

# Journal of Information Technology and Applications

(BANJA LUKA)

# JITA

Exchange of Information  
and Knowledge in Research

---

APEIRON  
ЖУРНАЛ



VOLUME 14

NUMBER 1

BANJA LUKA, JUNE 2024 (1-88)

ISSN 2232-9625 (Print)

ISSN 2233-0194 (Online)

UDC 004

#### THE AIM AND SCOPE

The aim and scope of the Journal of Information Technology and Applications (JITA) is:

- to provide international dissemination of contributions in field of Information Technology,
- to promote exchange of information and knowledge in research work and
- to explore the new developments and inventions related to the use of Information Technology towards the structuring of an Information Society.

JITA provides a medium for exchanging research results and achievements accomplished by the scientific community from academia and industry.

By the decision of the Ministry of Education and Culture of the Republic of Srpska, no.: 07.030-053-160-4/10 from 3/3/2010, the journal „Journal of Information Technology and Applications“ Banja Luka is registered in the Registry of public organs under the number 591. Printed by Markos, Banja Luka in 300 copies two times a year.

**Indexed in:** LICENSE AGREEMENT, 3.22.12. **EBSCO** Publishing Inc., Current Abstracts

 <a href="http://ebscobase.com">ebscobase.com</a>	 <a href="http://road.issn.org">road.issn.org</a>
 <a href="http://erihplus.nsd.no">erihplus.nsd.no</a>	 <a href="http://citefactor.org">citefactor.org</a>
 <a href="http://scholar.google.com">scholar.google.com</a>	 <a href="http://cosmosimpactfactor.com">cosmosimpactfactor.com</a>
 <a href="http://doisrpska.nub.rs">doisrpska.nub.rs</a>	
 <a href="http://crossref.org">crossref.org</a>	

Printed on acid-free paper

Annual subscription is 30 EUR  
Full-text available free of charge at <http://www.jita-au.com>

# JITA

---

VOLUME 14 NUMBER 1 BANJA LUKA, JUNE 2024 (1-88)

---

## CONTENTS

IMPORTANCE OF KNOWLEDGE MANAGEMENT FOR CI/CD AND SECURITY IN AUTONOMOUS VEHICLES SYSTEMS .....	7
<i>PAVLE DAKIĆ</i>	
ENHANCING MARKETING INTELLIGENCE IN THE INSURANCE SECTOR: A STUDY IN THE BELGRADE REGION .....	17
<i>NIKOLA MEDAN</i>	
E-COMMERCE MANAGEMENT - EXPLORING USER PREFERENCES FROM THE TERRITORY OF THE BOSNIA AND HERZEGOVINA.....	23
<i>ALEKSANDRA VIDOVIĆ</i>	
USE OF AI APPLICATIONS IN PROVIDING FREE LEGAL ASSISTANCE TO CITIZENS OF BiH .....	29
<i>ADMIR AGIĆ, BOŠKO JEFIĆ</i>	
DIGITAL IDENTIFICATION FROM SMART CARD TO DIGITAL WALLET –EU LEGAL FRAMEWORK AND SITUATION IN BOSNIA AND HERZEGOVINA .....	37
<i>SINIŠA MACAN</i>	
FRAMEWORK OF DIGITAL TRANSFORMATION READINESS AT A MAJOR COMPANY.....	47
<i>KRUNOSLAV RIŠ, TOMISLAV RADOŠ</i>	
DIGITAL TRANSFORMATION AS A STARTER OF THE CREATION OF NEW ECONOMIC BUSINESS MODELS.....	55
<i>NATAŠA ĐALIĆ, ŽIVKO ERCEG</i>	
FROM .NET CORE TO .NET 8: A COMPREHENSIVE ANALYSIS OF PERFORMANCE, FEATURES, AND MIGRATION PATHWAYS ....	69
<i>BRANIMIR CVIJIĆ, PERO RANILOVIĆ</i>	
COMPARISON OF AGILE AND DEVOPS METHODOLOGIES: ANALYSIS OF EFFICIENCY, FLEXIBILITY, AND APPLICATION IN SOFTWARE DEVELOPMENT.....	78
<i>VLADIMIR RADOVANOVIĆ, OLJA KRČADINAC, JASMINA PERIŠIĆ, MARINA MILOVANOVIĆ, ŽELJKO STANKOVIĆ</i>	
INSTRUCTIONS FOR AUTHORS.....	84

EDITORS:



DALIBOR P. DRLJAČA, PHD  
EDITOR-IN-CHIEF



SINIŠA TOMIĆ, PHD  
MANAGING EDITOR



ALEKSANDRA VIDOVIĆ, PHD  
TECHNICAL SECRETARY

HONORARY EDITORIAL  
BOARD



GORDANA RADIĆ, PHD



DUŠAN STARČEVIĆ, PHD

*Dear authors,  
Dear readers,*

As we enter the new year, we are excited to announce some changes at JITA. We are pleased to introduce Dr Dalibor P. Drljača as the new Editor-in-Chief, Dr Siniša Tomić as the Editor and Dr Aleksandra Vidović as the Technical Secretary of the Journal. We've also revamped and modernized the Journal's website, improving its visibility on the internet. JITA is now successfully indexed in the ERIH+ citation database. Additionally, we are expanding the scope and topics of the published papers. Furthermore, we have enhanced our presence on social media through our university's accounts.

The new leadership of the Journal would like to express gratitude to the previous esteemed editors and founders, especially Professor Dr Gordana Radić, Professor Emeritus Dr Dušan Starčević, and Professor Emeritus Dr Zoran Ž. Avramović. We acknowledge their contributions to the success and tradition of the Journal, which has been part of the academic community for fourteen years.

For this edition, the Editorial Board has selected nine papers. This issue opens a paper highlighting the importance of integrating Knowledge Management in Autonomous Vehicle Systems. Two papers have a focus on current topics in Digital Transformation. Furthermore, the papers in this edition demonstrate how modern technologies are being utilized in e-Commerce and Marketing, as well as how Artificial Intelligence is being leveraged to provide free legal assistance to citizens of Bosnia and Herzegovina. To effectively utilize these technologies, this edition includes a paper discussing the shift from smart cards to digital wallets and the legal frameworks governing this issue, specifically the eIDAS 2.0 regulation. Another two papers also explore software technologies. One paper analyses the transition from .NET Core to the .NET 8 platform, while the other discusses and compares Agile and DevOps software development methodologies.

On behalf of the Editorial Board, we extend our gratitude to the authors for their high-quality contributions and to the reviewers for their dedicated effort and time invested in the preparation of the Journal of Information Technology and Applications.

We warmly invite you and your colleagues to collaborate with JITA. We have an open call for papers published twice per year (in the June and December issues). Additionally, we have an open call for reviewers to consider the intensive developments in the scientific fields covered by JITA.

Dalibor P. Drljača  
*JITA Editor-in-Chief*

## IN MEMORIAM



**Prof. dr Lazo Roljić, professor emeritus**  
1945-2024

*On April 30, 2024, in Banja Luka, the esteemed and respected Prof. Dr. Lazo Roljić, professor emeritus, passed away, leaving the entire Republika Srpska, as well as Bosnia and Herzegovina, without one of the great pioneers in the development of computer science and informatics.*

*Professor Roljić was born on April 6, 1945, in Sarajevo. He completed his education at the Faculty of Electrical Engineering in Banja Luka, earned his master's degree at the Faculty of Technology at the University of Zagreb, and defended his doctoral dissertation at the Faculty of Organizational Sciences at the University of Belgrade.*

*As a professor and lecturer, he worked at several higher education institutions and universities in Bosnia and Herzegovina. He participated in dozens of scientific research projects and, in the academic year 1998/99, received a Fulbright scholarship and spent time furthering his education at Georgia Tech at the University of Atlanta, Georgia, USA. He was awarded the title of professor emeritus in 2021, and he left behind 24 published books and university textbooks, over 110 scientific papers, and more than 70 professional papers published in eminent scientific journals and conferences.*



*One of the notable achievements for which Professor Roljić will be remembered is that in 1971, in the presence of the then President of Yugoslavia, Josip Broz Tito, he personally inaugurated the first computer in Banja Luka with a disk capacity of 5 MB. At that time, only Ljubljanska Banka had a computer, making it the second computer in the former SFRY, operational even before some other, technologically more developed countries, which got their first computers a year later. The pioneering steps in the development of computer science and informatics took place at the then Institute of the INCEL company in Banja Luka. As Professor Roljić used to say, terms like informatics and information were not known at that time; only data and data processing on IBM computers were recognized.*

*Another notable fact about Professor Roljić is that he was an excellent athlete. He was a member of the outstanding generation of Borac basketball players who played in the Second League of Yugoslavia in the early and late 1960s. Additionally, with the Borac team, he won the BiH Cup in November 1962, defeating the host Bijeljina (72:55) and*



*Bosnia (86:48) in the final tournament, marking Borac's first-ever BiH Cup trophy. Lazo Roljić was also a member of the BiH national team that played a friendly match against the strongest team in Yugoslavia, which was preparing for the EuroBasket in Italy, on June 1, 1969, in Sarajevo.*

*Professor Roljić was a beloved professor to many generations of students he educated. He was always smiling and ready for a joke, yet impeccably serious in his work and selfless in imparting knowledge to his students. I had the opportunity to attend Professor Lazo's lectures, which were always filled with anecdotes and experiential examples from a man who*

*had "lived through the development of computer science" from its beginnings to the modern personal computers we know today.*

*We deeply mourn the loss of a respected professor, esteemed colleague, friend, and role model for many generations of students who had the honor and privilege of knowing him and being his contemporaries.*

*May his memory be eternal, and may we always be grateful for everything he did.*

Dalibor P. Drljača

Editor-in-Chief and student of esteemed prof. Roljić

# IMPORTANCE OF KNOWLEDGE MANAGEMENT FOR CI/CD AND SECURITY IN AUTONOMOUS VEHICLES SYSTEMS

**Pavle Dakić**

*Faculty of Informatics and Information Technologies, Slovak University of Technology in Bratislava, Bratislava, Slovakia  
Faculty of Informatics and Computing, Singidunum University, Belgrade, Serbia, pavle.dakic@stuba.sk,  
0000-0003-3538-6284*

**Original research paper**

<https://doi.org/10.7251/JIT2401007D>

UDC: 621.355:629.33-514.59

**Abstract:** The development of autonomous vehicles (AV) entails complex design, production, testing, and deployment procedures that require excellent information and knowledge management in the event of security breaches. As researchers and managers, we must have a good understanding of the development of AV technology. Communication and information exchange, as well as knowledge management (KM) strategies and approaches, are undoubtedly important components. The most difficult challenge is to save the lives of drivers and passengers who use and travel in an AV that is partially or entirely managed by a machine learning model (ML) and artificial intelligence (AI). In this paper, we attempt to investigate the manufacturing process of AVs and intelligent vehicles (IVs), emphasizing the importance of information management (IM) within the factory and processes that are not explicitly articulated in the majority of scenarios. Furthermore, we discuss our method for using the knowledge management life cycle for information exchange in an organization, which could allow for faster and more efficient resolution of security issues within vehicle operating systems. This study seeks to provide an essential theoretical foundation to characterize the future scope of integrated manufacturing, which integrates software and the industry that employs it within the vehicle.

**Keywords:** autonomous vehicles, knowledge management, artificial intelligence, system integration, safety and security, System design with modeling and deployment

## INTRODUCTION

Communication and knowledge management are crucial in ensuring the successful production of autonomous vehicles by facilitating seamless collaboration between stakeholders, investors, managers, and software developers involved in this process [1], [2]. The development of various technologies in the transport industry created significant changes with safer and more efficient ways of transport. Still, we also have other problems that did not exist until now. One of them is reflected in the increased complexity during production, which includes complex design, testing, and standardization of development procedures that require having sufficient information about the required final product. As result of their enhanced convenience, safety benefits, and possible commercial worth, autonomous cars, ships, and intelligent vehicles (IVs) [3] have received worldwide

attention [4] increasing their demand and direct application in various environments that are dangerous for human life. In most cases, this creates certain security problems that have arisen due to the interconnection of several different software and hardware components of the system. Knowledge management (KM) is essential for this following security part with the possibility to capture, store, organize, and share knowledge within the production ecosystem of the automotive industry.

Risk management in cases of breaches and data leaks, requires checking the connection of several units such as Data management in the auto systems, information retrieval, decision-making algorithms processes, and communication systems are just some of the parts that security professionals must examine [2], [5], [6]. Regardless of industry or product, all companies rely on the knowledge of their employees to be successful which is why organizations must



treat knowledge as an asset, it's not enough to just hire skilled employees. Instead, successful companies should build processes to store, grow and share knowledge to increase the knowledge base of the overall workforce using KM.

The continued advancement of technology has the potential to transform the way of transportation. Autonomous vehicle (AV) technology has an influence on logistics, supply chain management, and operational efficiency. These dramatic gains are accompanied by sophisticated security problems inside the underlying software systems. This discussion digs into the security issues surrounding autonomous car system software from the angle of industrial production, as well as the crucial role of preventing this by using Continuous Integration and Continuous Deployment (CI/CD) procedures in guaranteeing a secure, efficient, and sustainable manufacturing process [7].

