны на рис. 7. Обе там представленные переменные, как можно видеть, характеризуются значительными темпами роста, причем рост экспорта превосходит рост занятых.

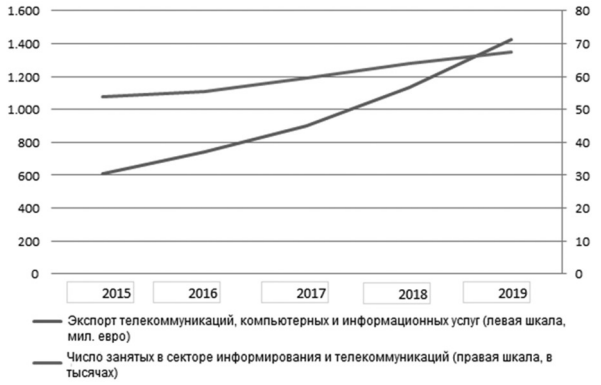

Рис. 7 – ИТ сектор в Сербии: экспорт ИТ услуг (мил. евро) и занятые в секторе информирование и телекоммуникации (в тысячах)

Источник: [17]

V. ЗАКЛЮЧЕНИЕ

Проблемы влияния цифровизации на конкурентную среду и на рынок имеют значение как на теоретическом, так и на практическом уровнях. С аспекта компаний понимание этого воздействия нужно и может им помочь в создании стратегий, направленных на повышение конкурентоспособности. В этом смысле в экономической науке пока сформулированны две конкурирующие теории – концепция «Пять сил» и теория «Длинного хвоста», и исследования проводятся, исходя из их положений. С аспекта государства, потребности регулирования цифровой экономики сталкиваются с большими проблемами, связанными не только с пониманием сущности влияния на рынок и рыночные отношения, но и с фактами стремительного развития информационных технологий и большим количеством инноваций, внедряемих повседневно в современные экономические процессы и компании. Особой проблемой оказывается именно скорость перемен, превосходящая политические структуры на власти, из-за чего и решения часто опаздывают.

По поводу перспектив развития этой деятельности можно сделать вывод, что Сербия представляет хорошую основу для начинания бизнеса в ИТ индустрии, поскольку имеет качественные рабочие, которые, тем не менее, могут обеспечить рост домашних компаний только до определённого уровня. С другой стороны, иностранцы приезжают на рынок Сербии преимущественно из-за качественных ИТ кадров, а все другие источники роста они обеспечивают вне Сербии. Вообще, сектор ИКТ оказался в закончившемя десятилетии самым быстрорастущим в экономике Сербии. Наконец, как сказано в Стратегии, конкуренция между ИТ компаниями в Сербии теперь происходит на рынке рабочей силы, для привлачења соотвветственных рабочих – в период ещё до года или два тому назад они соперничались между собой, чтобы привлечь лучших экспертов, а теперь лучших практикантов, пока они ещё учат, поскольку спрос на кадры далеко превосходит предложение. В такой ситуации, величина заработка становится главным «конкурентным преимуществом» работодателей, а тут ёмкость важнее качества, а она всегда на стороне международных компаний. Здесь кроется и ответ почему домашние ИТ фирмы растут медленнее тех которые в иностранной собственности, и которые к тому же приносят и международный рынок и решения. Производность иностранцев стремится к максимуму, а издержки к минимуму, пока цепь прибавленной стоимости в их деле почти целиком находится вн Республики Сербия.

Но, что касается темы интересующей нас в этом докладе – конкуренции, кажется что основ для оценки пока ещё нет. Подобных исследований в Сербии не было, а данные приведенные здесь показывают, что цифровая экономика ещё находится в формировании. Хотя предпосылки для её полного развития уже созданы, оказывается, что некоторые из её ключевых сегментов (электронная торговля, например) всё-таки недостаточно развиты. Что касается самого сектора информации и телекоммуникации, данные подтверждают его взрывное развитие, с ежегодным увеличением числа новых предприятий, также их результатов, особенно экспорта. Это само по себе свидетельствует о существовании сильной конкуренции в этой области. Какими будут результаты этой конкуренции, пока ещё рано давать прогнозы. Так что в целом проблемы цифровой экономики и конкуренции в Сербии пока ожидают исследователей.

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Кризис банковского маркетинга в условиях грядущего Open Banking

Мария В. Сигова

Кафедра Экономики и финансов предприятий и отраслей «Международный банковский институт имени Анатолия Собчака»,
Санкт-Петербург, Россия,
e-mail: mitina@ibispb.ru

Сергей А. Васильев

Кафедра Экономики и финансов предприятий и отраслей «Международный банковский институт имени Анатолия Собчака»,
Санкт-Петербург, Россия,
e-mail: mitina@ibispb.ru

Валерий А. Долбежкин

Научный отдел ФГБОУ ВО «Российская академия народного хозяйства и государственной службы при Президенте Российской Федерации (РАНХиГС)»
Москва, Россия

Кафедра Банковского бизнеса и инновационных финансовых технологий
АНО ВО «Международный банковский институт имени Анатолия Собчака»,
Санкт-Петербург, Россия
dolbezhkinva@ibispb.ru

Аннотация - Статья посвящена маркетинговым аспектам внедрения в финансовый сектор технологии open banking. Показаны объективные предпосылки внедрения этой технологии на российском рынке, последующие принципиальные изменения структуры поставщиков продуктов и услуг финансового рынка и неизбежность изменения как бизнес-модели коммерческого банка в целом, так и приоритетов банковского маркетинга в частности. В среде open banking появляются новые конкуренты в секторе услуг/продуктов, и радикально сокращаются потребности в коммуникации банка с потребителем. В статье проанализированы основные угрозы (риски) функционирования традиционного банка в среде open banking и обсуждается вероятная потеря эффективности традиционных инструментов маркетинга. Для удержания коммерческих позиций банка в новой экономической среде предложены варианты моделей развития и рекомендовано адаптировать к выбранному варианту инструменты банковского маркетинга.

Keywords—open banking, банк, маркетинг, встроенные финансы.

I. ВВЕДЕНИЕ

Open banking – это концепция, предполагающая использование открытых API для предоставления третьим сторонам с согласия клиента возможности запрашивать, получать и анализировать его банковские данные, интегрировать различные приложения и сервисы, тем самым повышая качество клиентского обслуживания и увеличивая ассортимент продуктов и сервисов для граждан и бизнеса [1]. Это обобщенная точка зрения регулятора.

В рамках подхода настоящей статьи, посвященной маркетингу, open banking – это критическая трансформация финансового сектора, лишающая коммерческие банки привычной приватности и открывающая их клиентов третьей стороне для активного вовлечения в экономический оборот на основе новых цифровых технологий. Использование коммерческими банками обще рыночных, межотраслевых преимуществ open banking требует пересмотра бизнес-модели для подавляющего большинства банков.

Очевидно, что возможность выбора разных стратегий (бизнес-моделей) приведет к стратификации банковского рынка. Возникнет конкуренция между банками с традиционной моделью, преимуществом которых в новых условиях останутся компетенции и масштаб, и новыми моделями (необанками), которые должны еще доказать свою способность радикально снизить затраты и быстро нарастить клиентскую базу. Отдельные примеры необанков, как успешные в целом (например, Modul), как и провалы (например, Rocket) - не формируют однозначного тренда. Поэтому обсуждение неизбежных изменений банковского бизнеса актуально.

Примечание: схожий с «open banking» другой термин «opening bank» значит просто «банк выдающий аккредитив», то есть обозначает лодин частный вид традиционного банковского бизнеса.

II. МАТЕРИАЛЫ ИССЛЕДОВАНИЯ

Цель исследования: определить влияние open banking на рыночные позиции традиционного банка, выявить основные угрозы и возможности их преодоления на базе изменения бизнес-модели, а также рассмотреть задачи банковского маркетинга в новых условиях.

Маркетинговые аспекты open banking. С точки зрения маркетинга open banking - это погружение банковского бизнеса в среду экономического обмена, где акт получения потребителем благ для удовлетворения первичных потребностей уже не сопровождается процедурой меновой сделки, то есть нет платежа в привычной форме – от наличных до виртуальной банковской карты. Крайней и наиболее яркой формой такой сделки является розничное потребление «бесплатных» социальных благ. Это и бесплатный транспорт, и бесплатная медицина, и ряд государственных услуг. Потребитель не платит за потребляемое им благо, хотя это не означает отсутствия покрытия издержек на создание блага в общеэкономическом процессе. Но, с точки зрения банковского маркетинга (клиентских отношений), в этой системе расчетов между потребителем и поставщиком благ, банк не существует. Конечно, эти примеры ограничены и базируются на государственной социальной политике и специфичны только для обособленных типов благ, групп потребителей, территорий. Более универсальным примером «погружения банка» может служить реализация платежных опций в социальных сетях, например, VKPay, расчетный банк которой практически не афишируется, но главное – он совершенно не интересен участникам сделки перевода денег. Безусловно, банковские организации технически участвуют в исполнении расчетов между сторонами, финансовые услуги исполняются и тарифицируются. Но потребитель финансовых услуг и продуктов, как субъект банковского маркетинга, в этих примерах исчезает.

Open banking можно рассматривать как распространение процессов «скрытых расчетов сторон в потребительской сделке» на широкий розничный рынок без ограничения по сегментам потребителей или товарным группам. С точки зрения автора, это резко снижает поле применения коммерческими банками инструментов маркетинга для управления выбором потребителя.

Во-первых, сам банковский продукт, по существу нематериальный, автоматизируется до удобной незаметности для пользователя. Мобильные технологии, и без open banking, уже делают сам банк, и как официальное учреждение, и как место совершения операций, - невидимым для потребителя. Незаметность денежных операций для клиента при совершении им потребительской сделки обозначает термин embedded finance (вложенные финансы). Оснастить дополнительной полезностью банковский продукт, уже удобный до незаметности, становится крайне сложно.

Во-вторых, сам продукт уходит из типичного ассортимента банка, так как фактическим поставщиком все чаще становится не банковская кредитная организация, а специализированный поставщик платежных и сервисных услуг. Open banking предполагает возможность исключения банка - держателя средств клиента из схемы платежной операции, за счет предоставления права инициализации платежа (снятия денег с банковского счета клиента) специализированным субъектам финансового рынка (PISP- Payment Initiation Service Provider). В российских документах аналогичный участник пока именуется СППУ (Сторонний Поставщик Платежных Услуг) – юридическое лицо, предоставляющее пользователю услугу по инициированию перевода денежных средств [2]. Очевидно, что эти новые игроки нашего рынка будут зарабатывать на организации клиентских платежей с банковских счетов. Таким образом некоторая часть комиссионных доходов российского банковского сектора, которые составляют до 400 млрд руб./квартал (ЧКД), подпадает под угрозу в среде open banking.

Более того, новые участники рынка получают возможность создавать через API собственные, формально банковские услуги, не получая банковской лицензии и, соотвественно, не подпадая под многие ограничения регулятора. Примером может служить развитие кредитного продукта BNPL (Buy Now / Pay Later), и, хотя коммерческий банк в схеме взаимодействия сторон пока сохраняет позицию держателя счета клиента, поставщиком решения о выдаче займа выступает уже сторонняя организация. Лидер этого направления – австралийский финтех Afterpay, кстати недавно приобретенный за 29 млрд. долл. лидером криптовалютного рынка американской компанией Block (быв. Square) [3]. Такая интеграция технологий кредитования и блокчейна может стать образцом прорывного проекта на финансовом рынке. Помимо платы, взимаемой с банка/продавца за предоставление ему заемщика/покупателя, поставщик нового продукта часто получает так же сервисные и штрафные сборы [4].