In the dynamic environment of changes and demands of industrial production, certain security problems are in most cases inherited or difficult to solve since there is still no suitable relevant solution that would cover certain concerns. These security problems are not only of a technical or software nature, some concern moral and psychological attitudes, which create additional implications and difficulties in the production of system software that complies with all the required standards of one or more countries and regulatory bodies. This, therefore, affects the automotive and all other related industries of the production of hardware and software components on a chip or with directly integrated logic [8], [9].

In terms of depth, we covered insights into specific knowledge management techniques and methodologies for AV and IVs. Many studies have proposed novel approaches to capture, store, and utilize information in the autonomous driving ecosystem [10]. But the techniques involved frequently rely on a variety of fields, including artificial intelligence (AI), machine learning model (ML) [11], [12], big data analytics (BI) [13], and sensor technology. The research conducted within this work is part of the author's doctoral thesis and it's a continuation of previous research in this area. Where investigations in this paper should help industry and educational institutions to understand specific problems with practical answers to the information challenges that AV encounters during production and conducting certain relevant tests [14], [15].

The presented work should present an original scientific paper with a new approach of the organization in acquiring knowledge. The focus of the research itself is on outlining proposals and gaps, to ensure prevention of future security threats and information exchange in timely manner. Since there is a very high demand for experts in this field and AV gained recognition and became an active research subject with a growing interest in the use of CI/CD and information knowledge management [16–18]. Which is therefore another reason for the importance and relevance of this topic. The research's contributions and innovation stem from its complete examination and integration of new approach denoted as organizational process for knowledge management (OPKM).

This paper is organized as follows: introduction, materials and methods, security concerns and research gaps for future research, autonomous vehicles, importance of knowledge management, results, and conclusion.

## METHODS AND MATERIALS

The utilization of research questions formed the basis for the research approach adopted in this study. These study questions should focus on the educational features of industrial settings, with the goal of improving future accessibility and learning. To explore approaches and provide hands-on learning, we addressed the challenges that students and professionals face during their learning process. The research method was focused on the practical aspects of group administration and regulatory compliance to obtain industry-specific knowledge. The study approach is based on non-numerical data and organizational science methods, which include logistical concerns while designing the teaching process. The answers to the defined questions are offered in each of the following sections, with the results section being the most significant contribution of the new approach. The reviewed literature spanned a longer time range, from 2016 to 2024. The reasons for the specified study term are reflected in the requirements of this research paper. Whereas during the selection of relevant literature, was on the emphasis and the relationship between industry, software, and the generation of new knowledge.

Large language models were utilized to ensure the text's grammatical accuracy, implying the use of the Grammarly program.



## RESEARCH QUESTIONS

The research in this paper will be structured and implemented according to the following research questions:

1. What are security concerns and research gaps in industrial production?
2. Why knowledge management is importance for CI/CD and Autonomous Vehicles?
3. How can a new approach be created in the organization of knowledge, production and creation of software for vehicles?

## SECURITY CONCERNS AND RESEARCH GAPS FOR FUTURE RESEARCH

Our commitment to innovation, efficiency, and quality as researchers place us at the forefront of driving transformational improvements in industrial production. The current short-comings in the industry are mostly reflected in the partial application or complete neglect of the procedures regarding software, which is one of our research frameworks within this paper. Security-related research problems [19], [20] and current research gaps can be categorized and presented within the following units [21–23]:

1. **Real-Time Intrusion Detection and Response:** In an age when AVs are part of a dynamic, networked ecosystem- IoT [24], real-time intrusion detection and response is critical. This research gap necessitates the development of novel technologies capable of continuously monitoring the software landscape, detecting anomalies, and orchestrating rapid reactions to possible threats. By combining KM and CI/CD approaches, we maybe can build an agile system that not only automates software update deployment but also includes powerful intrusion detection capabilities Firefly algorithm (FA) [25]. This collaboration would allow us to protect production operations from potential dangers, assuring the continuous flow of AV manufacture in the factory.
2. **Adversarial Machine Learning [26]:** The integration of industrial manufacturing with machine learning (ML) is critical for achieving operational excellence and minimal interference with the operation of the vehicle itself. The vulnerability of ML models to adversarial attacks can be, on the other hand, a multidimensional

difficulty when analyzing and seeing what led to a certain action. Supporting the rapid deployment of model additions, corrections, and adaptations requires including KM and CI/CD procedures into the equation. This collaboration would enable us to continuously strengthen machine learning models against adversarial attacks, ensuring that AV system software remains resilient, dependable, and aligned with growing production demands. Which in this way enables the application of appropriate relevant standards in different areas [27].

3. **Secure Over-the-Air Updates [28]:** AVs' ability to remotely update software has revolutionized maintenance and feature enhancement. But the main problem is the reliability of over-the-air updates, on the other hand, is a very difficult puzzle to solve when it comes to securing the integrity and encryption of updates/patches. The way of updating itself can be presented as a solution when one of the current research deficiencies dictates the creation of a system guarantee process to ensure the authenticity, reliability, trustworthiness, and non-disruptive nature of systems updates. We could in the future create smooth update CI/CD pipelines that adhere to strict security and standards constraints by combining the best practice techniques. This relationship would increase the adaptability of AV firmware and the entire manufacturing process by speeding up the data transfer.
4. **Privacy-Preserving Data Sharing [29]:** Collaborative production environments underscore the importance of secure data sharing by using methods such as KM. However, the intricacies of sharing data while preserving privacy demand innovative solutions and checkpoints in time, similar to backup solutions called snapshots used on Virtual Machines (VM). To establish controlled data-sharing frameworks that ensure sensitive information remains protected we would need to have and use data management systems software (DMS) [30] to solve this and ensure that sensitive information remains protected. This way of collaboration should empower the industry to balance between leveraging data insights for production

optimization while respecting privacy rights and adhering to regulatory obligations created by government bodies.

5. Testing and Validation [31], [32]: Robust testing and validation procedures are the bedrock of quality assurance in industrial production. In the context of AV systems software, this research gap requires exploring automated testing methodologies that encompass the intricacies of software interactions. Using CI/CD integration we could offer a conduit for implementing comprehensive testing protocols that rigorously assess the software's security, functionality, and performance. The result for the industry in this case would mean a software production process organized and controlled by CI/CD tests that have undergone meticulous validation to minimize the potential defects and vulnerabilities.

Based on the conducted research and the collected knowledge, we saw that the best solution for solving the majority of research deficiencies could be implemented and partially solved by applying CI/CD pipelines. Incorporating CI/CD approaches into the fabric of AV system software development would create a transformative opportunity and a significant advantage for every car company. By addressing these research gaps, we could build a comprehensive approach that not only leverages our production-related knowledge but also infuses it with the agility, inventiveness, and scalability of requests created by end customers. This integration could improve the resilience of manufacturing sectors, fortify the industry against upcoming obstacles, and pave the way for the secure, economical, and continuous incorporation of new technologies into industrial manufacturing procedures.

### **AUTONOMOUS VEHICLES**

Autonomous vehicles (AV) can be defined as self-driving cars, buses, trucks, and lorries that employ modern technology to negotiate highways, rivers, and seas without human involvement. They use a combination of cameras, radars, lidar systems in general, and GPS to carry out these tasks, accurately evaluate their surroundings, and make real-time decisions. Autonomous vehicles play an important role in en-

hancing road safety, reducing traffic congestion, and providing accessible transportation options, making them the ideal option for persons who are unable to drive or do not believe they are capable of driving a car independently. We tried to look at different production perspectives that would have the opportunity of direct application in the industry. Since information knowledge management for AV production is characterized by its breadth and depth, there is limited research specific to direct practices of use in this context. Interesting research for us was covering knowledge management theories in the medical industry and their business conditions for the production of different products.

Specifically, the most complex historical example is certainly the production of vaccines [33] during the pandemic period (COVID-19). Based on the findings of this research, we may also apply effective management practices to the automotive industry. Based on this, we try to create a good foundation for future researchers within this field and industry that has one of the most complex software [34], [35]. The research covers a wide range of subtopics and provides a thorough overview of the field's challenges and prospects to further advance knowledge and contribute to the development of AV.

### **Importance of Knowledge Management**

Knowledge Management (KM) is the backbone that keeps the development process constant and secure in the world of AVs. We can present this with an example of a well-organized library where engineers and industry specialists share their knowledge and expertise. This sharing aids in the development of dependable AV systems by learning from previous occurrences and near-misses in factory production. KM promotes collaboration across many domains, ensuring that everyone's expertise contributes to the larger picture of safety and innovation. Picturing the evolution of AV software is a well-orchestrated orchestra with CI/CD in the role of conductor that guides the orchestras [36].

The rhythm of automated testing steps that seamlessly weave new code, test it thoroughly, and deploy (staging, testing, production) improvements without missing a beat. Like a diligent dirigent, CI/CD ensures for us that the AV software orchestra never misses a note, while a user is playing and using our final prod-

uct - AV. Importance is in accelerating and pushing the introduction of new features, maintaining a high standard of quality (QA), and efficiently adapting the AV technology to the ever-changing road ahead, governed by standards.

The intersection of security concerns, industrial production, and the integration of CI/CD practices represents a pivotal junction that defines the future trajectory of both AV production and the broader automotive industry. This convergence underscores the significance of addressing security challenges and research gaps, forging a path toward innovation, efficiency, and sustainable growth.

The industry has to fulfill some of the core basic items, to be profitable and maintain it in the long term. Therefore, from the point of view of business, it is necessary to fill in the following items:

1. **Efficiency and quality:** The quest for operational excellence is at the heart of industrial production. Integrating CI/CD principles into antivirus software development simplifies update distribution, lowers manual intervention, and shortens the production cycle. This integration speeds up the detection and resolution of security flaws, resulting in increased manufacturing efficiency and the upholding of rigorous quality standards that concern the very health and life of passengers, as well as the driver. The capacity to quickly resolve these issues through regular updates guarantees that manufacturing processes stay nimble and responsive to changing industry needs in the future.
2. **Compliance and Regulation:** The automotive sector is subject to an expanding regulatory framework aimed at assuring vehicle system security and privacy. The inclusion of compliance processes demonstrates a proactive commitment to regulatory compliance by developing secure update pipelines, keeping correct records, and quickly installing security fixes. This proactive approach not only reduces legal risks for the industry but also promotes responsible and dependable members of the transportation ecosystem.
3. **Safety and reliability:** In the automotive business, the importance of safety and dependability cannot be emphasized. Where increasing the safety of pedestrians, vehicle occupants, and the environment by ensuring the security of AV system software which controls the normal functioning of all systems is of essential importance. Since implementation of safer AVs requires quickly fixing security flaws and hardening software against potential threats and preventing remote control by third parties. This, in turn, builds customer trust, promotes widespread adoption, and solidifies the industry's position as a safety steward. This as a final result ensures a stable and continuous financial income for the company and the vehicle model they sell on the market. Collaboration and Innovation: The collaborative attitude that pervades industrial production finds an echo in embracing KM and CI/CD principles to develop an innovative culture that allows quick experimentation, iteration, and adaptability. Innovation and the possibility of cooperation is the key to the success of applying and adding new technologies to the existing system of a single vehicle. The use of these approaches promotes cross-functional collaboration among production engineers, cybersecurity specialists, software developers, and stakeholders/investors that are interested in listening. By applying this process of exchanging ideas and knowledge, the industry is able to speed up innovation, culminating in the development of cutting-edge technologies that push the frontiers of AV manufacturing.
4. **Sustainability:** At the heart of modern industrial production philosophy are sustainable methods and integration to address security concerns with research gaps that coincide with sustainability goals. Sustainability is mostly reflected in the ability to react effectively on time and solve problems without impairing the ability to use functionality with swift software upgrades, rapid bug repairs, and vulnerability patching in the whole AV system lifespan. This extended lifecycle decreases the need for frequent physical hardware upgrades while also supporting resource efficiency and environmental responsibility concepts.
5. **Market Competitiveness:** Involves automobile sales, with global competitors competing for market share being intensely competitive

and requires industry participants to gain a competitive advantage by adopting specific processes that can improve the security and reliability of their AV systems software. This means that companies that can quickly deploy new features, upgrades, and security updates can position themselves as leaders in innovation, responsiveness, and customer happiness.

6. Economic Resilience: Robust AV production has far-reaching economic repercussions in case of lacking a safe and efficient manufacturing process. This in the worst case can result in a negative effect, which all companies try to avoid and achieve a positive side to long-term growth, job creation, and economic sustainability. Minimization of negative effects is mostly realized through continuous research and testing to protect itself against potential disruptions, unforeseen liabilities, and reputational damage by addressing security risks and research gaps. This resilience strengthens the industry's ability to overcome problems, adapt to changing consumer tastes, and remain a driving force in the global economy.

Based on the mentioned units, we can see that certain expertise is needed in the application of technologies and best software practices during factory AV production. The integration of all these factors is a very complex and difficult task for industrial production as a transformative element of society and the creation of a trajectory in the modern movement. This is why recognizing these entities and solving them through research projects can lay the foundation for a future characterized by efficiency, safety, innovation, sustainability, and market competitiveness. Where the position and financial benefit can be achieved by companies that are pioneers and the first to apply in their production, making them the leaders that shape the future of transportation and the appearance of vehicles.

## RESULTS

We decided to use this paper as an educational instrument to help new aspiring DevOps engineers or software developers in the automotive industry gain a better understanding of how the aforementioned technologies work and how to implement them in

their projects, assuming that we weren't the only ones who struggled to understand microservices and management.