Это объективно радикальная трансформация рынка, что показывает непростая практика директивного внедрения концепции open banking в ЕС. Собственно, правовая база директивы PSD2 [5] была введена Еврокомиссией в действие в 2015 году, со сроком полного внедрения до 14 марта 2019 года, это главная дата реализации PSD2. Однако за четыре года, отведенные коммерческим банкам на подготовку и внедрение open API, только 4 из 9 крупнейших британо-европейских банков выполнили все условия директивы [6, 7]. По мнению некоторых экспертов, сама трансформация платежного рынка open banking в западной Европе была стимулирована кризисом 2008 года, когда гашение кризиса деньгами резко увеличило объем транзакций денег, а платежная система ЕС оказалась избыточно монополизирована [6].

Сейчас, в рамках действующего регулирования российского рынка, клиент пользуется услугами 2-х…3-х кредитных организаций, 1-3-х карточных

провайдеров, платёжными сервисами например ЮMoney или СБП. В грядущем open banking потребитель будет взаимодействовать не с банками, а управлять личными финансами в распределенной умной сети, представляющей продукты и сервисы множества участников финансового рынка. Для описания иногда используют термин «распределенные финансы» – DeFi, особенно в случае привлечения блокчейн технологий.

Стоит ли коммерческим банкам защищаться, адаптироваться, готовиться к open banking? Или инновация останется уделом узкого сегмента наиболее продвинутых пользователей open API?

Есть по меньшей мере три фактора, обуславливающие неизбежность полномасштабного внедрения на российском финансовом рынке концепции open banking в краткосрочной перспективе.

1. 1. Это необходимость решения коллизии с конкуренцией в платежной сфере. Несмотря на наличие трех десятков платежных систем, и трех сотен коммерческих банков «рынок платежных услуг характеризуется высокой концентрацией бизнеса. Доля первых пяти банков-эмитентов (по объему операций) в сегментах карточных переводов, платежей за товары и услуги, совершенных их клиентами, составляет порядка 96 и 90%, доля крупнейшего банка-эмитента – 92 и 71% соответственно. … В результате доступ к исторически сложившемуся большому массиву данных клиентов получил один из участников рынка, что позволило ему занять значимые позиции в сфере платежей и переводов.» [1, стр. 32]
2. Это наличие в стране необходимых и достаточных технологий открытых API. Есть разработанные и утвержденные стандарты [8] совместимые с ISO20022, есть пилотное тестирование концепции с участием 10 российских коммерческих банков (декабрь 2021), есть интенсивная успешная практика применения этих технологий в Системе Быстрых Платежей с 2019 года [9]. В июле 2021 года Ассоциация «Финтех» объявила о запуске в промышленную эксплуатацию сертификационного стенда и портала открытых API [10]. Более того, на профильных сайтах можно найти репозитарий API-плагинов уже для трех десятков банков России, Белоруссии и даже Узбекистана самостоятельно тестирующих технологию [11].
3. Это объективная необходимость последовательного обособления финансового сектора низкорисковых быстротечных платежных операций от сектора высокорисковых долгосрочных активно-пассивных (сберегательно-кредитных) операций банков. Лидирующая региональная трансформация финансового рынка - PSD2 в Европейском Союзе, преследует именно эту регуляторную цель. Более того, трансформацию финансового рынка подталкивают прогнозы McKinsey лета 2021 года, согласно которым внедрение open banking может стимулировать рост ВВП на 1,5% для США, ЕС, Великобритании и даже до 5% для Индии [12]. Это сильнейший экономический аргумент.

Безусловно, такая трансформация требует значительных затрат со стороны инициирующего субъекта (государства). Однако, как показывает финансовая отчетность специального регулятора Великобритании (OBIE), внедрение open banking позволяет быстро и существенно снижать прямые организационно-регуляторные издержки уже со второго года внедрения [13]. Это можно рассматривать как еще один аргумент за активную трансформацию.

Поэтому необходимо признать, что воплощение этой концепции в реальные правовые нормы отечественного регулятора хоть принудительные, хоть стимулирующие - неизбежно. Выжить с open banking смогут только банки своевременно принявшие новую бизнес-модель в соответствии с желаемой позицией в новой архитектуре финансового рынка. «Все четыре элемента — технология, клиенты, коммуникация и данные, будут меняться в процессе развития Open Banking» - утверждает Томас Лабенбахер, председатель Financial Services Club CEE, партнёр фонда Life.SRE-DA [14]. Есть и более радикальные утверждения: «Суть Open Banking выражается в разделении функций ведения счета и пользовательского интерфейса ... за банками остается бэк-офисная роль оператора счета, инфраструктурной базы финансовых услуг» [15].

Проблемы open banking на уровне банка. Сохраняя в малой степени роль посредника в финансах, банк в значительной мере теряет сферу взаимодействия с клиентами, которая в последнее время считалась ключевой компетенцией. Это действительно принципиальная новизна рыночной позиции банка. По мнению Т. Лабенбахера стратегию традиционного банка в среде open banking необходимо радикально пересматривать [14]. Можно, например, переосмыслить варианты типовых стратегий уклонения от угроз, описанные в классических работах Котлера Ф., Портера М., Анцоффа И. и др. Обзор вариантов регулирования open banking и моделей банковского бизнеса, используемых участниками в новых условиях на примере Европейского Союза, приведен в работе [16]. В дискуссии, сфокусированной на open banking, интересна конкретикой работа Бояринцева В.И., предложившего банкам выбирать из трех вариантов модели развития: интегратор, инноватор и платформа [17].

Главная задача выживания - поиск источников дохода, замещающих выпадающие доходы от транзакционных услуг, а в перспективе - утраченные доходы и от других продуктов. Как минимум, в open banking снижаются тарифы за счет новых технологий и жесткого ценового соперничества с высокотехнологичными конкурентами. Как максимум - продукт целиком переходит к новым игрокам рынка.

Вторичная задача - сохранение банком активной роли в платежных операциях, оптимизация тарифной

политики, острая конкуренция с платежными операторами, в том числе путем получения банком статуса СППУ. При этом придется признать, что сохранение прежней роли банка противоречит цели самой трансформации рынка – исключение универсальных посредников в расчётах.

Экстенсивная модель. Возможно активное расширение продуктовой линейки банка с целью удовлетворить спрос в новых сегментах рынка. Слабым проявлением этого варианта является развитие инвестиционно-сберегательных продуктов и брокерских пакетов. Сильным проявлением – создание на основе крупного коммерческого банка экосистем, выходящих за рамки банковского бизнеса, очерченного лицензией. Для средних банков, которые не имеют ресурсов для развития «автономной» мульти-отраслевой экосистемы, возможно получение замещающего дохода от сдачи в аренду собственной инфраструктуры [7], например, как цифровой платформы. Однако необходимо постоянно совершенствовать такой ресурс поддерживая спрос арендаторов.

Интенсивная модель. Возможно активное профилирование банковских продуктов для приоритетных (целевых) сегментов потребителей, на основе специфических компетенций кредитной организации. Важнейшей специфической компетенций здесь является KYC (ЗСК – знай своего клиента), иначе говоря – уникальный опыт финансового обслуживания своей клиентской базы. Владение новыми технологиями конечно тоже важно, но здесь маловероятно накопление специфичного опыта. Слабым проявлением такой стратегии можно считать специализацию, например, в сфере оборота специфических форм обеспечения заимствований (в сельском хозяйстве, в транспорте, в электронной торговле, сегментах совместного пользования (sharing)…), и/или предоставление клиентам «около банковских» услуг (бухгалтерия, юристы, аудит). Здесь примерами могут служить маркетпейсы B2B, например, «Собери свой бизнес» у МТС-банка. Сильным, но и рискованным, вариантом представляется формирования узкоотраслевых пакетов продуктов для финансового сопровождения бизнеса клиента. Например, развитие таких «экстремальных» (пока) специализаций, как финсервис для компьютерных игр и киберспорта, или для микро-срочной аренды или поминутного страхования имущества. Конечно, узкий рынок повышает значимость отраслевых рисков, однако риск поражения «старого» банка в новых условиях никто не отменял.

Безусловно, уже сделано много в направлении конструирования пакетного финансового сервиса с учетом особенностей партнеров и потребителей клиента, цикличности потребностей клиента в ресурсах, «индивидуальных» климатических и санкционных рисков и пр. Но преимущественно в ручном режиме только для высокомаржинальных клиентов и лишь отдельными банками. Здесь же разговор о выживании многих.

Решение о выборе перспективной модели банка не простое. Как показывает практика недавней российской реформы пропорционального управления (2018 г.), до 30% банков с базовой лицензией не смогли наладить бизнес в новых условиях незначительного ограничения высокорисковых операций, в 2021 году их бизнес был крайне пассивен. Более того за два года приспособления к новым условиям 15 кредитных организаций сами прекратили поиски «жизненного» решения и аннулировали свои лицензии [18]. А ведь грядущая трансформация open banking меняет условия банковского бизнеса более существенно, чем пропорциональное регулирование.

Проблемы open banking на уровне маркетинга Какие задачи такая трансформация финансового рынка ставит перед банковским маркетингом? Надо строго определить, что маркетинг не может иметь самостоятельных целей в бизнесе, поэтому выбор главной задачи маркетинга будет всецело определяться стратегией кредитной организации.

Банки быстро теряют свое уникальное позиционирование в системе удовлетворения потребностей клиента. Уже не только банки воспринимаются как поставщики финансовых услуг, а, следовательно, выбор потребителя усложняется. Причем новые конкуренты приходят уже владея своими массовыми клиентскими базами, своими собственными bigdata и брендами, респектабельными в исходных отраслях (Яндекс, МТС, X5, VK …). Это плохо и для банков, и для клиентов. Банки желают сохранить свой ключевой ресурс – клиентов, а клиенты желают простоты и удобства сервиса. Значит задача маркетинга удовлетворить потребности клиентов в интересах банка. Для это есть четыре испытанных инструмента создания дополнительной полезности (ценности), по крайней мере такая классическая модель – «4P», используется уже более 50 лет.

Банковский продукт. Можно, например, упростить кредит. Есть уже банки, которые выдают потребительские кредиты легко и просто, наполняя кредитный портфель на 50%+ займами, и даже НПС, с ПДН более 80%. Здесь возможности упрощения сервиса должны быть ограничены риск-менеджментом банка, и уже серьезно ограничиваются регуляторными нормами. Генерация новых продуктов безусловно зависит от выбранной банком стратегии и в значительной мере от распространения потребительских компетенций в среде клиентов. И без специализации на рынке высока вероятность предложить новый «commodities» с низкой удельной эффективностью.

Сбыт продукта. Естественно, что система доставки банковского продукта должна переориентироваться на

те места, где концентрируются потребители. И теперь «место» - это не географическое понятие, а комьюнити в социальных сетях. Здесь не просто общаются, здесь возникают экономические отношения, которые требуют финансового сопровождения, и значит банк должен иметь свою точку продаж там. Выбор успешной «локации» предложения банка в интернете совершенно не очевиден. Множатся примеры сделок, в том числе крупных (недвижимость), в совершенно непрофильных интернет ресурсах (игровых, спортивных, ...). Просто потому, что клиентам это оказалось удобно. Построение в бесконечно расширяющейся сети новых каналов сбыта, конечно – цифровых, требует новых компетенций.