## INTEGRATION OF KNOWLEDGE MANAGEMENT IN AUTONOMOUS VEHICLES

The main reason for the importance of application is that KM can be utilized to manage and monitor all of a company's knowledge and AV production processes. But first, it is necessary to understand the processes of knowledge application and how the handling process works. The main reason is reflected in the knowledge of the individual, which is based on an understanding, which consists of discrete or intangible skills.

The field of knowledge management distinguishes two forms of knowledge. We have an explicit understanding of knowledge or abilities that can be pure to articulated and understood. Although other types of knowledge form are related directly to how quickly we can transfer knowledge to others, this is known as formal or codified knowledge. Additionally, we may divide these knowledge types into four categories [16]:

1. Factual knowledge is data that are measurable, observable, and verifiable
2. Conceptual knowledge is concerned with viewpoints and systems
3. Expectational knowledge refers to knowledge that is based on expectations, hypotheses, or judgments Methodological knowledge is concerned with problem solving and decision making.

Within the production process, information can be structured into several crucial aspects that cover and apply the knowledge of all workers in the factory [16], [27], [35]. With our new approach known as the organizational process for knowledge management (OPKM) we can present and organize this process as shown in Figure 1. This is a proposal for a process that should be implemented in 7 steps to minimize the impact of security breaches. That is why efficient information and knowledge management is very important for the production of AV (Figure 1) for several reasons as follows:

1. Knowledge creation processes - Design: In the design phase, extensive data must be collected from various sources including customer re-

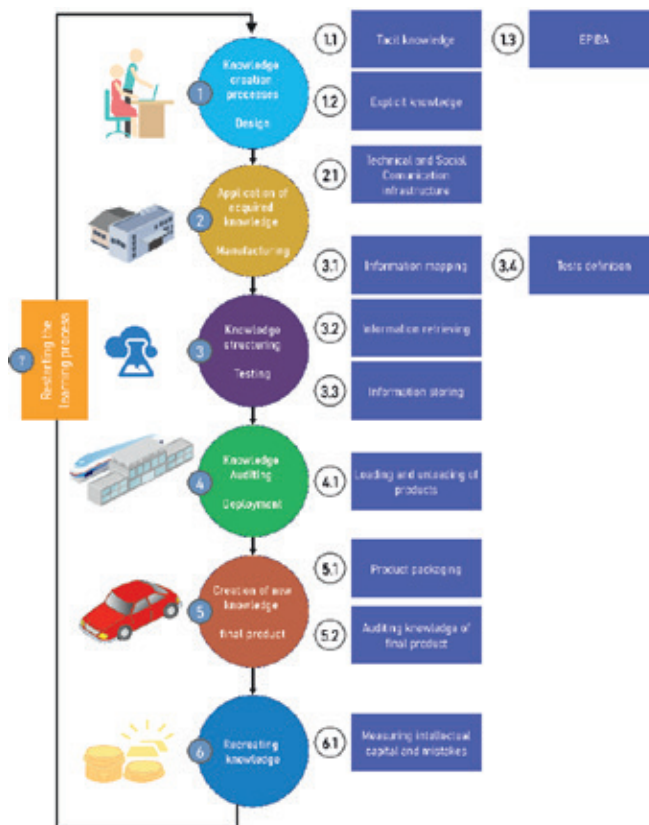


quirements, regulatory standards, environmental conditions, etc., which must be organized systematically to design reliable AV systems. The following knowledge is included and used in this part: explicit and tacit knowledge. The steps outline specific actions such as data collection methods, stakeholder involvement, and documentation requirements.

2. Application of acquired knowledge - Manufacturing: During the manufacturing process itself, it involves different stages, such as assembly line operations with multiple robots working together autonomously; therefore, it requires accurate instructions or programs delivered at precisely defined intervals resulting from efficient data flow management throughout these phases.
3. Knowledge structuring - Testing: Rigorous testing is necessary during different scenarios such as harsh weather conditions or unexpected events such as system failures or accidents. To conduct thorough testing protocols and effectively analyze test results using statistical methods, analysis tools should be available within a comprehensive knowledge base accessible to all relevant stakeholders.
4. Knowledge Auditing - Deployment: After the successful completion of development stages, deploying an AV on roads requires compliance with regulatory standards and legal considerations must be taken into account while ensuring the safety of passengers and other road users. The efficient management of information plays a vital role in meeting these requirements.
5. Creation of new knowledge - final product: Information is collected during the use of the vehicle and new knowledge is gained that can later be used during the production of a new series of vehicles. Also, in this way, new knowledge is recreated and the existing knowledge is supplemented.
6. Recreating knowledge: measuring the acquired knowledge and carrying out the evaluation.
7. Restarting the learning process: re-realization and initiation of all steps 1-6 in this process.

Integration between information and knowledge management systems facilitates seamless collabora-

tion between stake- holders involved in AV production processes. Researchers have suggested various technologies or platforms, such as cloud- based storage systems or collaborative project management tools that enable real-time sharing of access control security measures to ensure that stakeholders can contribute their expertise throughout the development lifecycle of different phases, offering input suggestions based on lessons learned from previous projects that improve the overall quality of the final product [36]. Implementing effective information and knowledge management systems is not without challenges in this domain. The processes themselves can be represented through the following cycle, which is shown in Figure 1.



**Fig. 1.** The Knowledge Management Life Cycle for AV hardware and software production - organizational process for knowledge management (OPKM). Source: author's contribution.

Real-world examples highlight successful KM implementations in various industries. By exploring these case studies, we managed to get valuable insights into best practices. That is why we noticed that certain companies focus more on collabora-

tion platforms for seamless communication sharing design specifications or test results with advanced analytic techniques. For predictive maintenance, the best method is to use the captured data from vehicle sensors to enhance overall performance [36]. In addition, cultural barriers, organizational resistance, and law changes can also pose difficulties during the implementation process that need to be addressed [37-39]. Some mitigation strategies include conducting thorough risk assessments, implementing robust security measures, fostering a culture of knowledge sharing, providing training programs, and promoting understanding as the first rule of importance for stakeholders that are involved.

## DISCUSSION

In the dynamic arena of software development, the intended order of flow phases orchestrates a debate and a compelling dance of innovation and correctness. This is occasionally referred to as performance since it starts with defining the goal and then moves on to planning, software development, and testing, constructing intricate patterns of participation. Integration, like a symphony combining instruments, harmonizes disparate elements.

Safety improvements are significant with KM, and sharing information across a fleet allows AVs to better anticipate and reduce dangers. For example, if one car encounters a hazard, the knowledge is rapidly shared to avoid similar events in other vehicles.

KM also encourages cross-disciplinary collaboration, bringing together skills in AI, machine learning, and data analytics. This promotes discussion and innovation, resulting in more advanced and reliable AV systems.

In summary, combining knowledge management with AVs improves decision-making, assures continuous learning, and increases safety, hence promoting business innovation and operational efficiency in the autonomous vehicle industry.

## CONCLUSION

Effective information and knowledge management plays a crucial role in the production of AV and any other final product. The complex nature of designing, manufacturing, testing, and later deploying AVs demands seamless collaboration among all involved in the production process. By integrating

various management systems and KM, organizations can overcome challenges related to data privacy, security concerns, and ethical issues while promoting a culture of knowledge sharing. Future case studies should demonstrate the positive results that can be achieved through the implementation of effective communications in the context of producing any type of intelligent vehicle. When ensuring successful production processes, will be imperative that organizations recognize the importance of efficiency and the best management practices throughout all phases of the development lifecycle of software and hardware. This could give the opportunities to capitalize on their emerging technology on the market, together with sharing knowledge, value, and trust that is created within a company that takes care of its employees.

## ACKNOWLEDGEMENTS

The work reported here was supported by the Slovak national project Increasing Slovakia's Resilience Against Hybrid Threats by Strengthening Public Administration Capacities (Zvýšenie odolnosti Slovenska voči hybridným hrozbám pomocou posilnenia kapacít verejnej správy) (ITMS code: 314011CDW7), co-funded by the European Regional Development Fund (ERDF), the Operational Programme Integrated Infrastructure for the project: Research in the SANET network and possibilities of its further use and development (ITMS code: 313011W988), Advancing University Capacity and Competence in Research, Development and Innovation (ACCORD) (ITMS code 313021X329), co-funded by the ERDF, rurALLURE project - European Union's Horizon 2020 Research and Innovation program under grant agreement number: 101004887 H2020-SC6-TRANSFORMATIONS-2018-2019-2020/H2020-SC6-TRANSFORMATIONS-2020, by the Slovak Research and Development Agency under the contract No. APVV-15-0508, Erasmus+ ICM 2023 No. 2023-1-SK01-KA171-HED-000148295 and Model-based explication support for personalized education (Podpora personalizovaného vzdelávania explikovaná modelom) - KEGA (014STU-4/2024).

## INFORMED CONSENT

Not applicable

## CONFLICT OF INTEREST

The author(s) declare(s) that they have no conflict(s) of interest.

## ETHICAL APPROVAL

Not applicable.

## DATA AVAILABILITY STATEMENT

Not applicable.

## REFERENCES

- [1] AOKI, S.; RAJKUMAR, R. Safe Intersection Management With Cooperative Perception for Mixed Traffic of Human-Driven and Autonomous Vehicles. *IEEE Open Journal of Vehicular Technology*, v. 3, p. 251-265, 2022.
- [2] BUTTERWORTH-HEINEMANN (Ed.). *Intelligent Vehicles*. [S.l.]: Elsevier, 2018.
- [3] CHEN, J. et al. ACP-Based Energy-Efficient Schemes for Sustainable Intelligent Transportation Systems. *IEEE Transactions on Intelligent Vehicles*, v. 8, p. 3224-3227, May 2023.
- [4] ČURČIĆ, M. et al. Economic potential of agro-food production in the Republic of Serbia. *Ekonomika poljoprivrede / Economics of agriculture*, v. 68, p. 687-700, 2021.