Цена потребления. Активно работая этим инструментом, банки уже испробовали многое и почти исчерпали резерв создания дополнительной полезности своих продуктов через ценовые привилегии. Все кешбэки, рассрочки, бонусы, возвраты процентов - срочно копируются любыми финансовыми компаниями, быстро теряя маркетинговую эффективность. А предложение 0-й цены финансовой услуги (СБП) не оставляет места для ценовой конкуренции. Вероятно, одно из немногих некопируемых ценовых предложений – это узко сегментные цены при ясной специализации банка (хотя остаются юридические вопросы публичной оферты и добросовестной конкуренции).

Продвижение. Существенно, что open banking не просто использует новые технологии, но меняет отношение клиента к банку. Для клиента престают быть значимыми прежние фундаментальные параметры кредитной организации: история, размер активов, число клиентов, государственная поддержка, рейтинги по финансовым показателям, доступность сети продаж и пр. Теперь необходимо продвигать иные факторы, и продвигать их новым, преимущественно молодым потребителям. Фактически приходится отстраиваться от своего прошлого и многие банки просто создают нового носителя для нового имиджа – дочерние кредитные организации. С нулевой историей, новым брендом, новыми маркетинговыми коммуникациями. Так известнейший банк Santander SA, входит на рынок open banking с брендом… «Openbank»! В продвижении продуктов необходимо иначе формулировать дополнительную полезность. Теперь главное – время клиента. Поэтому придется отстраиваться от солидного и консервативного прошлого и конкурировать на уровне новых соперников из финтеха – быстрый, адаптивный банк работающий с клиентами в привычных для них каналах на новом для себя языке.

Open banking меняет сразу несколько значимых параметров банковского бизнеса: защищённость клиентской базы, приоритеты потребительского выбора, структуру конкуренции, источники доходов, значимость рисков. Сейчас практически невозможно указать, кто из участников финансового рынка окажется конечным бенефициаром трансформации. И банкам, традиционно занимавшим место «престолоблюстителя», предстоит бороться за свое место на обновленном рынке.

Выводы. Концепция open banking является принципиальной трансформацией финансового рынка, создающей не просто дополнительное конкурентное давление на коммерческие банки, но существенно меняющей их роль в денежном обороте и угрожающей существенной части привычных операционных доходов. Неизбежность внедрения концепции open banking обусловлена ее объективными преимуществами как для финансового регулятора - в части разделения рисков, так и для экономики государства - в части стимулирования ВВП. Коммерческим банкам в среде open banking неизбежно придется менять «усредненную» бизнес-модель и выбирать новую стратегию из ограниченного количества вариантов. Существенное изменение роли банков в денежном обороте критически влияет на клиентские отношения и требует пересмотра приоритетов банковского маркетинга при предложении потребителям дополнительной полезности финансовых продуктов.

БЛАГОДАРНОСТЬ

Статья подготовлена в рамках реализации ФГБОУ ВО «Российская академия народного хозяйства и государственной службы при Президенте Российской Федерации (РАНХиГС)» программы стратегического академического лидерства «Приоритет 2030».

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Бенчмаркинг как инструмент развития предприятий и отраслей в условиях цифровой трансформации экономики

ЕленаА.Мидлер

Кафедра Экономики и финансов предприятий и отраслей «Международный банковский институт имени Анатолия Собчака», Санкт-Петербург, Россия, e-mail: midler2005@yandex.ru

Инна А. Круглова

Кафедра Мировой экономики и менеджмента «Международный банковский институт имени Анатолия Собчака», Санкт-Петербург, Россия e-mail: kruglova@ibispb.ru

Ирина А. Никитина

Кафедра Мировой экономики и менеджмента «Международный банковский институт имени Анатолия Собчака», Санкт-Петербург, Россия; e-mail: sizn@mail.ru

Аннотация - В статье исследуется потенциал бенчмаркинга в аспекте управления инновационным развитием предприятий и отраслей в условиях цифровых трансформаций. Представлены теоретико-концептуальные подходы к трактовке бенчмаркинга. Рассмотрены практические аспекты, возможности и ограничения использования бенчмаркинга в частном секторе и в сфере государственного управления.

Keywords—бенчмаркинг, прогнозирование, технологический бенчмаркинг, инновационное развитие, цифровая экономика, цифровой бенчмаркинг.

I. ВВЕДЕНИЕ

Open banking – это концепция, предполагающая исОдной из важных задач развития российской экономики является построение долгосрочного отраслевого прогноза (технологического и экономического) в условиях цифровой трансформации экономики. Применение передовых методов прогнозирования позволяет улучшить качество итогового анализа, что способствует выявлению передовых технологий на этапе научных разработок и заделов, повышению конкурентоспособности приоритетных отраслей. В данной связи возникает необходимость использования инструментов цифрового бенчмаркинга для оценки технологического и инновационного развития.

В настоящее время остаются нерешенными проблемы, связанные с применением технологического бенчмаркинга на корпоративном и отраслевом уровнях, а также отсутствие системности в практике его его применения в условиях цифровизации российских компаний и государственных учреждений.

II. МАТЕРИАЛЫ ИССЛЕДОВАНИЯ

Для решения указанных проблем и вызовов целесообразным является анализ подходов к оценке эффективности управления инновационной деятельностью на основе технологического бенчмаркинга, систематизация методологий его построения с применением цифровых инструментов, а также анализ лучших практик его применения в практике компаний.

Методологической основой данного исследования является системный подход для исследования места технологического бенчмаркинга в стратегиях технологического (включая цифровой аспект) и инновационного развития компаний и структурно-функциональный метод для выделения отдельных цифровых инструментов в методологии проведения бенчмаркинга технологического (инновационного) уровня развития компаний.

В качестве объекта исследования выбрана система технологического бенчмаркинга в компаниях, использующих цифровые инструменты.

Целью статьи является выявление потенциала технологического бенчмаркинга в условиях цифровых трансформаций для построения комплексной системы оценки эффективности управления инновационной деятельностью компаний в приоритетных отраслях экономики РФ.

A. Место технологического бенчмаркинга в системе управления компаниями и отраслями

Современный бизнес-ландшафт требует наличия цифровизации от каждого бизнеса, независимо от отрасли. Этот факт мотивирует предприятия внедрять или планировать внедрение цифровой стратегии.

Технологический бенчмаркинг в современных условиях также опирается на цифровые инструменты, что позволяет использовать его потенциал для оптимизации производственных процессов на уровне компаний, а также в процедурах их стратегирования. Преимущества этого типа сравнительного анализа заключаются в его универсальности и относительной простоте структурирования. Это позволяет с одинаковым успехом применять его как в небольшим компаниях, так и в крупных международных организациях.

Особенностью технологического бенчмаркинга с применением цифровых инструментов является оценка и сопоставление ключевых показателей функционирования аналогов в целях совершенствования производства путем заимствования передового опыта и внедрения лучших практик в области технического и технологического обеспечения [1].

Обращаясь к проблеме технологического бенчмаркинга отметим, что основным условием его применения в индустриально развитых экономиках является использование цифрового инструментария в процедурах его применения, что обусловлено доминирующим технологическом укладом.

Ассоциируя бенчмаркинг с простым сравнительным анализом, многие исследователи указывают на то, что это «процесс анализа деятельности компании в целях выявления областей, требующих положительных изменений» [2].

Однако распространена и иная точка зрения, трактующая бенчмаркинг как конкурентный инструмент [3] исходя из того, что технологический бенчмаркинг может применяться в любой деятельности, в т.ч. и инновационной за счёт поиска и адаптации лучших из применяемых методов и практик осуществления бизнес-процессов.

Объектами проведения технологического бенчмаркинга являются как техника или конкретная технология ее производства (включая цифровые), так и методология, структура или процесс производства, цифровые инструменты и методы управления производственным процессом. Технологический бенчмаркинг на основе сопоставления ключевых показателей эффективности способен давать оценку достижения целей программы инновационного развития и ключевых показателей эффективности, включая достигнутую динамику относительно ведущих зарубежных компаний-аналогов [4] .

Таким образом, необходимость построения системы технологического бенчмаркинга обосновывается тем, что она позволяет в достаточно точной мере установить области применения ограниченных ресурсов, а также способствует эффективному функционированию предприятия, системному подходу к выявлению ключевых ориентиров стратегического развития в условиях цифровой трансформации внутренней среды компании.. Это один из распространенных подходов к исследованию природы корпоративного бенчмаркинга.

Учитывая как европейский опыт использования бенчмаркинга, так и азиатские корни данного явления в контексте заимствования опыта, следует отметить, что "современный бенчмаркинг в рамках данного подхода состоит из четырех базовых элементов:

- оценки собственного потенциала и способностей для объективного выявления сильных и слабых сторон производственного цикла;
- сравнения производственных мощностей, уровней технологического развития и узкоспециальных показателей и характеристик рассматриваемой организации с её отраслевыми конкурентами;
- обучения и интеграции в производство знаний, полученных от более развитых участников рынка, с целью улучшения собственных производственных показателей;
- развития, которое является основополагающей целью всего процесса бенчмаркинга "[5];
- использования цифровых инструментов.

В конечном итоге успешный бенчмаркинг позволяет предприятию качественно повысить свои производственные показатели путём оптимизации производственных циклов.

Целесообразно выделить четыре преимущества использования бенчмаркинга в целом и - цифрового - в частности, в рамках корпоративного планирования:

- бенчмаркинг способствует формированию критической точки зрения на бизнес-процессы, что позволяет в результате анализа исходных данных избрать стратегию развития производственных цепочек;
- бенчмаркинг мотивирует интегрировать активный образовательный процесс в производственные циклы организации для обеспечения устойчивого и всестороннего развития и модернизации;
- путём применения бенчмаркинга организация получает возможность по новому оценить процесс производства, а также найти новые пути для поиска решений бизнес-проблем;
- благодаря бенчмаркингу становится возможным формирование единой и универсальной системы координат, упрощающей совокупную оценку производительности предприятия или организации [5].

Следует отметить еще одну точку зрения на теоретическое основание бенчмаркинга как современного феномена [4]. В рамках данного подхода бенчмаркинг рассматривается как определение самых высоких стандартов качества для продуктов, услуг или процессов, а затем внесения улучшений, необходимых для достижения этих стандартов. Подобная модернизация называется «лучшей практикой». Одним

из первых наиболее ярких примеров применения сравнительного анализа в целях стратегического развития является корпорация Xerox.

В истории компании был период, когда Xerox терял долю рынка и испытывал сильное давление со стороны своих конкурентов. В попытке попытаться «вернуться в игру» Xerox решил сравнить свои действия с действиями своих конкурентов. После нахождения стандартов качества, с которыми можно сравнивать себя, Xerox начал одну из инновационных тенденций в современном мире. С каждым годом бенчмаркинг становится все более популярным. Таким образом, процесс бенчмаркинга — это больше, чем просто средство сбора данных о том, насколько хорошо компания работает против других [4, 5]. Ключевыми в типологии бенчмаркинга являются [5] такие виды, как:

- внутренний: заимствование опыта в рамках одной организации или ее филиалов;
- конкурентный: заимствование опыта у отраслевых компаний-конкурентов;
- функциональный: заимствование опыта у компаний из других отраслей, но выполняющих схожие задачи;
- общий: заимствование опыта у лучших компаний без привязки к их отраслевой направленности и бизнес—процессам;
- цифровой: сравнение цифровой стратегии или ее частей с конкурентами в той же отрасли, позволяющее составить карту конкурентных преимуществ.