- [5] DAKIĆ, P. et al. Choosing, creating and developing managers. **Oditor**, v. 7, p. 105–134, 2021.
- [6] DAKIĆ, P.; DJORDJEVIĆ, S. Lokalni biznis – Proizvodnja hrane Lokalni Biznis - The Local Business, 2010.
- [7] DAKIĆ, P.; DJORDJEVIĆ, S. Oblak racunarstvo - Cloud Computing, 2010.
- [8] DAKIĆ, P.; DJORDJEVIĆ, S. Menadžerske kontrolne table Management Dashboards – Management control table, 2011.
- [9] DAKIĆ, P.; FILIPOVIĆ, L.; STARČEVIĆ, M. **Application of fundamental analysis in investment decision making: example of a domestic business entity**. ITEMA 2019. [S.l.]: Association of Economists and Managers of the Balkans - Udekom Balkan. 2019.
- [10] DAKIĆ, P.; SAVIĆ, J.; TODOROVIĆ, V. Software quality control management using black-box testing on an existing webshop trinitishop. **FBIM Transactions**, v. Vol. 9 No 1, May 2021. Disponivel em: <<https://www.meste.org/ojs/index.php/fbim/article/view/1137>>. Acesso em: 2 November 2021.
- [11] DAKIĆ, P.; TODOROVIĆ, V. Isplativost i energetska efikasnost autonomnih vozila u EU. **FBIM Transactions**, v. Vol. 9 No 2, October 2021. Disponivel em: <<https://www.meste.org/ojs/index.php/fbim/article/view/1198>>.
- [12] DAKIĆ, P.; TODOROVIĆ, V.; BILJANA, P. Investment reasons for using standards compliance in autonomous vehicles. **ESD Conference, Belgrade 75th International Scientific Conference on Economic and Social Development Development, ESD Conference Belgrade, 02-03 December, 2021 MB University, Teodora Drajzera 27, 11000 Belgrade, Serbia**, 2021. ISSN ISSN: 1849-7535 (Online). Disponivel em: <<https://www.shorturl.at/diMRS>>.
- [13] DAKIĆ, P.; TODOROVIĆ, V.; VRANIĆ, V. **Financial Justification for using CI/CD and Code Analysis for Software Quality Improvement in the Automotive Industry**. 2022 IEEE Zooming Innovation in Consumer Technologies Conference (ZINC). [S.l.]: [s.n.]. 2022. p. 149-154.
- [14] DAKIĆ, P.; TODOROVIĆ, V.; VRANIĆ, V. Financial Sustainability of Automotive Software Compliance and Industry Quality Standards. In: \_\_\_\_ **Proceedings of Eighth International Congress on Information and Communication Technology**. [S.l.]: Springer Nature Singapore, 2023. p. 477–487.
- [15] DAKIĆ, P.; TODOSIJEVIĆ, A.; PAVLOVIĆ, M. The importance of business intelligence for business in marketing agency. **International scientific conference ERAZ 2016 Knowledge based sustainable**, 2016. Značaj poslovne inteligencije za poslovanje marketinške agencije.
- [16] DAKIĆ, P.; ŽIVKOVIĆ, M. **An Overview of the Challenges for Developing Software within the Field of Autonomous Vehicles**. 7th Conference on the Engineering of Computer Based Systems. New York, NY, USA: Association for Computing Machinery. 2021.
- [17] GHANSIYAL, A.; MITTAL, M.; KAR, A. K. Information Management Challenges in Autonomous Vehicles. **Journal of Cases on Information Technology**, v. 23, p. 58–77, July 2021.
- [18] GHOSAL, A.; HALDER, S.; CONTI, M. Secure over-the-air software update for connected vehicles. **Computer Networks**, v. 218, p. 109394, December 2022.
- [19] GOLIS, T.; DAKIĆ, P.; VRANIĆ, V. **Creating Microservices and using infrastructure as code within the CI/CD for dynamic container creation**. 2022 IEEE 16th International Scientific Conference on Informatics (Informatics). [S.l.]: IEEE. November 2022.
- [20] HRONCOVA, N.; DAKIC, P. **Research Study on the Use of CI/CD Among Slovak Students**. 2022 12th International Conference on Advanced Computer Information Technologies (ACIT). [S.l.]: IEEE. September 2022.
- [21] HU, Z. et al. Review and Perspectives on Driver Digital Twin and Its Enabling Technologies for Intelligent Vehicles. **IEEE Transactions on Intelligent Vehicles**, v. 7, p. 417–440, September 2022.
- [22] JU, Z. et al. A Survey on Attack Detection and Resilience for Connected and Automated Vehicles: From Vehicle Dynamics and Control Perspective. **IEEE Transactions on Intelligent Vehicles**, v. 7, p. 815–837, December 2022.
- [23] KROCKA, M.; DAKIC, P.; VRANIC, V. **Automatic License Plate Recognition Using OpenCV**. 2022 12th International Conference on Advanced Computer Information Technologies (ACIT). [S.l.]: IEEE. September 2022.
- [24] KROČKA, M.; DAKIĆ, P.; VRANIĆ, V. **Extending Parking Occupancy Detection Model for Night Lighting and Snowy Weather Conditions**. 2022 IEEE Zooming Innovation in Consumer Technologies Conference (ZINC). [S.l.]: [s.n.]. 2022. p. 203-208.
- [25] PETRIČKO, A.; DAKIĆ, P.; VRANIĆ, V. **Comparison of Visual Occupancy Detection Approaches for Parking Lots and Dedicated Containerized REST-API Server Application**. [S.l.]: [s.n.]. 2022.
- [26] POPOVIĆ, M.; MILOSAVLJEVIĆ, M.; DAKIĆ, P. **Twitter Data Analytics in Education Using IBM Infosphere Biginsights**. Sinteza 2016 - International Scientific Conference on ICT and E-Business Related Research. [S.l.]: [s.n.]. 2016. p. 74-80.
- [27] ROPER, J.; LIN, M.-H.; RONG, Y. Extensive upfront validation and testing are needed prior to the clinical implementation of AI-based auto-segmentation tools. **Journal of Applied Clinical Medical Physics**, v. 24, December 2022.
- [28] STRANDBERG, K.; NOWDEHI, N.; OLOVSSON, T. A Systematic Literature Review on Automotive Digital Forensics: Challenges, Technical Solutions and Data Collection. **IEEE Transactions on Intelligent Vehicles**, v. 8, p. 1350–1367, February 2023.
- [29] SUZUKI, J. et al. **Semantic-based and Learning-based Regression Test Selection focusing on Test Objectives**. 2023 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW). [S.l.]: IEEE. April 2023.
- [30] SZARKA, R.; DAKIC, P.; VRANIC, V. **Cost-Effective Real-time Parking Space Occupancy Detection System**. 2022 12th International Conference on Advanced Computer Information Technologies (ACIT). [S.l.]: IEEE. September 2022.
- [31] TAMBARE, P. et al. Performance Measurement System and Quality Management in Data-Driven Industry 4.0: A Review. **Sensors**, v. 22, p. 224, December 2021.
- [32] TANG, X. et al. Prediction-Uncertainty-Aware Decision-Making for Autonomous Vehicles. **IEEE Transactions on Intelligent Vehicles**, v. 7, p. 849–862, December 2022.
- [33] TENG, S. et al. Motion Planning for Autonomous Driving: The State of the Art and Future Perspectives. **IEEE Transactions on Intelligent Vehicles**, v. 8, p. 3692–3711, June 2023.

- [34] TODOROVIĆ, V.; DAKIĆ, P.; ALEKSIĆ, M. Company management using managerial dashboards and analytical software. **ESD Conference, Belgrade 75th International Scientific Conference on Economic and Social Development, ESD Conference Belgrade, 02-03 December, 2021 MB University, Teodora Dražera 27, 11000 Belgrade, Serbia**, 2021. ISSN ISSN: 1849-7535 (Online). Disponivel em: <<https://shorturl.at/diMRS>>.
- [35] VUONG, Q.-H. et al. Covid-19 vaccines production and societal immunization under the serendipity-mindsponge-3D knowledge management theory and conceptual framework. **Humanities and Social Sciences Communications**, v. 9, January 2022.
- [36] WIRTH, F. N. et al. Privacy-preserving data sharing infrastructures for medical research: systematization and comparison. **BMC Medical Informatics and Decision Making**, v. 21, August 2021.
- [37] YANG, X.-S. Firefly Algorithms. In: \_\_\_\_ **Nature-Inspired Optimization Algorithms**. [S.l.]: Elsevier, 2021. p. 123–139.
- [38] YOUSIF, A. et al. Greedy Firefly Algorithm for Optimizing Job Scheduling in IoT Grid Computing. **Sensors**, v. 22, p. 850, January 2022.
- [39] ZHANG, P.; SILVA, L. A. D. A discussion on the integration of data management systems in ship operations. **Maritime Technology and Research**, v. 2, p. Manuscript, April 2020.

Received: May 9, 2024

Accepted: May 15, 2024

## ABOUT THE AUTHORS



**Pavle Dakić** is currently PhD. student in Electrical Engineering and Computing at Singidunum University and Applied Informatics at Faculty of Informatics and Information Technologies, Slovak University of Technology. He is an experienced academic lecturer and expert solution architect in telecommunications and IT. His current research interests are in the field of computer networks, security, high-performance systems (HPC), IoT, software development and testing, QA, SEO/SEM, CI/CD, cryptography, and data security with business applications of information and telecommunication technologies.

## FOR CITATION

Pavle Dakić, Importance of knowledge management for CI/CD and Security in Autonomous Vehicles Systems, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-Europien University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:7-16, (UDC: 621.355:629.33-514.59), (DOI: 10.7251/JIT2401007D, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# ENHANCING MARKETING INTELLIGENCE IN THE INSURANCE SECTOR: A STUDY IN THE BELGRADE REGION

**Nikola Medan**

*University of Belgrade, Faculty of Organizational Sciences, Serbia, nikolamedan13@yahoo.com*

**Original research paper**

<https://doi.org/10.7251/JIT2401017M>

UDC: 654.191:32.019.5(497.11)

**Abstract:** In the rapidly evolving landscape of data-driven business, marketing intelligence has become a cornerstone for organizational success. This entails the systematic collection, analysis, and interpretation of vast data sets, empowering businesses to make strategic marketing decisions. Employing techniques like data mining, machine learning, and sentiment analysis, marketing intelligence uncovers hidden patterns, identifies opportunities, and predicts challenges. A pivotal outcome is enhanced customer understanding through detailed profiles derived from sources like social media, website interactions, and purchase history. This depth of insight allows for the creation of personalized, precisely targeted campaigns, fostering stronger customer relationships and loyalty. Moreover, marketing intelligence facilitates data-driven decisions aligned with overarching business goals, optimizing resource allocation, budgeting, and strategic planning. Utilizing software solutions such as RapidMiner, organizations gain efficiency in data analysis, machine learning, and predictive analytics. Net Promoter Score (NPS) acts as a key metric, gauging customer sentiment and likelihood to recommend products or services. This paper focuses on evaluating customer satisfaction in the insurance sector, aiming to propose enhancements for service quality based on existing research results. Through a comprehensive examination of customer satisfaction levels, the study seeks to provide actionable insights for continual improvement.

**Keywords:** Marketing intelligence, Customer satisfaction, Data-driven decision making, RapidMiner

## INTRODUCTION

Today, information undoubtedly represents one of the key elements that provides a competitive advantage, given that having timely, accurate, reliable and objective information enables effective decision-making, which will, in turn, enable the use of the strengths a company has at its disposal to achieve the desired goals. In today's dynamic landscape, it is imperative for all organizations to effectively harness and navigate information in order to stay abreast of the latest advancements in knowledge sciences and technological innovations. This becomes particularly crucial in the face of the challenges posed by the 21st-century realities, such as the expansion of markets, increasing product diversity, the rapid evolution of information technology, and the intense competition within the realm of university education (Hussein, 2020). However, the problem of the modern era is that information is everywhere around us, so a problem for the management is how to single out the "best" informa-

tion, that is, the information that has the previously mentioned characteristics (Azeez, 2020). More than ever before, information is found in the environment of the organizations, and it is a product of technological progress, primarily the Internet, which has enabled the development and distribution of a large volume of structured and unstructured information. However, despite such a large volume of information, companies are often forced to conduct empirical research themselves and to obtain primary data. Nevertheless, this is not only applied to quantitative values, but to a combination of text messages, numbers and multimedia content. Such nature of information requires the use of specific software tools, which will identify trends based on analytical processes and ensure the prediction of certain actions and their outcomes (Harrison & Cupman, 2013).

Marketing intelligence is relevant in the aforementioned domain. It refers to the application of specific software solutions for the needs of strategic and tacti-

cal planning of organizations, and which can be more precisely defined as “the gathering of marketing information from all available sources, i.e. as marketing research, market development, internal and external environment, verification and validation of reliability and consistency of information sources and their use for decision-making” (Vishnoi & Bagga, 2020; Lies, 2022; Aripin et al, 2022). In simpler terms, it is a special approach in the identification, collection and the analysis of information from the internal and external environment that can be used in the decision-making process, and which provides a competitive advantage. In that process, three categories of information are analysed separately in order to identify opportunities and threats (Azeez, 2020): information about customers, information about competitors and information about the marketing environment.

With regard to the previously mentioned attitudes, three relevant groups of marketing intelligence activities can be identified (Vishnoi & Bagga, 2020): acquisition, i.e. gathering information from various sources, information analysis and activation, i.e. the use of information for decision-making purposes.

Marketing intelligence fulfils numerous roles within organizations, especially highlighting its roles in supporting decision-making when entering a new market, minimizing business risk, gaining a competitive advantage, meeting customer needs, and developing a corporate identity (Harrison & Cupman, 2013).

This paper is divided into four sections. The first section will discuss the concepts related to marketing intelligence, while the second section will focus on marketing intelligence in the insurance sector. The third section presents the relevant aspects of Net Promoter Score. The final section presents the findings of the empirical research.

### THE BASICS OF MARKETING INTELLIGENCE

Business and marketing intelligence systems combine data collection, data storage and knowledge management with analytical tools to present complex internal and competitive information to managers and decision makers. In this respect, we should highlight some of the relevant components of marketing intelligence, which include the integration of decision-making tools and processes, with the aim of improving the quality of information that will be used in business decision-making. In particular, the following

components should be highlighted (Negash, 2004): real-time data storage, data mining, automated detection of anomalies and exceptions, proactive warning, automated learning, geographic information systems and data visualization.

When conducting marketing analysis and marketing intelligence related activities, various methods and techniques are used, usually supported by software solutions. More precisely, they are tools that help in the application of said processes and the automation of information processing analysis (Hedin et al, 2014). They refer to a broad category of applications and technologies for collecting, storing, analysing and providing access to data to help users make better business decisions (Kolhe et al, 2011). Considering the abovementioned, marketing intelligence techniques and tools include (Olszak & Zurada, 2015): tools, technologies and software products; knowledge management; decision support systems; control panels; new ways of handling information or a specific philosophy and methodology of working with information and knowledge; analytical processes; competitive intelligence and big data analytics.

Marketing intelligence is not a new activity and has actually existed since marketing information has been actively used and analysed for decision-making purposes. However, today various information systems and software solutions are actively used in this process. Not only do they facilitate the analysis process, but they also shorten the analysis time and improve the quality of the obtained results. Considering the subject and aim of this paper, the prospects of applying the RapidMiner software solution will be presented in particular.

### MARKETING INTELLIGENCE IN THE INSURANCE SECTOR

Today, the insurance sector is met with a very large volume of data that can be used for the process of making business decisions. Insurance companies typically use customer relationship management systems and enterprise resource planning technologies to collect and analyse this data. However, the lack of use of specific software solutions and technologies creates problems with the conversion of information into knowledge used to improve competitiveness. To resolve this issue, insurance companies need to centralize their data by keeping it at a single location. This ensures that authorized personnel, including actuaries, financial



analysts and managers, can access the data. After that, the data must be submitted for appropriate analysis in order to draw accurate conclusions. Marketing intelligence enables insurance companies to streamline their operations, leading to cost reductions and more competitive pricing for their products and services (Renuka & Shankar, 2020).

The insurance industry is entirely dependent on the ability to translate data into information about customers, competitors, markets and the business environment. The implementation of marketing analytics in the insurance industry involves the following processes (Rostek, 2009):

- Justification analysis of its implementation viewed from the aspect of cost-effectiveness and potential effectiveness of goal attainment.
- Infrastructure and marketing intelligence systems planning.
- Business analysis, which includes requirement assessment, data availability assessment and the assessment of software to be applied.
- System and data storage design.
- Implementation of a marketing analytics system through the application of specific analytical approaches, methods and techniques.

Some aspects of the application of marketing intelligence in the insurance sector provide the following (Renuka & Shankar, 2020):

- the ability to detect inconsistencies and fraud, i.e., the identification of suspicious cases, on the basis of which companies can avoid paying premiums for false claims;
- storage for a large volume of different types of data, including unstructured data;
- the identification and classification of profitable and valuable clients;
- improvement to the sales process and the volume of sales of insurance policies;
- predictive modelling;
- customer relationship management.

Customer relationship analysis helps in developing new products and adapting products to current customer needs and to appropriate customer segments. Data collection tools are used particularly for customer satisfaction analysis. Understanding customer needs in order to identify satisfaction is

based on a multidimensional analysis that includes segmentation and segment analysis. Segmentation is used to identify segments of customers with common characteristics. The segments thus identified can be treated as distinct entities and future cooperation can be directly adapted to their needs. Client segmentation enables the creation of offers aimed at specific groups of customers, which lowers marketing costs and significantly increases efficiency (Rostek, 2009).

Sentiment analysis is a natural language processing technique (NLP), which includes the assessment of the sentiment or an emotional aspect expressed by customers (i.e. insurance customers) in a segment of text. The goal of sentiment analysis is to automatically identify whether a text expresses positive, negative, or neutral emotion and, in some cases, to quantify its strength (Struhl, 2015).

### NET PROMOTER SCORE

Net Promoter Score is one of the metrics for identifying and measuring the degree of customer satisfaction. In its most basic form, Net Promoter Score involves asking customers a single question: "How likely are you to recommend our company to a friend or colleague?" - on a scale from 0 to 10. Customers with a score of 0 to 6 are categorized as detractors, those with 7 and 8 as passives, and those with 9 and 10 as promoters. Net Promoter Score is calculated as a percentage by subtracting the detractor score from the promoter score and dividing by the total number of responses, excluding passive buyers, i.e. (Baquero, 2022):

$$NPS = \frac{\text{Promoters} - \text{detractors}}{\text{total responses}} \times 100$$

Results ranging from 100 to 0 are considered unsatisfactory, while those falling within the range of 100 to 50 are categorized as deficient, and those from 49 to 0 are considered insufficient. In case the result is insufficient, it implies that the service quality is very negatively perceived by the customer.

### EMPIRICAL RESEARCH

#### Subject, Aim and Research Questions

Marketing intelligence, in the context of insurance customer satisfaction, involves systematic collection, analysis and interpretation of data, in order to obtain information that can be used to make marketing decisions. This process allows insurance companies to

understand the importance of customers’ feelings, attitudes and behaviours, which in turn leads to more effective decision making. Using this information, insurance companies can discover patterns and trends in customer satisfaction data. Through rigorous data analysis techniques, such as sentiment analysis, clustering and trend identification, companies can gain a comprehensive understanding of their customers’ perceptions and opinions.

Considering the existing results of research on customer satisfaction in insurance, the *subject* of this paper is the level of customer satisfaction in insurance. The *aim* is to examine the level of customer satisfaction, in order to formulate proposals for further improvement of service quality. In order to examine the goal, the research was conducted in 2022 among respondents coming from the Belgrade region. In the research process, a sample of 449 respondents was formed.

Starting with the subject and the aim, the following research question was posed: *Which key recommendations can be identified based on the analysis of consumer attitudes in the process of marketing intelligence?*

Rapid Miner was used in this paper in order to process the opinions of the respondents. Descriptive

statistical analysis was used as a statistical technique.

### Analysis of the Results

Firstly, the results of the descriptive analysis regarding the age of the respondents and their average NPS score can be identified. According to the results, it is first noted that the average age of the respondents is 48.26, with an average deviation of 13.13 years. The average NPS score is 8.88 with standard deviation of 2.658.

After analysing certain invalid answers (for example, some respondents did not provide an answer or indicated that they were very old - in most cases 124), a total of 449 attributes were identified. When it comes to the answers, Table 2 shows the answers that have a frequency greater than 1, that is, the ones written by more than one respondent.

If we analyse the responses with a frequency greater than 1, it can primarily be noted that 40 of them do not provide any suggestions regarding changes in the service structure, which indicates a certain degree of satisfaction with the offer. The results of the frequency analysis are presented in Table 1.

However, looking at the remaining responses (Table 2), the following suggestions for improvements to

**Table 1.** The most frequent responses

Responses	Frequency
The main thing is that I work for Triglav, so I recommend it to friends.	3
Simply, the best conditions.	3
Online shopping	3
I do not know what you are like in case I had the need to activate it, that is why I gave this response.	3
Because it is the most affordable insurance, the possibility to conclude insurance online, which is very simple	3
Fast, efficient	2
Fast, safe and efficient	2
Good quality of insurance and an affordable price.	2
Efficient, fast and simple to get travel insurance online	2
Buying a policy online in 2 minutes. For several years now, for every trip, I have been buying policies in the same insurance company	2
A simple and quick way to get insurance online.	2
I also like the way and speed of concluding insurance contracts in these fast-paced times.	2
It is online and there is a discount	2
The staff is very pleasant and I am very satisfied with the services and offers	2
Reliance	2
The advantage of online contract conclusion and competitive pricing compared to other insurance companies	2
I would recommend it because I work in the company.	2
I would recommend it to everyone, as my wife and I have been using it (exclusively) for the last 10 years or so.	2
Professionalism	2
Luckily I didn't have to activate it, I hope I never have to.	2
Everything is great	2
Because it is possible to buy the insurance online.	2
Because of your promptness, efficiency and trust shown.	2



the service in the future can be identified: introduction of group insurance, introduction an optional user account, recognition of those customers who have used the service on the Internet previously, improvement in the simplicity of the user message regarding covid-19, and reduction of bureaucracy.

In the continuation of the analysis, cluster analysis (k means method) was applied. As noted below, a total of five clusters (0-4) and 449 attributes were created: Cluster 0: 118 items; Cluster 1: 92 itens; Cluster 2: 67 items; Cluster 3: 167 items; Cluster 4: 36 items.

Cluster 0, which is the second largest, includes clients with an average age of 33.7, whose NPS is 9.576. Cluster 1 has fewer respondents, their average age is slightly higher (49,435), but that is why these respondents (insurance customers) achieve the highest NPS score, which is 9,674. Cluster 2 is smaller compared to the previous 2 clusters and includes the eldest insurance customers, with an average age of 67,985, and whose NPS score is the second highest (9,582). Cluster 3 is the largest with 136 respondents, the average age is 51,213, and their NPS score is 9,522. Cluster 4 has the fewest respondents, their average age is 45.167, but this is also the group of respondents with the lowest NPS score (0,8333).

Based on the results of the cluster analysis, it can be observed that the highest NPS score is actually achieved by older groups of respondents (over 49 years of age). Despite featuring different types of insurance, these insurance customers show the highest satisfaction and loyalty. These results can also be presented graphically, as shown in Figure 1.

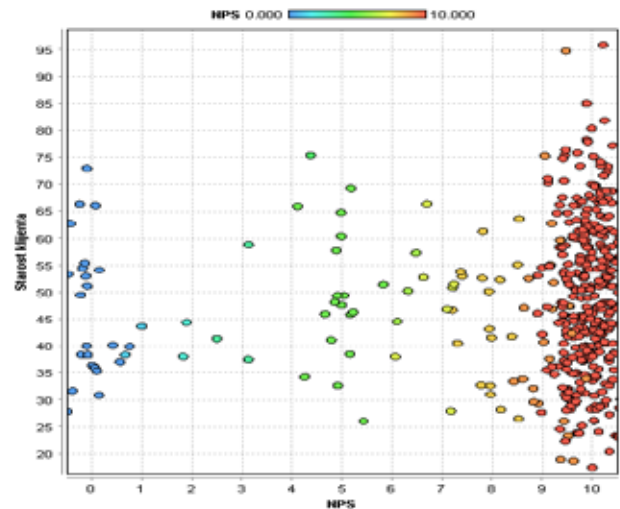


Figure 1. As can be seen from Figure 1, the clustering around the highest value of the NPS score occurs in respondents around the age of 49 (red dots).

Table 2. Other most frequent responses

Responses	Frequency
Nothing	40
There is no group insurance for fewer than 6 people, i.e. 4 or more	8
The same as last time. The introduction of a user account where all personal data will be stored and doesn't have to be input every time	3
I have no suggestions.	3
Nothing in particular.	3
For you to recognise your customers, who have used your internet services previously.	2
Shorter messages which would be clear and transparent to the users when it comes to covid-19 risk coverage.	2
Less paperwork.	2
I have no particular suggestions as I have always been more than satisfied with the service and the speed of the conclusion of the contract.	6
No complaints	4

Table 3. Cluster analysis results

Attribute	Cluster 0	Cluster 1	Cluster 2	Cluster 3	4Cluster 7
Customer age	33.712	49.435	67.985	51.213	45.167
NPS	9.576	9.674	9.582	9.522	0.833
Response	16	16	325	16	0
Additional comments	6	6	6	6	6
Response no.	1	1	1	1	1
Type of insurance	17.915	4.326	16.940	17.779	11.500

## CONCLUSION

This research highlights the critical role of marketing intelligence in enhancing insurance client satisfaction through systematic data collection, analysis, and interpretation. By understanding customer attitudes and behaviors, insurance companies can make better decisions, identify patterns, and predict future trends. Customer segmentation emerges as a potent strategy, allowing companies to tailor communication and business decisions to different customer segments effectively. Leveraging predictive modeling, insurance firms can anticipate changes in satisfaction and adjust their offerings accordingly, fostering innovation and personalized services. Specialized software tools facilitate the management and analysis of vast customer data, leading to actionable insights. The research emphasizes key areas for improving insurance services, including introducing group insurance, optional user accounts, simplifying communication regarding COVID-19, and reducing bureaucracy. These initiatives aim to enhance the overall customer experience, requiring continuous feedback collection and refinement. However, the research acknowledges limitations in sample size and methodology, suggesting the need for broader representation and additional statistical analysis to ensure comprehensive insights.

## REFERENCES

- [1] Azeez, E.H. Marketing intelligence system and its impact in determining strategies of competitive positions. / E.H. Azeez // *Utopía y Praxis Latinoamericana*. 2020; 25(1): 530-543.
- [2] Aripin, Z., Suganda, U.K., Kusumah, A.Z. Marketing intelligence: Innovation ability to anticipate global competition. / Z. Aripin, U.K. Suganda, A.Z. Kusumah // *INTERNATIONAL JOURNAL OF RESEARCH IN BUSINESS AND SOCIAL SCIENCE*. 2022; 11(1): 328-339.
- [3] Baquero, A. Net Promoter Score (NPS) and customer satisfaction: relationship and efficient management. / A. Baquero // *Sustainability*. 2022; 14(3): 1-20.
- [4] Harrison, M., Cupman, J. Using market intelligence & competitive intelligence to add value to your business. / M. Harrison, J. Cupman // *B2B International*. 2013; 1-16.
- [5] Hussein, E.A. Marketing Intelligence System and its Impact in Determining Strategies of Competitive Positions. / E.A. Hussein // *Utopía y Praxis Latinoamericana*. 2020; 25(1): 530-543
- [6] Kolhe, S.R., Saikute, V.R., Patil, M.P. Business intelligence (BI) tools and techniques: Indian scenario. / S.R. Kolhe, V.R. Saikute, M.P. Patil // *Current Development in Artificial Intelligence*. 2011; 2(1): 31-38.
- [7] Lies, J. Marketing Intelligence: Boom or Bust of Service Marketing. / J. Lies // *International Journal of Interactive Multimedia and Artificial Intelligence*. 2022; 7(7): 115-124.
- [8] Negash, S. Business intelligence. / S. Negash // *Communications of the Association for Information Systems*. 2004; 13(1): 177-195.
- [9] Olszak, C.M., Zurada, J. Information technology tools for business intelligence development in organizations. / C.M. Olszak, J. Zurada // *Polish Journal of Management Studies*. 2015; 2(1): 132-142.
- [10] Renuka, M., Shankar, S. A study on impact of business intelligence on insurance industry. / M. Renuka, S. Shankar // *Journal of Emerging Technologies and Innovative Research*. 2020; 7(5): 77-82.
- [11] Rostek, K. Business intelligence for insurance companies. / K. Rostek // *Foundations of Management*. 2009; 1(1): 65-82.
- [12] Stone, M. Marketing intelligence: A managerial approach. / M. Stone // *Routledge*. 2001.
- [13] Struhl, S. Practical text analytics: interpreting text and unstructured data for business intelligence (marketing science). / S. Struhl // *Kogan Page: London*. 2015.
- [14] Srirahayu, D.P., Anugrah, E.P., Layyinah, K. Influence of satisfaction and loyalty on Net Promoter Score (NPS) in academic libraries in Indonesia. / D.P. Srirahayu, E.P. Anugrah, K. Layyinah // *Library Management*. 2021; 35(7/8): 1-15.
- [15] Vishnoi, S.K., Bagga, T. Marketing intelligence: antecedents and consequences. / S.K. Vishnoi, T. Bagga // *3rd International Conference On Innovative Computing And Communication (ICICC-2020)*. 2020; 1-10.