Целесообразно также отметить легально-этический аспект бенчмаркинга, особо определяя его значение для компаний, желающих повысить свою производительность. Признавая, что на заре бенчмаркинга, его часто критиковали за схожесть с промышленным шпионажем, А. Бьорн, например, заявляет, что современный бенчмаркинг не должен фокусироваться на какой—либо коммерческой или крайне важной корпоративной информации. Пример европейского правового регулирования этой сферы путем статьи 85 европейского договора обозначает вектор, в рамках которого должен проводиться бенчмаркинг. Договор запрещает какие—либо действия, результатом которых будет подрыв конкуренции на внутреннем европейском рынке. С другой стороны, также отмечается, что до сегодняшнего дня в международном бизнес-сообществе еще не было серьезных разбирательств по вопросам бенчмаркинга [6].

Бенчмаркинг, в особенности - цифровой, может использоваться в различных отраслях - как в сфере услуг, так и в производстве. Являясь методом выявления новых идей и новых способов улучшения процессов и, опосредованно, он направлен на наилучшее удовлетворение ожиданий клиентов. Конечной целью бенчмаркинга является улучшение процесса, которое отвечает ожиданиям клиентов.

Таким образом, бенчмаркинг позволяет легко определить разрыв между тем, где исходным состоянием предприятием и его целевыми ориентирами. Эта дистанция и представляет потенциал улучшения и эталон обновления, к которому стремится организация. В краткосрочной перспективе попытка преодоления этой дистанции без отказа от изменений уменьшают возможности для выживания и развития организации в долгосрочной перспективе.

Б. Инструментарий цифрового бенчмаркинга

Цифровой бенчмаркинг - это универсальная методика, использующаяся как в сфере технологического бенчмаркинга, так и в системе государственного управления [9].

Цифровые сетевые маркеры (участие в социальных сетях и подписка, новостная активность, мобильный и веб-трафик, показатели отказов и кликов и пр.) раскрывают информацию о стратегиях конкурентов, об отраслевых тенденциях формирования этих тенденций.

Цифровые маркеры подчеркивают положительные стороны стратегии компании, показывая возможность их дальнейшего использования. После сбора информации цифровой бенчмаркинг позволяет систематизировать аналитические данные и создавать оценочные метрики.

Одним из действенных приемов цифрового бенчмаркинга является анализ исторических трендов, увеличивающих глубину сопоставления и показывающих, как менялись эталонные точки и какие факторы оказывали доминирующее влияние.

Выделим ключевые универсальные показатели цифрового бенчмаркинга, относящиеся как к технологическому бенчмарингу, так и к бенчмаркингу в государственном управлении [9].

Во-первых, это показатель трафика и вовлеченности (Traffic and Engagement). Данный инструмент позволяет сравнивать показатели до пяти сайтов одновременно, проверять и сравнить объем и распределение трафика, получать представление о доле бренда на цифровом рынке и качестве их трафика.

Во-вторых, это прямой трафик на сайт. Прямой трафик, то есть трафик, исходящий от пользователей, которые напрямую ввели URL-адрес в браузере, может быть очень полезен при проведении исследований цифрового сравнительного анализа. Посетители, которые добавляют веб-сайты в закладки и регулярно посещают их напрямую, вероятно, будут одними из самых лояльных и вовлеченных пользователей сайта. Эта же метрика может использоваться для оценки силы цифрового бренда веб-сайта. В итоге, показатели прямого трафика являются важным показателем силы бренда.

В-третьих, инструмент "Перекрытие аудитории" (Audience Overlap), позволяющий определить адресную аудиторию и размер рынка, оценить общую аудиторию и рассчитать рыночный потенциал сайта компании в сравнении с сайтами конкурентов. Эта информация помогает компаниям оценивать рынки, находить потенциальных партнеров и определять возможности расширения.

В-четвертых, инструмент «Лояльность аудитории» предоставляет информацию о посетителях, которые посещают исключительно анализируемый сайт, в сравнении с теми, кто посещает два или более сайтов за один сеанс. В этом случае используется отраслевой фильтр для сравнения каждого сайта со средним показателем по отрасли.

Сравнение лояльности аудитории определяет цифровые бренды по лояльности пользователей в отрасли, что, в свою очередь, воздействует на эффективность процессов удержания и вовлеченности потребителей.

Таким образом, цифровые инструменты при проведении бенчмаркинга позволяют фиксировать позицию компании на рынке по сравнению с конкурентами и, как следствие, нивелировать информационную асимметрию и трансакционные издержки в целом по отрасли.

B. Бенчмаркинг в сфере государственного управления

Учитывая, что сфера применения бенчмаркинга не ограничена какой-либо одной отраслью, существует множество точек зрения как на теоретическую, так и на практическую суть процесса бенчмаркинга. В соответствии с конкретными областями применения сравнительного анализа, бенчмаркинг может рассматриваться в аспекте специфики использования возможных его типов в различных отраслях и предприятиях, таких как частный сектор и сфера государственного управления.

В течение последних двух десятилетий менеджмент качества в сфере государственного управления был растущей и развивающейся концепцией. Экспертное сообщество пришло к пониманию того, что эффективность и результативность — это две идеи, которые будут и должны управлять всем, даже самыми отсталыми и неповоротливыми бюрократиями.

Ученые отмечают, что хотя бенчмаркинг может показаться универсальным инструментом для использования в любом бизнесе или организации, у него действительно есть определенные требования, которые необходимо соблюдать, чтобы он функционировал должным образом. Особенно важно соблюдение этого правила при реализации бенчмаркинга в сфере государственного управления [6].

Среди проблем и ограничений сравнительного анализа отмечаются принуждение к сравнительного анализа в государственном секторе, снижающее его понимание и мотивацию.

Большое внимание в настоящее время также уделяется «проблеме спецификации» как ситуации, в которой возможно неправильное восприятие того, что делает бенчмаркинг универсальным в конкретной области. «Проблема идентификации» рассматривается как потенциальная опасность предвзятого сравнительного анализа и может служить инструментом для продвижения интересов доминирующей стороны, а не основываться на многостороннем подходе. В свою очередь, возникающая вместе с этим «проблема приложения» связана с вопросом о том, с какими методами используется сравнительный анализ [6].

Учитывая эти вопросы, а также преимущества сравнительного анализа, с точки зрения государственной политики очень важно распознавать и сравнивать слабые и сильные стороны бенчмаркинга связанные с различными аспектами этого процесса. В данной связи выделяются ограничения сравнительного анализа, которые нужно учитывать для применения бенчмаркинга в государственном сектор.

Во-первых, это статическое восприятие, поскольку сравнительный анализ представляет собой сравнение компании и ее структуры с аналогичными характеристиками конкурентов в конкретный момент времени. Хотя такие моментальные сравнения полезны, они могут привести к несоответствиям между реальным состоянием компании и результатами сравнительного анализа. Это считается недостатком, поскольку итоговый анализ не отражает динамических проблем организационного развития.

Во-вторых, это ретрансляция опыта. Одной из ключевых проблем в сравнительном анализе, даже после завершения сбора и анализа данных, является возможность передачи накопленного опыта. Помимо невозможности реализовать данный план действий, могут возникнуть проблемы с точки зрения организационной культуры или стиля управления.

В-третьих, это количественная неопределенность. Прибегая к сравнительному анализу менеджмент может обеспечить сбор соответствующей информации и выявление передового опыта. Однако, поскольку число компаний-партнеров в сравнительном исследовании может сильно различаться, следует отметить, что чем меньше число партнеров, тем возможнее разные недостатки исследования. Это связано с тем, что меньшие группы бенчмаркинга не всегда могут обеспечить возможное улучшение процесса из-за малого количества исследовательских образцов. Впрочем, стоит учитывать, что и многосторонние исследования могут быть неточными.

В-четвертых, отсутствие стратегии. Хотя бенчмаркинг информирует менеджеров и директоров о конкурентном разрыве, с которым могут столкнуться их организации, он не обязательно формирует программу модернизации, необходимой для преодоления разрыва. Другими словами, бенчмаркинг обеспечивает ситуационный анализ. Это означает, что в то время, как бенчмаркинг может дать четкое представление об исходной точке, он не объяснит, как находясь в ней достичь желаемой цели.

И, наконец, редукционистский подход. Считается, что редукционистский подход в бенчмаркинге может ввести в заблуждение и его следует избегать. Вместо этого следует применять системный подход. Согласно ему, целое состоит из частей, которые самоорганизуются и имеют правила, которые не зависят от общесистемных правил. Это означает, что в то время, когда целое нельзя считать однородным, отдельные единицы также не могут считаться идеальным представителем целого.

Итак, методология сравнительного анализа основана на показателях, связанных с различными сферами деятельности. Сравнительный анализ объединяет картину практики и производительности в рамках всей организации и может использоваться как в частном секторе, так и в государственном.

Г. Подходы к построению системы технологического бенчмаркинга

В последние годы концепция бенчмаркинга стала синонимом успешной деятельности промышленных организаций. Главная задача бенчмаркинга — получение обратной связи о реальной ситуации и конкретной информацию о факторах успеха, а также о трудностях и разочарованиях. Бенчмаркинг — это уменьшение разрыва в производительности по сравнению с лучшими практиками или компаниями-лидерами. Контрольные характеристики и ключевые показатели эффективности — это два вида измерений, которые могут помочь компаниям улучшить свою производительность и успешность.

Бенчмаркинг обладает определенным набором инструментов и методов, необходимых для выполнения поставленных задач. Важным аспектом в теории бенчмаркинга является определение этих методов как основополагающих понятий для процесса сравнительного анализа. Комплексный теоретический анализ способствует успешному переносу алгоритма проведения сравнительного анализе на практик, поэтому для достижения целесообразности применения технологический бенчмаркинг должен принимать во внимание специфику отрасли. Отметим следующие виды бенчмаркинга на отраслевом уровне: внешний внутриотраслевой (сочетаемый), внешний межотраслевой, комбинированный межотраслевой и внешний [7].

Проведение технологическогобенчмаркинга делится на следующие этапы.

- **Подготовительный этап.** Формируется перечень компаний-конкурентов (аналогов) в отрасли на базе определенных критериев. Также учитываются финансово-экономические показатели, показатели производственной деятельности, позиции в международных отраслевых рейтингах.
- **Основной этап.** В рамках данного этапа осуществляется первичный сбор и обработка находящейся в открытом доступе информации обо всех компаниях, которые были отобраны с целью проведения бенчмаркинга. При этом дается общая характеристика компаний-конкурентов (аналогов), перечень и описание передовых технологических, продуктовых и организационных решений, проводится анализ уровня конкуренции на важнейших рынках присутствия компании, используемых компаниями-аналогами/конкурентами, выполняется SWOT-анализ выбранных компаний, оценивается уровень технологического развития и качества оказываемых услуг ведущими компаниями-конкурентами (аналогами) на основе прямого обследования.
- **Заключительный этап.** Проводится оценка соответствия комплекса технологических, продуктовых и организационных решений, используемых рассматриваемой компанией и ведущими компаниями-конкурентами (аналогами), лучшему мировому уровню; анализ возможности и целесообразности применения технологических решений, выявленных в практике компаний-конкурентов (аналогов), в деятельности рассматриваемой компании; оцениваются степень зависимости компании от импорта передовых технологических решений, а также возможности по снижению такой зависимости.

Таким образом, при осуществлении технологическогобенчмаркинга необходимо помнить о его значении на отраслевом уровне. Большинство показателей, характеризующих эффективность деятельности организации, возможно правильно интерпретировать только внутри границ той или иной отрасли, из чего вытекает потребность его применения не в глобальных масштабах, а в пределах определенной сферы, к которой относится исследуемая компания.