Received: January 18, 2024  
Accepted: March 28, 2024



## ABOUT THE AUTHORS

**Nikola Medan** completed his undergraduate and master's studies at the Faculty of Economics, University of Belgrade. He enrolled in PhD studies at the Faculty of Organizational Sciences in Belgrade in 2022. He has been working at Triglav Insurance since 2020.

## FOR CITATION

Nikola Medan, Enhancing Marketing Intelligence in the Insurance Sector: A Study in the Belgrade Region, *JITA – Journal of Information Technology and Applications*, Banja Luka, Pan-Europien University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:17-22, (UDC: 654.191:32.019.5(497.11)), (DOI: 10.7251/JIT2401017M, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# E-COMMERCE MANAGEMENT - EXPLORING USER PREFERENCES FROM THE TERRITORY OF THE BOSNIA AND HERZEGOVINA

**Aleksandra Vidović**

*Pan-European University APEIRON, Banja Luka, Bosnia and Herzegovina, [aleksandra.b.vidovic@apeiron-edu.eu](mailto:aleksandra.b.vidovic@apeiron-edu.eu)  
ORCID 0000-0002-0913-8546*

**Original research paper**

<https://doi.org/10.7251/JIT2401023V>

UDC: 005.96:004.738.5(497.6)

**Abstract:** Electronic or Internet commerce is the process of buying, selling, transferring, and exchanging products, services, or information through computer networks. With the rapid development of information technology, collaborative consumption supported by platforms is becoming attractive to consumers. It enables quick and straightforward communication, transmission of information over long distances, easy publication of various documents, and transactions via the Internet. The goal of every trading company is to understand each client individually and use this understanding to facilitate the customer's decision to work with a specific company -rather than the competition. Online shopping is experiencing exponential growth and has many advantages compared to traditional shopping. Hence, the goal of the research is to examine the impact of modern electronic solutions on shopping. The research subject is related to determining the attitudes and decisions of consumers on the issue and making the final decision about the purchase using electronic services. The purpose of the research is to present a set of activities that affect the success of electronic commerce. From the comparative study of consumer behavior, the hypothesis was tested where  $H_0$  - electronic commerce has a significant impact on the behavior of consumers of this type of commerce. The research conclusions refer to the observation of variables that can be useful when making more effective decisions in the future.

**Keywords:** electronic commerce, management, buyers, sellers

## INTRODUCTION

Electronic commerce involves business communication, the transfer of goods and services via networks and computers, as well as the transfer of capital using digital communication. Internet trade is considered the most profitable form of trade due to its very low costs and simplicity. An online store has no working hours, making shopping possible 24 hours a day. The product is available even to the most remote Internet users. More than 300 million Internet users [3] worldwide become potential customers, and there is no need to pay for office space lease because instead of a storefront, only one Internet site is needed.

The Internet market is one of the world's largest developing markets. If there is a quality offer, users easily decide to buy via the Internet because it implies a larger selection, simple price comparison between several sellers, and door-to-door delivery service, which means saving time. All information or prices

in the online store can be changed immediately so that the information reaches the customers as soon as possible. Electronic commerce includes all forms of business transactions performed by both natural and legal persons, based on the processing and transmission of digital data, including text, sound, and image. Electronic commerce can occur between a company and a customer or between business partners. It can also be conducted between the government and other parties, between individual customers, and between a firm and its employees.

Electronic commerce includes: internal electronic mail and email messaging, online publication of corporate documents, online search of documents, projects and relevant knowledge, logistics automation, supply chain management, distribution and storage, order information processing and supplier reporting to customers, tracking orders and deliveries, distributing information to employees, managing account-

ing and personnel systems, as well as numerous other business activities.

The subject of the research is related to determining the attitudes and decisions of consumers on the issue and making the final decision about purchasing using electronic services. The purpose of the research is related to the recognition of a set of activities that affect the success of electronic commerce.

Instagram and Facebook in the territory of Bosnia and Herzegovina represent a gray marketing zone, as followers have certain expectations, e.g., favorite actors, singers, groups, and the like. There is a situation where these same public figures receive certain products from well-known brands free of charge, which are advertised by well-known individuals through social networks, thereby achieving a better and more effective marketing reach to the audience. [9]

Amazon and eBay are considered the largest online stores today. These two e-commerce giants exemplify why e-commerce is the most successful form of business. Today, technology serves profit and promotion. Through the Internet, every promotion has a stronger resonance than through traditional media, and the Internet as a medium enables competition.

## LITERATURE REVIEW

EDI (Electronic Data Interchange) refers to electronic data exchange. It is a standard format for exchanging business data, typically done via email or fax. EDI is defined as the exchange of structured business data between computers of separate companies, carried out without manual intervention, electronically, through standardized messages that replace traditional paper documents. [6]

EDI represents the exchange of business or administrative messages (order, invoice, payment notification, stock status) between the computers of two or more business partners with the application of agreed norms for structuring transactions or data. [4]

The application of electronic commerce began in the early seventies of the last century with the introduction of electronic business applications in large corporations and a small number of business firms. The use of EDI expanded the types of firms that participated in these businesses, from financial institutions to manufacturers, retailers, and services. EDI represents "the exchange of structured commercial data between computers of separate companies, car-

ried out without manual intervention, electronically, through standardized messages that replace traditional paper commercial documents." [1]

A business model is a method of planning a business in a way that brings profit to the company, indicating where it will be positioned in the market chain. Since there are a large number of different interpretations of various models of electronic commerce, only some models, which are the most widely accepted in the literature, will be explained here. These are: storefront model, auction model, portal model, dynamic pricing model, and online trading and lending model.

Storefront model - an online catalog with products, purchase procedure, secured payment, manufacturer's server, and manufacturer's database. It usually offers a wide variety of products and services, and it is possible to place multiple orders in one transaction. ([www.amazon.com](http://www.amazon.com)) Auction model - in this case, it is mediation. Internet users appear, who can come in the role of either a seller or a bidder. Auction sites make money by taking a commission from both parties. ([www.ebay.com](http://www.ebay.com).) Portal models - are goal-oriented towards knowledge products, knowledge integration, and knowledge management, directed towards a specific market segment or a specific event ([www.webmd.com](http://www.webmd.com), [www.women.com](http://www.women.com)) Dynamic pricing model - characterized by buying and selling products and services on the free market where prices vary depending on supply, demand, and consumer preferences. Online trading and lending models refer to brokerage companies for insurance, real estate, and securities trading over the web. [6]

The three payment methods that are most commonly used are processes that use models such as debit/credit cards, electronic funds, i.e., digital cash, and digital checks. Browser add-ons, known as electronic wallets, represent identified customers by displaying their credit card and digital asset data, they can be used freely by browser manufacturers and some of the sites that take advantage of those files. Digital cash is a payment system that enables the digital transfer of asset reports from one computer to another. The e-commerce payment processor application enables transactions, encrypted security, and verification. The main participants in payment transactions can be divided into buyers, sellers, intermediary institutions - banks, and state regulatory bodies.



Each of these participants shows different preferences towards existing payment systems, depending on their interests and goals. [5]

The Department for Combating Computer Crime of the Federal Police Administration (FUP), due to increasingly frequent internet scams, warns citizens that when shopping online, they must ensure that the site they are shopping on is legitimate, as frauds occur when shopping on fake sites. They note that there are still ongoing frauds that happened and are still happening on a domestic website for the sale of goods and services using the so-called "phishing", where the attackers presented themselves as customers and obtained data from bank cards from sellers of certain items on the said website with the aim of allegedly making a payment to the bank account for the goods they want to buy. In this way, the attackers obtained data from bank cards that are needed for online shopping, after which they "removed" money from the victims' accounts in various ways. [8]

The first question that arises when performing a transaction is the question of trust in those with whom the work is being done. On the Internet, one cannot be sure whether one gets what one wants before the payment is made, and the possibility to return the product if it does not fit often does not exist. Some types of services and products cannot be returned, and this has a negative effect on creating trust for online business. Products that cannot be delivered in this way require a special delivery process in addition to the process of review of the offer, payment, and execution of the order. Before starting the e-commerce process, it is necessary to decide when the products should be delivered and when the customer should make the payment. Losing money in Internet business is also a problem that attracts a lot of attention. That is why it is necessary to define ways to prevent loss, as well as multiple and unauthorized use of money.

When segmenting the market in the conditions of electronic commerce, it is very important to analyze the interrelationship between the consumer and the product, whereby in the segmentation the interrelationships must be checked whether the consumer is willing to buy a product or he is less willing to buy and use a certain product. [2]

Customers may have legitimate reasons to return products; however, some buyers take advantage of a

generous return policy as an incentive to buy without paying and to use the retailer. Due to a wide range of commercial considerations, this consumer behavior issue has long been of particular interest to both scholars and businesses. Likewise, other research studies have looked at the issue from a motivational standpoint, which is dishonesty and scam intention, such as returning products for personal gain by taking advantage of a flexible return policy. [7]

Growing marketing pressures, along with attractive market opportunities and technological developments, have induced many e-commerce platforms to leverage their strong brands. Being an intangible asset that can shape a firm's competitive advantage, a strong brand is crucial for customer loyalty, price premium, and long-term brand equity value. [10]

Customers also write online reviews in a more concise, diverse, and relaxed fashion, conveying positive emotion and a more subjective tone than expressed by hosts' project descriptions. Additionally, a large topic difference, reflected by customers' more details about various attributes elaborated in their online reviews, increases sales. [11]

## METHODOLOGY RESEARCH

The analysis of e-commerce management, the results of which are presented in this paper, is based on the data from the conducted survey as well as interviewing methods. The aim of the paper is to determine the opinions of respondents regarding electronic shopping. The research part of the work aims to show how electronic commerce, which is available 24/7, influences and facilitates the making of the final purchase decision for potential customers, that is, how much this kind of commerce facilitates the work of users of this kind of commerce. The study adopted a survey research design. A research instrument was used for data collection Questionnaire on about the attitudes about electronic commerce. The technique used in the research function is the method of anonymous filling in of questionnaires and interviews. The research in the paper is non-experimental research, i.e., it is a representative sample, which means that the research was conducted on the target group of respondents. The respondents are divided into two groups, one group of respondents consists of respondents who consume this type of purchase, while the other group of respondents consists of respondents

who deal with this type of sales. The first group consisted of a group of 108 respondents, while the second group of respondents consisted of 30. The list of research questions used in the research, in addition to general socio-demographic questions, included a certain group of questions that show the consumer's attitude towards electronic shopping, i.e., how much influence this type of trade has in the territory of Bosnia and Herzegovina with a series of open and closed questions. The questions related to questions about the type of electronic commerce that is used, how often respondents use this type of trading, how safe they are when making this type of purchase, how much influence did social networks have when entering this type of trading.

The research was conducted in the period from mid-January to March 2024, 138 respondents from the territory of Bosnia and Herzegovina, male and female, aged between 18 and 50, participated in the survey.

The questionnaire was created and distributed via DM (direct message), in which followers participated (acquaintances and unknown respondents), via Facebook and Instagram profiles.

Based on the review of the literature and previous research, the null hypothesis was set, which reads:  $H_0$  - electronic commerce has a huge impact on the behavior of consumers of this type of commerce.

## RESULT AND DISCUSSION

Based on the research conducted in the observed period, the following empirical data were collected, the results were analyzed using the statistical program StatPlus, the author presented the results theoretically, tabularly, and graphically. The variables in this study are on non-parametric scales, and therefore it is necessary to transform them into higher-order scales, and in this case, it is necessary to apply the analysis of variance (ANOVA), to test the hypothesis, that is, the statistical significance of the difference in the distribution of the frequencies of attitudes, the Chi-Square test was used and Tukey Kramer test.

138 respondents participated in the research, looking at the socio-demographic structure of the sample it is possible to state that in the sample of respondents there were slightly more female respondents  $N=88$  (64.77%) while there were male respondents  $N=50$  which makes (36.23%) of respondents.

According to the age structure of the respondents, 90 respondents (57%) are between the ages of 20 and 30, the other respondents, 48 of them (34.7%) are respondents over the age of 31-50, according to education with a university degree or more, there were 27 (19.56%) of the respondents, 102 (73.91%) had secondary education, 9 (6.52%) had primary education. The following table shows socio-demographic data.

**Table 1.** Socio- demographic structure

Variable	Category	No.
Gender	Male	50
	Female	88
Age structure	20-30	90
	31-50	48
Education	Elementary education	9
	High school education	102
	Faculty and higher	27

When looking at the skewness ratio and its standard errors, the results shown in Table No. 2 indicate that the results are within the interval  $\pm 1.96$ . In this case, they are considered acceptable in the interpretation of the normality of the distribution, considering the symmetry of the obtained results.

**Table 2.** Methodological approach to presenting data

Source	Result Details		
	SS	df	MS
Between-treatments	220.96	4	55.24
Within-treatments	13000	20	650
Total	13220.96	24	
Skewness:	0.058321.	F = 0.08499	
Kurtosis:	-1.989869.		