При измерении производительности возникает опасность так называемых ловушек производительности [8].

Ловушка 1. Замкнутый анализ. Чтобы оценить, насколько хорошо организация справляется с процессом анализа своих производственных циклов, требуется информация о критериях, которые наиболее важны не для конкретной организации, а для отрасли, в целом.организации. Они помогут определить истинные конкурентные приоритеты и связать оценку результатов бенчмаркинга с реальными показателями по отрасли.

Проблема в том, что сравнение с конкурентами трудноосуществимо в режиме реального времени. Именно поэтому множество компаний прибегают к бенчмаркингу в сравнении со стратегиями развития и бюджетами прошлых лет. Один из способов разорвать вынужденную изоляцию - опросить клиентов и партнеров организации. Главной задачей менеджмента становится организовать такую коммуникацию.

Ловушка 2. Зацикленность на прошлом. Как уже было отмечено, наряду с бюджетными показателями пакет оценки эффективности часто включает сравнения между нынешним и прошлым годами. В этом видится еще одну опасность, т.к. прошлогодние статистические данные не помогают в планировании развития компании не только в стратегической перспективе, но и в ближайшие месяцы.

Ловушка 3. Прогнозирование на основе статистики, которая подвержена искажению под влиянием человеческого фактора. Недостатки в функционировании опросных механизмов могут вызвать неадекватные результаты изучения общественного мнения. Необходима определенная доля скептицизма при работе с большими массивами статистических данных, а также постоянное повышение квалификации сотрудников, в независимости от их связи с процессами бенчмаркинга.

Ловушка 4: Манипуляции с данными. Так, А. Линкерман признает, что статистические данные – один из ключевых, хоть и не единственный способ оценки результатов бенчмаркинга. Но вместе с тем он обращает внимание, что корпоративная статистика может подвергаться искажениям. Как показывает опыт автора, администраторы и менеджеры, ответственные за выполнение показателей очень быстро начинают стремиться исключительно к выполнению планов, игнорируя общее движение вперед [8].

Возможным решением данной проблемы может стать диверсификация применяемых статистических показателей, так как манипуляции трудно распространять сразу на несколько из них.

Ловушка 5. Зависимость от числовых данных, поскольку системы оценки производительности редко развиваются быстрее самих производственных процессов.

И все же, невзирая на описанные сложности, бенчмаркинг представляет собой один из наиболее эффективных и практичных методов запуска кардинальных инновационных изменений в структуре корпоративных бизнес-процессов.

Выводы. Бенчмаркинг — это сравнение процессов, практик или процедур. Процессы могут сравниваться между собой как в рамках рассматриваемой организации, так и с аналогичными производственными циклами внешних организаций и отраслей, при этом цифровой бенчмаркинг является универсальным инструментом для выявления конкурентнных преимуществ в любой отрасли.

В современных условиях цифровых трансформаций наблюдается углубление исследований в части типологизации бенчмаркинга. Типы сравнительного анализа являются скорее взаимодополняющими, чем взаимоисключающими. Их можно выбирать и комбинировать для конкретной цели. Сочетание выбранных вариаций основано на релевантности типа сравнительного анализа для конкретных предприятий и отраслей.

Таким образом, можно сделать вывод о важности сложной и многоаспектной подготовительной работы, затрагивающей как основополагающие теоретические основания процесса бенчмаркинга, так и уже имеющиеся цифровые кейсы его применения на практике.

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Diagnostics of using IT in agriculture of the Nizhny Novgorod region

Nikolay Zavivaev

Senior Lecturer the Department "Economics and Automation of Business Processes"
Nizhny Novgorod State Engineering and Economic Univesity,
Knyaginino, Russia
zavivaev_nik@bk.ru https://orcid.org/0000-0002-6654-6685

Abstract—Modern agriculture is in full need of digital transformation through the introduction of digital technologies into the production process of all sub-sectors and spheres. This phenomenon is reflected through a variety of cause-and-effect relationships on each consumer of agricultural products and products of its processing. In this regard, the relevance of this issue increases for each person in connection with daily food consumption. In the scientific community, the development of digital agriculture is receiving increasing attention from both Russian and foreign authors. Digital transformation affects all branches of the national economic complex, depending on the current level of their development, and the agricultural sector is no exception. Therefore, the article is devoted to the diagnosis of the current state of digital agriculture.

Keywords—information support, agricultural development program, agriculture, trends in the development of digital agriculture, precision farming technologies, precision animal husbandry technologies, digital transformation of agriculture, digital economy.

I. INTRODUCTION

The influence of the IT factor on the efficiency of agricultural organizations is constantly and steadily increasing. Two decades ago information technologies acted as a supporting element of the management system, played an auxiliary (technological) role in the implementation of information exchange between participants in the management process, today technical modernization and intellectualization allows them to transform into one of the main elements of increasing competitiveness and strengthening the viability of agricultural organizations. The development, implementation and use of an effective IT system becomes the main component determining the optimality and success of any economic entity, including agricultural. The introduction of information and communication technologies into the organization's activities makes it necessary to pay close attention to the effectiveness of all elements of the production system: production, sales, logistics, personnel and, especially, management.

II. DISCUSSION

Information technologies in the Russian economy are developing rapidly as part of the implementation of the national project "Digital Economy of the Russian Federation". Its main objectives are the accelerated introduction of digital technologies in all sectors of the national economy through the creation of a stable and secure information and telecommunications infrastructure for high-speed transmission, processing and storage of large amounts of data, accessible to all organizations and households, the development and implementation of digital technologies [1,2,3,4,5]. The Center for Forecasting and Scientific and Technological Development of the Agro-Industrial Complex of the Kuban State Agrarian University has been monitoring the use of precision farming elements in the regions of Russia since 2017. According to their data, in the Nizhny Novgorod region in 2017, 50 farms using IT were recorded on an area of 158 thousand hectares, which compared with the reporting data of the Ministry of Agriculture and Food Resources of the Nizhny Novgorod region in 2020, there was an increase of 53% in the number of farms and 61% in the area of the use of precision farming elements. Agriculture, as an object of management, refers to territorial and sectoral objects that use a hierarchical principle at the heart of their organization. There are four levels in the agricultural management system:

1. Federal level of agriculture management;
2. The level of agriculture management of the subject of the Federation;
3. Municipal level of management;
4. he individual organization level of management.

Such a division of industry management into levels implies continuous improvement of its information support and increasing the degree of using information technologies. This requirement is explained by the fact that information support for the management of the agricultural economy sector, its composition and structure must clearly correspond to the implemented functions of the agricultural sector management system at all levels.

The reliability of information at the highest level of management depends on the entire chain of its occurrence, processing, storage and transmission from the lowest (operational) level – from the agricultural producer, their qualifications, integrity and other qualities, otherwise the picture of the real situation can be significantly distorted. This is evidenced by the report on the results of the expert-analytical event "Analysis of the impact of measures for the development of housing construction and engineering

infrastructure on the level of rural development" implemented in 2018, 2019 and 2020 within the State Program for the Development of Agriculture and regulation of agricultural products, raw materials and food markets and the state program of the Russian Federation "Integrated development of rural areas", approved by the Board of the Accounts Chamber of the Russian Federation on January 26, 2021. An important role in the process of improving the information support of agriculture in general and individual agricultural organizations, in particular, is played by material and technical support. Analyzing the availability of agriculture in the Russian Federation and the Nizhny Novgorod region, a tendency to reduce the number of equipment is revealed. So, in 2019, the number of vehicles in the Russian Federation is noticeably lower than at the beginning of 2015 (the tractor fleet in the Russian Federation in 2019 amounted to 65% of the level of 2015 and 90% of the level of 2016). In the Nizhny Novgorod region, the 2020 indicator by 2016 is 93.7%. This circumstance indicates the difficulties of agriculture in providing organizations with the necessary equipment. As for computer equipment and software, the analysis showed a low level of equipment for most agricultural organizations (in some agricultural organizations of the region, the IT infrastructure is completely absent).

Thus, in order for an agricultural organization to initiate measures for informatization and digitalization, it is necessary to be more actively involved in the processes of creating investment budgets for digital technology implementation projects, registration and receipt of appropriate grants, development of projects that allow obtaining financing through participation in various programs. It is particularly possible to highlight legislative and regulatory acts in the Russian Federation on this issue. The most significant for 2021 is the Departmental project "Digital Agriculture of Russia" created by the Ministry of Agriculture of the Russian Federation. The project includes: development goals and objectives; prerequisites for the need for project development; a phased implementation plan and other sections.

The main goal of the project is to achieve productivity growth at "digital" agricultural enterprises by 2 times by 2024 due to the digital transformation of agriculture through the introduction of digital technologies and platform solutions to ensure a technological breakthrough in the agro-industrial complex.

The results of the project implementation will be expressed in the growth and bringing up to 100% of data on agricultural facilities included in the digital platform by 2024. Based on the existing and target values, there is a tendency that the work on digitalization of data on agricultural land has already been started before 2018 and bringing its share to 100% is probably the fastest – already in 2022.

Agricultural machinery is at the second place in terms of digitalization of agricultural facilities. As of 01.01.2018, the share of information on it in digital form has already been formed by 25% and in 2023 it is possible to reach the level of 100%.

The most backward object for which no information was collected in 2018 (0%) is working and productive agricultural cattle. Bringing digitized information on this object is possible only by the end of the project – 2024.

III. RESULTS

Based on these targets, many practical questions arise: who will digitize data on organizations, who will be responsible, at what expense. If there are already significant developments in the direction of digitizing data on agricultural land (for example, a draft public cadastral map on the basis of which data can be integrated and transmitted, and integration databases from the State Traffic Inspectorate can be used according to technology data), then digital data on farm animals will have to be done almost from scratch. At the same time, it should be taken into account that all data on animals should be comparable between agricultural organizations, and more precisely, all animals should undergo a single certification. In developed farms, of course, such work is carried out, but in many organizations, including peasant farms, individual agricultural entrepreneurs, personal subsidiary farms, it is at a low level or completely absent. One of the most striking examples of the digitalization of agricultural processes is the application of the technology "Precision farming and precision animal husbandry". Precision farming is understood as an agricultural management system based on information and technologies for identification, analysis and management, taking into account differentiated spatial and temporal soil variations in a particular field, to optimize costs, increase the sustainability of agrocenosis and environmental stability of production.

Elements of precision farming:

1. Digitizing fields;

2. Local sampling of soil in the coordinate system;

3. Parallel driving;

4. Satellite monitoring of vehicles;

5. Differential spraying of weeds;

6. Differentiated fertilizer application;

7. Differentiated seeding;

8. Differential irrigation;

9. Differentiated tillage according to soil maps;

10. Monitoring the condition of crops using remote sensing (aerial or satellite photography);

11. Compilation of digital yield maps.

Precision farming technologies include: parallel driving, differentiated sowing, differentiated fertilization, differentiated spraying according to the weed map, differentiated irrigation, differentiated tillage according to soil maps, harvesting logistics, etc.

The goal of all technologies is to increase the efficiency of the production process by reducing fuel costs, saving time, increasing productivity, saving the main resource used (herbicides, water, etc.).

Despite the existing positive experience of introducing precision farming technologies, domestic farmers are in no hurry to introduce the latest technologies into the economy.