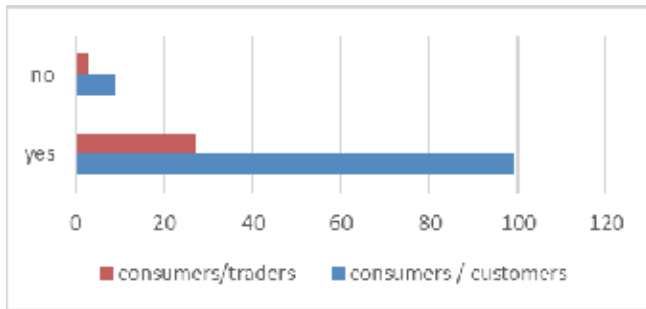
### Presentation of statistical results

The f-ratio value is 0.08499. The p-value is .986103. The result is not significant at  $p < .05$ .

The answer to the set null hypothesis was obtained by asking questions related to the attitude of consumers of this type of trading business system on the question of whether electronic commerce has a huge impact on the behavior of consumers of this type of trade.



**Figure 1.** the impact of electronic commerce on consumer behavior.



Presentation of respondents' answers to the question of the impact of electronic commerce on consumer behavior

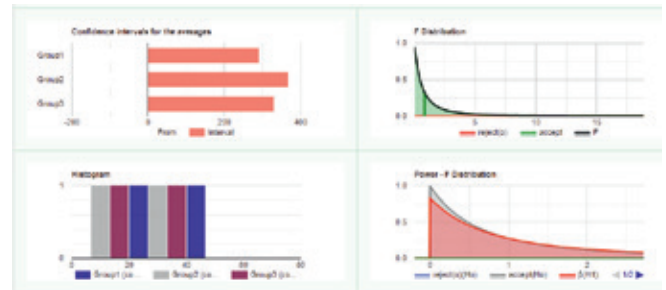
The results of this research showed that 71.739% of buyers in RS/BiH believe that the future of e-commerce is bright, the same opinion prevails among online sellers, while only 8.696% of respondents believe that e-commerce will not progress in the future. Consumers of e-commerce in RS/BIH are familiar with the advantages and disadvantages of this type of trading. The most important advantages of online shopping consumers are: the possibility of shopping 24/7, more favorable prices, the possibility of comparing prices as well as the variety of offers. Disadvantages of this type of trade are related to the insecurity of business, where fraud most often occurs (e.g., goods are ordered but not picked up, and therefore the postage is paid by the merchant or the goods are ordered to be picked up and when the package is opened it is not the ordered goods, misuse of personal data, misuse of data on credit/debit cards, etc.). Most often, consumers choose this type of trading because of the possibility of seeing the product at the moment of handing over the package.

**Table 3.** Answers of respondents

	yes	no	Marginal Row Totals
consumers / customers	99 (98.61); [0]	9 (9.39); [0.02]	108
consumers/ traders	27 (27.39) [0.01]	3 (2.61); [0.06]	30
Marginal Column Totals	126	12	138 (Grand Total)

The proposed hypothesis:  $H_0$  - electronic commerce has a significant influence on the behavior of consumers of this type of commerce was verified using the appropriate test, i.e.,  $X^2$  - test of independence

of characteristics and with a probability of 95%. The chi-square statistic is 0.0821. The p-value is .774414. This result is not significant at  $p < .05$ . The chi-square statistic with Yates correction is 0.0063. The p-value is .936545. This result is also not significant at  $p < .05$ , which means that the null hypothesis is accepted, the views of the respondents are in a close relationship where there is no statistically significant difference.



**Figure 2.** Tukey HSD / Tukey Kramer

According to the Tukey Kramer test, it was determined that there is no significant difference between the mean values of any pair shown in Figure 2.

**CONCLUSION**

Electronic commerce, as a new and completely different technology, will be maintained in the future. Thanks to the Internet and web technology, trade around the world has changed to electronic trade. With the development of Internet technologies, new types of mediation appeared, such as providers of electronic stores, electronic payment systems, and the like, which enabled direct sales from the manufacturer to the end customer. A significant advantage for companies is the collection of feedback from customers, related to products and services. Therefore, it is about interactive connections that complement each other in time and are in mutual dependence and coordination during the achievement of the set goals. The development of Internet technologies brings with it another "dark" side, where there are limitations and problems that may appear in electronic commerce. Some of the main issues relate to customer trust when purchasing, security of e-commerce systems, and interoperability between global market participants. Consumers should be educated on how to distinguish between legal and illegal electronic commerce, which is most associated with fraud and misuse of data. Users are greatly helped by the exist-

tence of the BiH Consumer Protection Law. The proposed hypothesis is accepted.

## REFERENCES

- [1] Jakovljević, O. (2016). E-trgovina. Podgorica, Crna Gora.
- [2] Končar, J. (2003). *Elektronska trgovina*. Subotica, Novi Sad: Ekonomski fakultet. Srbija
- [3] K.G. (2024, 04 10). *Mobilni Internet - Korisnici većina u svijetu*. Retrieved from MREŽA: <https://mreza.bug.hr/vijesti/mobilni-internet-korisnici-vecina-u-svijetu-37646>
- [4] Latinović, B. (2007). *Elektronsko poslovanje*. Banja Luka: Panevropski univerzitet "Apeiron", Bosna i Hercegovina
- [5] Lukić, D. (2015). *Elektronska trgovina*. Banja Luka: Panevropski univerzitet Apeiron. Bosna i Hercegovina
- [6] Musić, D. (2017). *Elektronska trgovina*. Banja Luka: Panevropski univerzitet Apeiron. Bosna i Hercegovina
- [7] Nugroho, A., & Wang, W.-T. (2024). Applying Justice Theory to Investigate the Effects of Consumer Complaints and Opportunistic Intention on Brand Reputation and Consumer Repurchase Behavior. *Journal of Electronic Commerce Research (JECR)*. Retrieved from (03.10.24) <http://www.jecr.org/node/701>
- [8] Odsjek za borbu protiv kompjuterskog kriminala, (2023). Oprez prilikom kupovine na internetu. Sarajevo. Bosna i Hercegovina, Retrieved from (03.14.24) <https://www.paragraf.ba/dnevne-vijesti/05042023/05042023-vijest4.html>
- [9] Vidović, A. (2019). *IMPACT OF INTERNET TECHNOLOGY ON TO CONSUMER BEHAVIOUR* (Vol. 8). United Kingdom: International Journal of Sales, Retailing and Marketing.
- [10] Zhu, T., Lu, Y., Wang, B., & Zhao, L. (2023). Pre-purchase and Post-purchase Sales Promotions on E-commerce Platforms: The Effects of Promotional Benefits on Customer-based Brand Equity. *24(2)*, 146.
- [11] Wang, Y., Zheng, Y., & Xu, X. (2023). The Impact of Discrepancies between Offerors Self-Disclosure and Customers' Reviews on Online Sales of Experiences in Sharing Economy. *International Journal of Electronic Commerce*, *27(4)*, 469-499.

Received: April 8, 2024  
Accepted: April 19, 2024

## ABOUT THE AUTHORS



**Ph.D. Aleksandra Vidović** is a Full Professor of College of Modern Management Department at Pan – European University Apeiron Banja Luka, Republic of Srpska/Bosnia and Herzegovina, received a Ph.D. on Science in Economics at Pan – European University Apeiron in 2012. Works as an Editor in Chief at the publisher Pan-European University Apeiron and as the head of the publishing Center Pan European university Apeiron. She published over 50 papers. Her research interests include sales promotion, personal selling, entrepreneurship and management. Editor Journal's - Annual of the Faculty of Law (Pan European University Apeiron) and EMC- Economy and Market Communication Review (Pan European University Apeiron).

## FOR CITATION

Aleksandra Vidović, E-Commerce Management - Exploring User Preferences from the Territory of the Bosnia and Herzegovina, *JITA – Journal of Information Technology and Applications*, Banja Luka, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:23-28, (UDC: 005.96:004.738.5(497.6)), (DOI: 10.7251/JIT2401023V, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# USE OF AI APPLICATIONS IN PROVIDING FREE LEGAL ASSISTANCE TO CITIZENS OF BIH

Admir Agić<sup>1</sup>, Boško Jević<sup>2</sup>

<sup>1</sup>Independent researcher, Tešanj, BH, adi@xnet.ba

<sup>2</sup>Mr.sc.it., Zenica, BH, bosko.jefic@zenica.ba

Preliminary communication

<https://doi.org/10.7251/JIT2401029A>

UDC: 007.52:791.221.8

**Abstract:** This article explores the integration of advanced AI technologies, including Python, Gradio, Langchain and Vector database to develop an innovative AI chatbot for legal assistance in Bosnia and Herzegovina. Leveraging cutting-edge models such as Mixtral8x7B and NVIDIA AI endpoints, the chatbot demonstrates enhanced conversational abilities, real-time recommendations, and efficient processing of Bosnian language inputs. Through meticulous tuning and optimization, the system achieves unparalleled accuracy in capturing semantic relationships and delivers contextually relevant responses. Challenges in language processing, ethical considerations, and privacy concerns are addressed through collaborative efforts and proactive measures. The study highlights the significance of technological advancements in AI for bridging language barriers, promoting social inclusion, and ensuring equitable access to legal assistance.

**Keywords:** Artificial Intelligence Chatbot, Legal Assistance, Bosnia and Herzegovina, Real-time Recommendations, Large Language Models, Vector Database and Embeddings

## INTRODUCTION

Free legal aid in Bosnia and Herzegovina covers legal assistance to citizens who do not have financial resources to pay for legal services. This service is provided by legal aid providers, lawyers, and non-governmental organizations.

Many citizens do not have sufficient financial resources to pay for legal experts, which results in a lack of legal protection for those with lower incomes. Geographic inequality further complicates access to legal services, with rural areas and smaller towns often lacking legal experts or organizations that provide legal aid.

The complexity of the legal system in Bosnia and Herzegovina makes it difficult for the average citizen to understand significantly increasing the need for accessible information and support. The lack of up to date and relevant information on laws and rights further complicates the situation, making it harder for citizens to protect their rights or solve legal problems.

The lack of general legal education also contributes to the problem, as citizens are often not ade-

quately educated about their rights and legal procedures, which can result in unnecessary legal disputes or the loss of rights.

All of these factors together create a need for innovative solutions that will enable citizens to access legal information and support more easily in solving their legal problems. AI applications that offer free legal aid can be key in addressing these challenges allowing citizens to quickly and efficiently find relevant information and legal advice.

The landscape of AI applications in legal assistance has seen substantial growth, focusing primarily on enhancing accessibility and efficiency in legal services. Previous research has emphasized the potential of AI to democratize access to legal information, particularly for underrepresented or economically disadvantaged populations.

Significant contribution by Katz et al. (2018) focused on predictive analytics in legal proceedings, demonstrating how AI could forecast case outcomes based on historical data. [1] Their work illustrated the practical applications of AI in reducing case back-

log and improving decision-making efficiency within the judicial system.

Our study builds on this foundational research by specifically addressing the unique challenges faced in Bosnia and Herzegovina. Our work focuses on developing an AI chatbot tailored to the Bosnian legal context, utilizing advanced AI technologies and vector databases to provide real-time legal assistance.

## METHODS AND MATERIALS

The role of technology in solving legal problems in Bosnia and Herzegovina is crucial in addressing the challenges of accessing legal assistance. Technological solutions indicate a new approach to providing legal support to citizens especially in the context of limited access to traditional legal experts. By applying advanced technologies such as AI (artificial intelligence) and natural language processing, legal applications can provide a fast and efficient way to access legal information.

Technological solutions enable citizens to quickly search for laws, regulations, and legal documents providing them with information about their rights and obligations. The use of AI allows for the automatic tagging of relevant sections of the law, making it easier for citizens to identify key information they need. In addition, advanced natural language processing algorithms allow applications to understand complex user requests and provide personalized responses to their inquiries.

Technological solutions can also improve the efficiency of the legal system, reducing the time needed to resolve legal disputes and processes. Citizens can use applications to research their legal problems and seek advice or information before engaging in legal proceedings. This can result in reduced court workload and faster legal procedures.

Technological solutions have a key role in facilitating access to legal assistance in Bosnia and Herzegovina, providing citizens with a quick and efficient way to access legal information and support. These solutions can improve legal literacy among citizens and contribute to the efficiency of the legal system. The application uses machine learning techniques to improve the accuracy of search and tagging of relevant sections of the law. Through machine learning algorithms, the application can adapt to users' needs and continuously improve its performance based on user feedback.

Natural language processing enables the application to understand and analyze textual data in the user's language. Through NLP techniques, the application can identify key words, phrases, and contextual information in laws and adjust search results to match user queries. The application uses advanced search algorithms to provide relevant results to users according to their queries. These algorithms allow for fast indexing and searching of large quantities of legal documents to identify relevant sections of the law. The application uses an efficient database for storing and managing laws, regulations, and other legal documents. This database enables the application to quickly access information and provides optimized performance in searches.

"Retrieval-augmented generation" (RAG) is a powerful paradigm in natural language processing (NLP) that combines the strengths of retrieval-based methods with generative models. In RAG, a generative model, typically a large pre-trained language model, is augmented with a retrieval component. This retrieval component accesses a large database of relevant documents or passages and retrieves information pertinent to the task at hand.

The key idea behind RAG is to leverage the vast amount of existing knowledge available in text corpora or databases to enhance the generation capability of the model. By incorporating retrieval, the model can access factual information, context, or relevant examples from the database, which can then be used to improve the quality, relevance, and coherence of the generated text. Retrieval-augmented generation (RAG) offers a solution by combining information retrieval with large language models (LLMs) for open-domain question and answering applications.