A survey conducted by the Kleffmann Group (1,756 respondents) showed that 57% of the surveyed farmers have no experience in using integrated precision farming solutions. The main limiting factor hindering the implementation of such solutions, respondents indicated a lack of funds for innovation. The use of precision animal husbandry elements is becoming increasingly popular. The main component of precision animal husbandry is the creation of the possibility of efficient execution of production processes using modern technology, software and hardware, and information and communication technologies. The following main groups of business processes are distinguished: the study of the quality of livestock products, the architecture of business processes of production, identification and satisfaction of personal needs of animals depending on their productivity, assessment of the health of the herd, automation of the milking process, microclimate regulation and control of harmful gases.

Elements of precision animal husbandry are:

1. Monitoring the quality of livestock products;

2. Electronic database of the production process

3. Identification and monitoring of individual animals using modern IT technologies (feeding ration, milk yield, weight gain, body temperature, activity), satisfaction of their individual needs;

4. Flock health monitoring;

5. Robotization of milking processes;

6. Automatic climate control and control of harmful gases in livestock buildings.

TABLE I. STYLES EQUIPMENT OF FARMS IN THE NIZHNY NOVGOROD REGION WITH ELEMENTS OF PRECISE AGRICULTURE, 2021

№	Elements and technical means used	Quantity, units	Cultivated area, hectares	Load per 1 unit, hectares	Percentage of farms using the element, %
1. Digitization of fields					
1.	John Deere Autotrac	1	1930	1930	0.3
2.	Trimble CFX 250	34	25903	761,8	2.5
3.	Garmin Etrex 10	1	3200	3200	0.3
4.	Teltonika FM3200 /	14	6812	486,6	1.1
5.	ARNAVI	2	6812	3406	0.5
6.	G7Farmnavigator /	1	3155	3155	0.3
7.	Trimble CFX 255	1	4200	4200	0.3
3. Parallel driving					
8.	GPS	115	25982	225,9	28.5
9.	TeeJet Matrix 430	1	1970	1970	0.3
10.	TeeJet Cenyer Lin 220	2	1840	920	0.5
11.	TeeJet Matrix 570 Pro	2	6837	3418,5	0.5
12.	JDlnk	1	5000	5000	0.3
13.	Trimble CFX 750	43	66008	1535	6.1
4. Satellite monitoring of vehicles					
14.	Glonass system	736	111342	151,3	8.7
15.	SCOUT	21	8200	390,5	0.6
16.	Autograph platform	40	13010	325	1.5
5. Differentiated spraying of weeds					
17.	John Deere 730	1	1970	1970	0.3

18.	Lemken primus A-35	1	2700	2700	0.3
19.	Sprayer-spreader Mist	1	5222	5222	0.3
20.	Sprayer-spreader Trackol	1	3429	3429	0.3
6. Differentiated application of fertilizers					
21.	Kuhn MDS 735 Spreader	12	1970	164,2	0.5
22.	Amazone	7	26850	3835,7	1.8
23.	Sprayer-spreader Trackol	1	3429	3429	0.3
24.	Sprayer-spreader Mist	1	5222	5222	0.3
25.	Amatron-3 Terminal	6	4500	750	1.0
7. Differentiated seeding					
26.	Maxima Precision Corn Seeder	1	1500	1500	0.3
27.	Amazone EDX 9000 Corn Seeder -TS	8	12423	1552,8	1.8
8. Differentiated irrigation					
28.	Valley	2	1337	668,5	0.7
9. Differentiated tillage according to soil maps					
29.	Kverneland Plow	4	8651	2162,7	1.2
10. Monitoring of the condition of crops using remote sensing					
30.	DJI Phantom 4Pro Drone	5	11467	2293,4	2.1
31.	Cropio system	1	4544	4544	0.3
32.	Exact Farming	1	1404	1404	0.3
11. Compilation of digital yield maps					
33.	Combine harvester	3	5082	16984	1.0

Digitization of fields was carried out in 22 farms or in 23.4% using elements of precision farming. This element creates electronic contours of fields in agronomic databases for their more efficient use, which allows fixing the types and timing of field work, a differentiated approach when using cultivation technologies, fertilization, etc. In the region, this element is used negligibly little in farms. The load on 1 unit of equipment is on average 963 hectares, and only about 6% of the total area of agricultural land is processed.

Differentiation of administrative-territorial entities and farms of the Nizhny Novgorod region using precision farming is high. To systematize the state of this process, according to the reporting data of the Ministry of Agriculture and Food Resources of the region, the indicator "The share of areas cultivated with the use of precision farming in the total area" was calculated; its values range from 0 to 1, where 1 is the maximum value involving the use of precision farming elements on 100% of the area. Also, 5 clusters with the following values were identified by expert method by groups 0–0.20; 0.21–0,40; 0.41–0.60; 0.61–0.80; 0.81–1.00 (Table 1). The 1st cluster includes 25 administrative-territorial entities with a low level of using precision farming, and in all of them the value of the calculated indicator equals 0. This cluster accounts for 43% of all sown areas of the region. The 2nd cluster is represented by two entities: the Uren Municipal District and the city district of Vyksa with the values of the indicator respectively 0.24 and 0.36. The share of sown areas of this cluster is small – less than 4%. The 3rd cluster includes 9 administrative-territorial formations (ATF) and they account for 25.7% of the acreage of agricultural enterprises. In the 4th cluster there are also 9 ATF with 18.3% of the acreage. The 5th cluster consists of 4 administrative-territorial entities (7.7% of their total number). Vacha and Spasskoe municipal districts have a high index of precision farming application with a value of 1.0, and in Vad and Lukoyanov municipal districts, the values are 0.85 and 0.81, respectively. It is worth noting that the total cultivated area of the 5th cluster with a high level of precision farming is 8.9% of the total sown area of the region. Indicators of the efficiency of grain production by clusters are shown in Table 2.

This table allows stating that traditional technologies currently provide an average level of yield and efficiency of

grain production – this is the 1st cluster and practically a "control option". The initial stages of the precision farming use, when only individual elements are used, leads to an increase in cost and does not give the desired economic effect. It is demonstrated by the 5th cluster, in which the grain yield is 40.4% higher than the 1st cluster, the cost price is 13.5% lower, and the profitability is almost 14% higher than the control option.

Let's analyze the situation with the use of precision animal husbandry elements in the region in 2020. Precision farming is used in 22 municipalities, which are represented by 4 urban districts and 18 municipal districts. The total number of farms using precision farming is 60 units out of 207 producing livestock products (less than 30%), of which only 2 are farms.

TABLE II. INDICATORS OF THE EFFICIENCY OF GRAIN PRODUCTION IN CLUSTERS FOR THE USE OF ELEMENTS OF PRECISION FARMING

Indicators	**Clusters on the use of precision farming elements (numbers and bounda boundaries of groups by the share of cultivated areas)**				
	1	**2**	**3**	**4**	**5**
	0-0.20	**0.21-0.40**	**0.41-0.60**	**0.61-1.80**	**0.81-1.00**
Number of municipalities, units	28	2	9	9	4
Acreage - total, ha	358679	30645	214221	156867	72726
Including grain crops	194742	11322	130776	91685	46446
Grain yield, hundred weight per 1 ha	22.5	10.3	25.7	29.4	31.6
Cost of grain sold, per 1 kilogram of rubles	7.4	10.4	16.7	7.5	6.4
Grain profitability, %	22.4	-11	31.7	32.5	36.3

IV. CONCLUSION

Assessing the processes of introducing precision farming and animal husbandry elements into the practice of agricultural production, it should be noted that, in general, positive dynamics is observed in the Nizhny Novgorod region. At the same time, the significant spatial differentiation is observed: a small number of administrative-territorial entities (less than 10%) and agricultural organizations (almost 20%) actively use precision farming, but almost 60% of both have not yet started this process. To clarify the causes of this phenomenon, a survey was conducted, the experts of which were 20 specialists of agricultural management at the regional and district levels (24%), 17 scientists of agricultural educational institutions (20%) and 47 managers and specialists of agricultural organizations (56%).

Respondents attribute the main obstacles to the development of precision agriculture in the region to insufficient financial resources in organizations for the introduction of new technologies due to the high cost of equipment and software (33%), the lack or insufficiency of qualified specialists (28%), poor coordination and support for the introduction of precision farming at all levels: federal, the subject of the Russian Federation and municipal (36%).

It is necessary to clarify that in the Nizhny Novgorod region there are regulatory legal acts, in accordance with which support for the introduction of elements of precision agriculture can be carried out. For example, according to the decree of the Government of the Nizhny Novgorod Region dated November 2, 2012 No. 781 “On approval of the provisions on financial support of the agro-industrial complex of the Nizhny Novgorod region”, part of the interest rate is reimbursed when purchasing equipment from credit institutions. Within the measures of state support, agricultural producers of the region can purchase modern agricultural machinery, including those equipped with precision equipment. According to the decree of the Government of the Nizhny Novgorod Region No. 729, November 10, 2015 “On the procedure for granting subsidies for reimbursement of part of the costs of purchasing equipment and machinery for the production of flax products”, compensation from 10 to 75% of the cost of the purchased equipment is provided. By the Decree of the Government of the Nizhny Novgorod region, December 15, 2015 No. 834 “On approval of the regulation on the procedure for granting subsidies for reimbursement of part of the costs for the purchase of equipment” provides for reimbursement from 20 to 50% of the costs. Admittedly, these measures do not solve all the problems of precision agriculture.

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Dairy farming. Prospects for digitalization

Tatyana Kirilova

SAssistant professor of the Department
"Economics and Automation of Business Processes"
Nizhny Novgorod State Engineering and Economic University,
Knyaginino, Russia
kirilovatatianaevg@yandex.ru
0000-0003-2252-8853

Abstract — In conditions of geopolitical instability and uncertainty, the state bodies, whose powers include coordinating the development of the dairy cattle industry and the agro-industrial complex as a whole, bear an increased level of responsibility in terms of reducing barriers to the development of production and sale of milk and dairy products. Acute competition in the market forces milk producers entering foreign markets to apply new methods and technologies for the production and promotion of their products. In this regard, the industry needs a new generation of development programs aimed at: the use of big data and the introduction of information technologies, improving forecasting methods, improving systems and methods of management, which is a strategically important task not only in the context of the socio-economic well-being of the Russian Federation, but also as a condition for preserving sovereignty against the backdrop of globalization and implementation of digital development programs by other participants of the world the market. At the moment, the primary task in dairy cattle breeding is to solve the problem of increasing the economic efficiency of milk production and sale by agricultural organizations.

Keywords— dairy cattle breeding, prospects, productivity, digitalization, efficiency

I. INTRODUCTION

Dairy cattle's breeding is one of the main branches of agriculture in the Russian Federation. The efficiency of milk production and sale determines the degree of food security, which is an integral part of the state national security. At the moment, the degree of efficiency of this industry in the Russian Federation is low and significantly inferior in terms of such indicators as milk yield per cow and milk production per capita in the developed countries of the world by 1.5 times. Despite the fact that agricultural organizations are the central element of ensuring the country's food security, they do not have the opportunity to significantly modernize their material and technical base, reduce high yield and infertility, improve the quality of the feed base, and increase the level of breeding and genetic work, which does not ensure their sustainable development. Due to the lack of sufficient own funds, the vast majority of milk producers are unable to independently carry out technical re-equipment, introduce modern production methods, increase its technological level, which is one of the reasons for the reduction in the number of agricultural organizations.

It should be noted that the scientific works of domestic and foreign scientists lay the foundations of theory, methodology and applied problems of economic efficiency of production, industries, enterprises, intersectoral complexes. However, the rapidly changing economic and technological conditions of management, the instability of dairy farming in many regions of the country dictate the need to develop practical recommendations adequate to modern economic conditions for improving the economic efficiency of milk production and sale, which led to the relevance and practical significance.

II. THEORETICAL BACKGROUND

At the beginning of the XXI century, the world's population was 7 billion people. According to scientists' forecasts, by 2025 the population will increase more and amount to 10 billion, as a result, foreign and domestic researchers put the problem of the population's food security in the first place, which is explained by the growth rate of the population, significantly outpacing the growth rate of the production of necessary food. Therefore, ensuring food security is one of the most important goals of both agrarian and economic policy of all states, being the basis of their national security.

The scientific literature describes many problems related to the efficiency of the agricultural sector of the economy; there are many contradictory criteria and performance indicators. The efficiency category itself shows the relationship between the resources used and the production goals.we share this point of view that it is impossible to increase the efficiency and competitiveness of the sub-sector without upgrading farms. In the conditions of the present

time, livestock complexes should be based on the latest technologies and technical means. Serious work in this direction is already underway in many areas [1, p. 47].

Thus, U. Safronova and O. Stolyarova argue that efficiency can be achieved with proper and timely updating of resources [2].

Researcher A. Bolgov believes that it is possible to solve problems in the industry by developing and using innovative methods in all areas of production activities of cattle breeding organizations [3, p. 30].

Currently, many scientists are talking about the problems of developing and mastering innovations in domestic dairy farming [4-13].

Innovative and information technologies in the near future will determine the nature and efficiency of economic activity of agricultural enterprises. The development of digitalization in agriculture will allow farmers to achieve the desired results with the help of various technologies that reduce production costs.

Based on the works of marginalists, which in addition to K. Menger include U. Jevons and L. Walras, a theory of business processes aimed not at the production of goods, but at satisfying customer needs was formed [14].

Based on the above approaches to understanding the category of "efficiency", as well as on the sectoral features of its formation in dairy cattle breeding, we can say that the economic efficiency of the functioning of a dairy farm is the ratio of the economic effect obtained by milk producers during its production and sale to the total cost of resources spent on its production, storage and sale, when at the same time satisfying the needs of other branches of the national economy of the country.

In the current economic situation in our country, many researchers give different classifications of factors affecting the economic efficiency of milk production [15, p. 54].

A factor is usually understood as a cause, or the driving force of a process, phenomenon, determining its features or individual features [16, p. 1412].

Factors of economic efficiency reflect the processes of production and economic activity of the enterprise [17, p. 106].

So, N. Denisova, in her works, pointed out that "factors are divided into two large groups; these are external and internal factors. The author attributed the economic environment, the crisis, Russia's entry into the world trade organization to external factors. The internal ones are technical, technological equipment, social climate in the team and innovations" [18, p. 17].

A number of researchers adhere to the opinion of N. Denisova [19-21]. Some authors argue that "integration processes, product sales markets, selection work, etc. should be attributed to the factors". At the same time, a number of other scientists give the most complete classification of factors that affect the economic efficiency of the dairy cattle industry.

The prospects for the development of digital technologies in the field of dairy cattle breeding are discussed in the works of [22-27] scientists who have identified a number of tasks necessary to achieve the goals of effective management of the industry. Its essence is as follows: restructuring of planning of management methods; new investment policy; acceleration of scientific and technological progress; saving of production of resources. An important factor affecting the efficiency of the industry is the productivity of cows.

III. DISCUSSION

Having studied the classifications of factors affecting the production and sale of milk, we came to the conclusion that they do not take into account the qualitative shifts taking place in the Russian economy, the specific features of the development of dairy cattle breeding.

The classification of the author's factors is divided into two groups: external and internal factors. The group of external factors is divided into two subgroups: macro-level – affects the production and sale of products and micro-level – affects the sale of dairy cattle products.

At the macro-level, such factors as: social; economic and political; innovative; geographical are highlighted. The micro-level includes: consumers; competitors; intermediaries; sellers and it technologies.

In the internal group, organizational, managerial, production and technological factors are considered.

In the group of factors affecting the economic efficiency of milk production and sale, the author identified social factors (population size, migration inflow (outflow) of the population, and the share of the able-bodied population). Now, according to statistical data, the state does not fully provide the population of the Russian Federation with dairy products.

An important external factor attributed to the group of economic and political influence is state support, the development of agricultural organizations as a whole depends on it. Import substitution, a move of the state that will allow organizations to increase the volume of domestic production and enter new markets for products. It is a kind of economic strategy and industrial policy of the state to strengthen the role of domestic production and protect domestic consumption by exchanging imported goods with domestic relatives. In the modern economic situation, the development and implementation of innovations is a decisive factor in increasing the economic efficiency of production and sales of products. In the group of external factors – innovative factors – two necessary categories are identified: the development of scientific and technological progress and digitalization.

According to forecasts of the Ministry of agriculture of the Russian Federation, using innovative technologies, the expansion of the food embargo will have a positive impact on the agricultural and industrial complex of the country. It is expected that in 5-7 years Russia will be able to completely replace imported products with the domestic ones.

Digitalization significantly increases productivity; it has become one of the top priorities for business leaders around the world. Taking into account the trends in the formation of the digital economy in the Russian Federation, it becomes relevant to form a new technological order, which is based on the informatization of economic efficiency factors. At each stage of the formation of economic efficiency in an economy specializing in dairy cattle breeding, from the point of view of the process approach, the informatization of factors determining it should correspond to the end-to-end digital technology specified in the program "Digital economy of the Russian Federation". The micro-level group includes factors affecting the sale of products. Consumers (loyalty, the desire to consume dairy products); competitors (the level of competition, the risk of new brands); intermediaries (the price of advertising, transport services); sellers and IT (mobile and online trading, personalized offers, the use of big data) have an impact on the sale of products.

The author proposed a factor – IT. They will assist in adapting the offer to demand, through the placement of discounts and special offers, personalized offers (as consumers increasingly expect offers specially prepared for them), the use of big data will allow analyzing consumers' behavior and customizing offers for the target audience. Also using multi-channel trading, for example, mobile and online trading (a modern person wants to make purchases at any time convenient) thereby increases the economic efficiency of milk sales.

In the group of internal factors that influence the economic efficiency of production, organizational and managerial factors are highlighted, for example, the effectiveness of management. The primary task at present is the need to form an attractive image of agriculture in order to attract competent specialists.

Free stockyards belong to a subgroup of production and technological factors, their presence may be formed due to the introduction of restrictions on the supply of products. The factor level of automation affects the economic efficiency of production, as the use of mobile electronic devices (weighing machines, dispensers, and feed mixers) reduces the cost of production.

Each organization has different development conditions and, as a result, this affects the efficiency of its economic activities. When studying the economic efficiency of an organization, much attention should be paid to the factors that affect it.

It is important to apply the principle of "data in exchange for support". The state should encourage agricultural producers to implement digital management platforms (digital management, digital inventory, and digital logistics). In exchange for objective data obtained automatically, for subsidizing and applying incentive measures.

IV. CONCLUSION

Summarizing the theoretical foundations of the formation of the economic efficiency of milk production and sale, we can say that at the present stage of the development of economic science, domestic and foreign scientists have a large amount of developments. However, the classification of factors affecting the economic efficiency of milk production and sale, clarified by the author, will allow taking into account the peculiarities of the development of the dairy subcomplex in the digital economy.

Assessment of the influence of factors determining the economic efficiency of milk production and sale contributes to the qualitative construction of the economic policy of dairy producers, which has a significant impact on the level of its development.

and increasing the degree of using information technologies. This requirement is explained by the fact that information support for the management of the agricultural economy sector, its composition and structure must clearly correspond to the implemented functions of the agricultural sector management system at all levels.

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Estimation of Energy Costs in a Network Cyber-Kinematic System with Mobile Devices

Tatyana Astakhova
Information System and Technologies
Nizhny Novgorod State University of Engineering and Economics,
Knyaginino, Russia
ctn_af@mail.ru
orcid.org/ 0000−0002−7032−0697

Darya Kirilova
Information System and Technologies
Nizhny Novgorod State University of Engineering and Economics,
Knyaginino, Russia
dasha.kirilova.96@bk.ru
orcid.org/0000-0002-3329-4821

Mikhail Kolbanyov
Information System and Technologies
Saint Petersburg Electrotechnical University "LETI",
St. Petersburg, Russia
mokolbanev@mail.ru
orcid.org/ 0000−0003−4825−6972

Abstract — The object of research in this article is a ubiquitous sensor communication network, consisting of sensor nodes that control the physical space, moving in space according to a certain law of motion, and a base station that accumulates information, processes and makes prompt decisions. The subject of the research is the energy consumption models of the ubiquitous sensor network, which provides interaction between sensor nodes in the physical and information space. The purpose of the study is to identify the mutual influence on energy consumption during information interaction of sensor nodes, taking into account the law of motion in space. The paper gives definitions of a certain class of cyber-physical systems. An estimate of energy consumption for organizing data transmission between a mobile sensor device moving in space according to a given Dubins law of motion and a base station is proposed. Also presented is the solution of a two-point control problem for the kinematic component of a network cyber-physical system using a discrete-switchable control function.

Keywords— cyber-physical system, discrete-switchable control function, Dubins law, energy consumption, movable sensor node, ubiquitous sensor network

I. INTRODUCTION

The cyber-physical system is a complex system of a new generation, which includes two key, and possibly more, components: cybernetic and physical. The physical component provides real-time data collection from the physical world and information feedback from cyberspace, the cybernetic component provides intelligent data management, analytics and computing capabilities that are created in cyberspace.

In 2009, in [1] W. Wolf suggested that cyber-physical systems may well become the theory that will contribute to the development of high-performance computing. This means that such systems must provide a new level of performance and efficiency thanks to the complex code scheme of control computations. Cyber-physical systems actively interact with the real world in real time and consume real energy. Research [2] gives the following definition of a cyber physical system (CPS) - these are physical and engineered systems, the operations of which are monitored, coordinated, controlled and integrated by the computing and communication core. Just as the Internet has changed the way people interact with each other, cyber-physical systems will change the way we interact with the physical world around us. Complex ones arise in such areas as transport, healthcare, manufacturing, agriculture, energy, defense, etc. The design, construction and testing of cyber-physical systems pose many technical problems that must be solved in the near future.

The article [3] is devoted to the design of cyberphysical systems using more advanced models: the PRET model, which allows you to show how accurately the process of synchronizing digital logic is performed at the software abstraction level; the Ptides model (programming of time-integrated distributed embedded systems), which shows that deterministic models for distributed cyber-physical systems have practical exact implementation.

In the work [4], the Markov model of reliability of a fault-tolerant cluster performing calculations in a cyber-physical system is considered. The results of the article are aimed at the possibility of assessing the likelihood of a cluster's operability, ensuring the continuity of computations and its operation until failure, leading to the interruption of the computational process (control) beyond the maximum allowable time. The presented solutions are aimed at homogeneous cyber-physical systems, i.e. on systems that can be described using deterministic models, both cybernetic components and physical. However, in real life, this approach is imprecise, because the physical process in most cases is a nondeterministic, nonlinear process.

II. METHODS

To build a model, it is necessary to solve several interrelated problems. The proposed model consists of three parts. The first part of the model allows to solve a twopoint problem of motion control of a kinematic nonlinear system, which characterizes the movement of the sensor unit according to a certain law of motion. For this, the Hilbert Uniqueness Method is used, which consists in reducing the problem of local controllability of a nonlinear control system to the existence of corresponding periodic trajectories and studying the controllability of already linear systems [5, 6]. The second part of the model allows solving the problem of controlling the cybernetic component, applying a multi-agent approach to the network communication layer, introducing the concept of speed control based on interaction into the structure of explicit speed control of communication networks, presented in the book [7]. In this case, each router (server or switch) interacts with its neighbors and adjusts the queue length based on one-stage information about the queue of neighbors' bottlenecks in accordance with a specific cooperative algorithm that operates at the network layer of a multi-level control system. The third part of the model is designed to estimate the energy consumption for the transmission of information from the mobile sensor node to the base station. For this, the approach developed in [8].

III. DEFINITION OF A CERTAIN CLASS OF CYBER-PHYSICAL SYSTEMS

In this paper, the definitions of cyber-physical systems are clarified from the point of view of the implementation of a physical process.

A cyber-mechanical system is a networked system of mobile devices that change over time their location on a plane or in space, interacting with each other and the external environment, integrating computing, communication and control technologies.

A cyber-electrodynamic system is a networked system of devices interacting with each other and the external environment through electromagnetic fields, which integrates computing, communication and control technologies.

A cyber-optic system is a hybrid system that includes elements of the physical world that interact with each other and the external environment through the use or detection of the behavior and properties of light, and integrates computing, communication and control technologies.

A cyber-kinematic system is a network system of mobile devices that change over time their location on a plane or in space, interacting with each other and the external environment, having a mutual effect on each other, integrating computing, communication and control technologies.

The presented definitions represent a new hybrid approach to solving complexly structured problems, in which it is necessary to take into account the dynamics (development) not only physical (spatial and temporal), but also informational.

For sensor networks with moving nodes, cyberkinematic models are needed, which should describe the motion of these conditions, in the simplest case by rectilinear equations, but in the most general plan by a nonlinear system of differential equations. In the second case, in particular, the movement of sensory nodes can be described by the Dubins model.

IV. NETWORKED CYBER-PHYSICAL SYSTEMS

Networked cyber-physical systems are fundamentally different from standard distributed systems in that the dynamics of the network affects the performance and physical dynamics of the closed-loop system. This interaction of three components: physical, cybernetic and network, and such an architecture significantly reduces the complexity of solving difficult formalized and poorly structured control problems.

Of course, wireless networks offer lower costs, better power management, easier maintenance, and easier deployment in remote and hard-to-reach locations. Thus, cyber-physical systems in conjunction with a wireless sensor network make it possible to implement large-scale projects and bring decision-making to a new, higher quality level. In an industrial environment, vital information can be transmitted over communication channels between mechanisms, control and monitoring devices, which must be transmitted in short "packets", which requires a relative bandwidth and connection speed. On the other hand, transferring large files such as production logs or real-time media transfer requires very efficient transfer of large amounts of data [7]. Therefore, one of the most important requirements is reliability and timely delivery without interruptions [9].

Therefore, one of the most important requirements is reliability and timely delivery without interruptions. Choosing the right wireless networking solution in an industrial environment requires high communication performance without sacrificing speed, flexibility, range, or reliability. A wireless CFS is characterized by physical network limitations, packet loss and latency, which in turn affect the performance of the entire surveillance / control system. The aforementioned disadvantages are especially relevant in the case of wireless communication, where the presence of collision and common channel phenomena can significantly degrade performance and even affect the stability of the closed loop [10, 11, 12, 13]. Various models and theoretical approaches were presented to analyze and study the stability of the CPS network [14, 15], stochastic protocols [16], real-time planning [17].

A. The control problem of networked cyber-kinematic systems

Consider the following architecture of the cyberkinematic system (Fig. 1). A networked cyber-kinematic system consists of a ubiquitous network of nodes used to monitor or control a given distributed physical system and a fixed base station.

Suppose each sensory node can be represented as

- a sensor for measuring the local physical variable of interest,
- a controller for implementing a control command,
- transit or hop for forwarding or generating packets,
- a node that has the ability to move in space (robot, quadcopter, car, tractor, etc.), and performs the assigned tasks (collection, transfer, aggregation and/or storage, etc.).

Each presented sensor node can interact with another sensor node, which in turn increases the complexity of the control task and the problem of formalizing the cooperation infrastructure, which in turn affects packet loss, time delays, power consumption, etc., and, consequently, on the performance of the entire cyberkinetic system as a whole.

Consider a control system of the following type [7]

$$x = f(x, u_x, q, \tau_{kn}) \quad (1)$$

$$q = g(q, u_q, \tau_{kb}) \quad (2)$$

where x is a measure or estimate of a variable of a distributed physical process (possibly a random variable) that needs to be monitored or controlled; q is the queue length on the router / switch (wired / wireless / ubiquitous) communication network; τ_{kb} is the network cyber time delay associated with the delay caused by the communication network protocol / architecture (eg propagation delay, collision phenomena and queue delay); τ_{kn} is the kinetic level time delay affecting information x due to τ_{kb}, sampling delay, computation delay, and compression measurement delay; $u_x = u(x)$ and $u_q = u(q)$ are, respectively, control applied at the application and network layers.

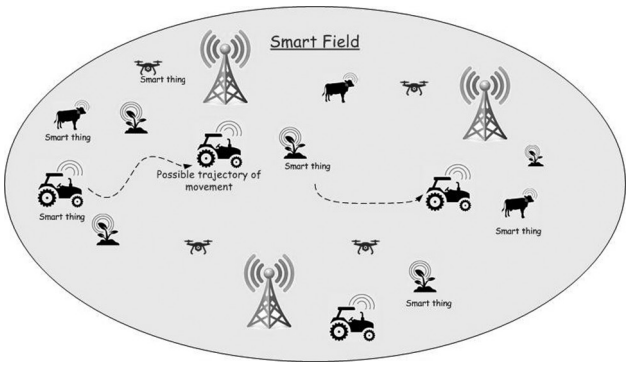

Fig.1. Sensory field

First equation (1) represents the model at the application layer, and the second (2) represents the dynamics of queues at the network layer. In [7] considered the development of hybrid control laws u_x and u_q, leading, respectively, to an application-level control system and a network-level control system. The setpoints q_0 and x_0 are fixed according to the characteristics required by the network and the application management system, respectively. A significant drawback of this work is the study of the issue of controllability only for linear and representative models.

In this paper, the issue of interaction of the nodes of the sensor network and the organization of data transfer between them is upset, provided that these nodes move in space according to a certain nonlinear law of motion control, which is most close to reality.

Suppose the nodes move according to Dubins' law and the directions of movement are bounded. According to the presented law, there is a mechanism that has the ability to regulate the movement of a physical component according to specified parameters. There is also a cybernetic mechanism that allows you to determine the state and position of a mobile sensor device in space, for example, by determining GPS coordinates.

B. Node movement models

Wireless sensor networks with mobile nodes are more efficient than stationary ones. There are various models of node movement in a wireless sensor network.

The Dubins model is used to control wheeled robots [18], for dispatching calculations in civil aviation [19], as well as in applied work on constructing trajectories of unmanned aerial vehicles in a horizontal plane [20].

The Random Walk Mobility Model assumes that the node moves in its chosen direction at a certain speed, which is given by a uniform (or Gaussian) distribution law for a period of time given at the beginning of the simulation. After the node reaches the border of the area covered by the WSN, the node changes direction depending on the angle of reflection from the border [20].

In Random Waypoint Mobility Models, a node starts moving in the direction of a given point at a speed that obeys a uniform distribution law. Upon arrival at the destination, a new point is determined in the direction to which the node continues to move [20].

The Gauss-Markov model allows you to adapt to random processes by adjusting certain parameters. The modeled node is given speed and direction, after a certain period of time the direction and speed change to new ones that obey the Gaussian law of distribution of random variables.

The Manhattan motion model is proposed to a greater extent for tracking the movement of nodes in an urban area. Nodes move only in a horizontal or vertical direction, along marked sections of streets, this model is similar to the model of movement along the highway, the only difference between the Manhattan model is that when crossing streets, the node with a certain probability chooses to turn right or left [20].

V. ESTIMATION OF ENERGY CONSUMPTIONFOR INFORMATION TRANSMISSION

Let $l = l(\tau, x_0, x_\tau)$ denote the path of motion of the sensor node from point x_0 to point x_τ for some time τ. Suppose that there is an optimal trajectory for solving the two-point problem *l*. It is necessary to quickly track the coordinate location of the sensor node and compare the real trajectory of movement with the given one. If the sensor node deviates from the optimal trajectory, it is necessary to adjust the control action to return to the specified trajectory. These actions are subject to restrictions related to the complexity of computational processes and an increase in the speed of execution.

As a model of optimal motion, consider a system of n nonlinear ordinary differential equations of the form:

$$\frac{\partial x_i(t)}{\partial t} = f_i(t, x_1, \dots, x_n), i = \overline{1, n}. \quad (3)$$

The motion of a system with a given initial condition, in which deviations from the given initial values have occurred, are called disturbed motion.

If we talk about the return of the sensor node to the optimal trajectory, then at each moment of time it is necessary to solve the two-point problem and the stability problem, and, based on the decision, make a decision about moving the node to a given point. Unfortunately, in real life, nonlinear conservative dynamical systems are usually not asymptotically stable. Asymptotic stability generally corresponds to asymptotically stable motion with respect to any initial deviations. Any arbitrarily small change in the initial conditions leads to a change in the motion parameters, which means that even greater restrictions are imposed on the information component of the cyber-kinematic system and computational loads increase.

This section presents a possible estimate of the energy consumption for transmitting a data block from a mobile sensor device to a fixed base station.

Suppose that there is a stable solution to system and denote it as $\tilde{x}(t, \phi(t))^2$. Then the distance traveled by the sensor node from the given starting point x0 to the point x_τ will be found as follows:

$$\bar{r} = \sqrt{\tilde{x}(t, \phi(t))^2 - x_0^2} \quad (4)$$

Substituting (4) into the Friis formula [22, 23, 24, 25], we can find the energy consumed for transmitting information to the base station at the time τ:

$$\bar{P}_{tr} = \frac{16 P_r \pi^2 r^2 f^2}{G_{tr} G_r c^2} \quad (5)$$

where G_{tr} is the gain of the transmitting antenna, G_r is the gain of the receiving antenna, P_{tr} is the radio signal power at the transmitting antenna [W], P_r is the power of the radio signal at the received antenna [W], r is the distance between the antennas of the mobile sensor devices of the ubiquitous sensor network in meters, c is the speed of light, f is signal flow frequency.

It follows from the Friis formula that reducing the distance between two mobile sensor devices by 2 times reduces the energy consumption for transmitting a data block from one to another by 4 times.

The average energy spent on the transmission of one data block to the base station from a sensor device located at a distance r from the base station is denoted as:

$$\bar{e}_c = \bar{P}_{tr} \cdot \tau \quad (6)$$

To obtain the average energy spent on the transmission of information of all sensor devices, it is necessary to sum all possible energy consumption at the average values of the distances from the sensor device to the base station.

VI. CONCLUSION

The paper gives definitions of a certain class of cyber-physical systems. An estimate of energy consumption for organizing data transmission between a mobile sensor device moving in space according to a given Dubins law of motion and a base station is proposed. Also presented is the solution of a two-point control problem for the kinematic component of a network cyber-kinematic system using a discrete-switchable control function. With such a law of motion of these sensor devices in the sensory space, the proposed model will significantly reduce the energy consumption required for the interaction of mobile sensor devices. In the future, it is planned to present solutions to the control problem at the cybernetic / network level and propose models of the total energy consumption for the implementation of hybrid control, which makes it possible to take into account all possible limitations and disadvantages at each level.

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