RAG provides LLMs with vast and up-to-date knowledge, efficiently addressing these limitations. The user interface and the application itself are developed using the Python language [2] and the Gradio development environment [3]. Python is an exceptionally popular programming language in the field of artificial intelligence and machine learning due to its simplicity, flexibility, and rich library of tools and frameworks. Its syntax is clear and understandable, making it easy to learn and use, even for those with little or no prior programming experience.

Additionally, Python has a large and active user and developer community, which means that there



are many resources and documentation available online. In the context of AI and machine learning, Python is an extremely useful and irreplaceable tool. Its simplicity, flexibility, and rich library of tools and frameworks enable quick and efficient development and implementation of intelligent systems. Additionally, Python can be integrated with other technologies and services, enabling the creation of interactive web applications and the implementation of AI and models on large datasets.

Gradio is an open-source framework for creating interactive web applications for artificial intelligence (UI/UX) and machine learning. This tool allows programmers and researchers to easily and quickly create and publish web applications for their models without requiring any knowledge of web technologies. By using Gradio, users can easily integrate their machine learning and artificial intelligence models into interactive web applications. This framework supports various types of inputs and outputs, including text, image, audio, and video files, as well as other formats. It also allows users to customize the appearance and feel of their applications according to their preferences and needs.

Application use Langchain library [4] to establish communication between application on Linux Ubuntu server and NVIDIA endpoints on NVIDIA AI server. Langchain, a cutting-edge natural language processing (NLP) tool, forms the linguistic backbone of our AI system. Built on state-of-the-art language models, Langchain facilitates seamless understanding and processing of textual data across multiple languages. Through advanced tokenization and embedding techniques, Langchain efficiently represents textual content in a dense, semantic space.

Langchain's modular architecture enables integration with diverse NLP tasks, including sentiment analysis, entity recognition, and semantic similarity computation. By leveraging pre-trained language models and fine-tuning on domain-specific data, Langchain achieves high-performance outcomes tailored to our recommendation system's requirements. The versatility of Langchain empowers our AI engine to interpret and respond to user queries and content in a contextually relevant manner.

Through continuous refinement and adaptation, Langchain adapts to evolving linguistic patterns and user interactions, ensuring robust performance in

dynamic environments. Langchain's compatibility with Python facilitates seamless integration into our existing workflow, streamlining development and deployment processes. The inherent scalability of Langchain allows our recommendation system to handle growing volumes of textual data without compromising on performance.

Langchain integration with NVIDIA AI endpoints enables users to utilize the NVIDIA Triton Inference Server for language models. This integration provides fast and reliable processing of language models with minimal latency. Users can integrate Langchain with NVIDIA AI endpoints via API. The integration supports multiple language models, including transformer models. Langchain enables users to leverage NVIDIA GPUs for processing language models. This integration delivers superior performance and accuracy compared to CPU-based solutions. Users can customize the size and performance of GPUs according to their requirements. Langchain and NVIDIA AI endpoints provide a secure and reliable platform for processing language models. This integration allows users to develop and deploy sophisticated language systems. Langchain and NVIDIA AI endpoints are ideal for applications in artificial intelligence, machine learning, and natural language processing.

Firstly we prepared data in txt format and using vector database and Facebook Faiss library [8] we prepare and store data in vector database (pkl format) and search indexes (faiss format) in process of embedding data. A vector database, also known as a vector database management system (VDBMS), is a type of database management system that specializes in storing and retrieving vectors efficiently. In the context of AI and machine learning applications, vectors are numerical representations of data points, often used to represent features extracted from text, images, audio, or other types of data. Process is showed in Figure 1.

Vector databases are designed to handle high-dimensional data efficiently, making them suitable for tasks such as similarity search, clustering, classification, and recommendation. These databases employ specialized indexing structures and algorithms optimized for vector operations, enabling fast retrieval of similar vectors based on distance metrics such as Euclidean distance or cosine similarity.



**Figure 1.** Creation of vector database using embedding model

Pickle is a module in Python that provides a way to serialize and deserialize Python objects into a binary format. The pickle format allows to save Python objects to a file or transmit them over a network, preserving their internal structure and state. The .pkl file extension is commonly used to denote files containing pickled Python objects. Pickle is particularly useful for saving trained machine learning models, custom data structures, or any other complex Python objects that need to be persisted or shared between different Python environments. Using pickle, Python objects can be serialized into a binary stream, which can then be written to a file or transmitted over a network. Later, deserialized binary stream can be used back into Python objects, allowing to restore the objects' state and use it in another Python session or environment.

Facebook's Faiss library is a high-performance library for efficient similarity search and clustering of dense vectors. It is primarily designed to handle large-scale vector databases efficiently, making it well-suited for tasks such as nearest neighbor search, approximate nearest neighbor search, and clustering in high-dimensional spaces. Faiss implements state-of-the-art algorithms for indexing and searching vectors, including both exact and approximate methods. One of its key features is the implementation of the Product Quantization (PQ) method, which allows for efficient compression and quantization of high-dimensional vectors, enabling fast search while minimizing memory usage. Faiss provides a way to save and load indexes to and from disk using its own binary format. This allows users to persistently store precomputed indexes and reuse them across different sessions or environments without the need to recompute them from scratch. Saving and loading indexes in Faiss format is straightforward and can be done using the provided serialization functions in the Faiss library.

We use NVIDIA AI Foundation Models [7] available on NVIDIA NGC online catalog. Utilizing NVIDIA AI Foundation Models from the NVIDIA NGC (NVIDIA GPU Cloud) online catalog represents a strategic deci-

sion to leverage cutting-edge AI technologies and accelerate the development of our AI application. The NVIDIA NGC catalog [6] serves as a centralized repository for GPU-optimized software, including pre-trained AI models, containers, and software development kits (SDKs), curated by NVIDIA and its partners. Availability of pre-trained models on the NGC catalog streamlines the development process by providing a starting point for our AI application, reducing the need for extensive training data and computational resources. This enables us to rapidly prototype, iterate, and deploy AI solutions with minimal overhead, accelerating time-to-market and increasing agility in response to evolving user needs and market demands.

Utilizing the `nvolveqa_40k` language model for generating embeddings (vector representations) developed by NVIDIA represents a strategic choice aimed at leveraging advanced natural language processing capabilities to enhance the functionality and performance of our AI application. The `nvolveqa_40k` language model, developed by NVIDIA, is specifically trained to encode textual inputs into high-dimensional vector representations, capturing semantic and contextual information essential for various NLP tasks. These embeddings enable our AI application to process and analyze textual data more effectively, facilitating tasks such as information retrieval, sentiment analysis, text classification, and more.

One of the key advantages of using the `nvolveqa_40k` language model is its ability to generate embeddings that capture rich semantic information from textual inputs, allowing for more nuanced and accurate representations of language. By leveraging deep learning techniques and large-scale training data, the model learns complex patterns and relationships within text, enabling it to encode subtle nuances of meaning and context into the resulting embeddings.

The `nvolveqa_40k` language model is trained on diverse and extensive datasets, encompassing a wide range of linguistic contexts and domains. This broad coverage ensures that the embeddings generated by the model are robust and generalizable across different applications and use cases, enabling our AI application to perform effectively across various domains and languages.

Utilizing the `Mixtral8x7B` AI model developed by Mixtral represents a significant advancement in our



AI application’s capabilities, particularly in its ability to process and understand Bosnian language inputs effectively. Mixtral, a team of experts interconnected through layers within the model, adopts a unique architecture that facilitates collaborative processing of tokens by selecting pairs of expert groups across different layers. This approach allows for the aggregation of diverse perspectives and insights, leading to more comprehensive and contextually rich representations of textual inputs. User interact with model and vector database is showed in Figure 2.



Figure 2. User interact with model and vector database to get response

The Mixtral model’s ability to communicate in Bosnian language is a testament to its versatility and adaptability across different linguistic contexts. By training the model on Bosnian language data, Mixtral ensures that it captures the intricacies and nuances of the language, enabling it to generate accurate and contextually relevant responses to Bosnian language inputs. This capability is particularly valuable for our AI application, as it enables seamless interaction with users who communicate in Bosnian, enhancing the accessibility and usability of our system. Complete workflow of application and user interaction is showed in Figure 3.

Furthermore, hosting the Mixtral8x7B AI model on the NVIDIA NGC catalog and optimizing it for deployment on the NVIDIA AI platform offers several key benefits. The models undergo rigorous testing and optimization processes to ensure optimal performance and reliability, making them fast and easy to evaluate and integrate into our AI application. Additionally, the seamless integration with the NVIDIA AI platform enables us to leverage NVIDIA’s accelerated stack, including GPUs and other hardware accelerators, to run the models at peak performance, further enhancing the speed and efficiency of our system.

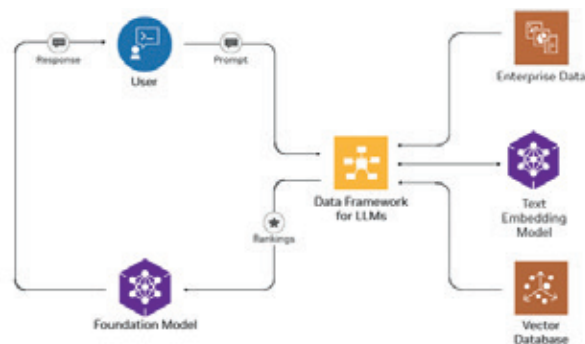


Figure 3. Complete workflow of application and user interaction from user request to LLM response

Availability of the Mixtral8x7B AI model on the NVIDIA NGC catalog underscores NVIDIA’s commitment to advancing AI research and development by providing access to state-of-the-art models and tools. This collaboration between Mixtral and NVIDIA facilitates the democratization of AI technology, empowering developers and organizations to leverage cutting-edge AI capabilities for a wide range of applications and use cases.



Figure 4. Our applied workflow of application and user interaction from user request to LLM response

Our applied workflow of application and user interaction from user request to LLM s showed in Figure 4. The review of the user interface and the search process are crucial elements that affect the user experience and the efficiency of using the application for searching and displaying the laws of Bosnia and Herzegovina.

**RESULTS**

The architecture of the AI chatbot developed for providing free legal assistance to citizens in Bosnia and Herzegovina (BiH) integrates several advanced technologies to ensure efficient, accurate, and user-friendly performance.

Through the integration of Python, Gradio, Lang-chain, and Vector Database, our AI chatbot demonstrates enhanced conversational abilities with seam-

less user interaction. Our AI-powered recommendation system, leveraging Python, Gradio, Langchain, and a vector database, showcases groundbreaking advancements in personalized content delivery. By integrating Faiss index and NVIDIA endpoints for foundational support, our model achieves lightning-fast processing speeds, ensuring real-time recommendations even with large datasets. Leveraging FAISS index, our system achieves efficient and scalable similarity search within large datasets, facilitating rapid retrieval of relevant information.

Through meticulous tuning and optimization, our embedding model demonstrates unparalleled accuracy in capturing nuanced semantic relationships between items. The utilization of NVIDIA endpoints not only accelerates computation but also enhances scalability, enabling seamless deployment across diverse platforms. Our AI chatbot showcases remarkable performance in understanding and generating natural language, thanks to sophisticated language models and embeddings. Use of Bosnian language still can be improved, especially grammar.

The incorporation of Gradio facilitates intuitive user interaction, empowering users to effortlessly fine-tune preferences and explore tailored recommendations. Leveraging Langchain, our AI engine transcends language barriers, offering personalized recommendations in multiple languages with high fidelity. The robustness of our system is underscored by its ability to handle diverse content types, ranging from text to multimedia, with equal proficiency.

By harnessing the power of vector databases, we ensure efficient storage and retrieval of embeddings, optimizing resource utilization and enabling rapid scaling. The Faiss index integration further bolsters our system's efficiency, enabling sublinear search complexity and enabling near-instantaneous retrieval of relevant recommendations.

By harnessing the power of deep learning, our system exhibits continuous improvement in comprehension and response quality over time. The seamless integration of various technologies allows for easy deployment and customization of the AI chatbot to suit diverse applications and environments. Through rigorous testing and evaluation, our solution demonstrates robustness and reliability, consistently delivering accurate and contextually relevant responses. The incorporation of Gradio ensures a user-friendly

interface, enabling effortless interaction with the AI chatbot across different devices and platforms.

Utilizing vector databases for storage and retrieval enhances the scalability and performance of our system, accommodating growing volumes of data with minimal latency. Overall, our AI chatbot represents a cutting-edge solution that harnesses the latest advancements in AI, NLP, and computational techniques to deliver a seamless and intelligent conversational experience.

The validation of the chatbot's feasibility and effectiveness was demonstrated through several key performance indicators: conversational abilities, real-time recommendations, semantic accuracy, scalability and performance. The integration of Python, Gradio, Langchain and the vector database has significantly enhanced the chatbot's conversational abilities, enabling it to handle complex legal queries and provide accurate responses. By leveraging the FAISS index and NVIDIA endpoints, the chatbot achieves lightning-fast processing speeds, ensuring real-time recommendations even with large datasets. Through meticulous tuning and optimization, the embedding model demonstrates unparalleled accuracy in capturing nuanced semantic relationships, which is crucial for understanding legal contexts and providing relevant advice. The use of NVIDIA's accelerated stack, including GPUs, ensures the models run at peak performance, enhancing the system's scalability and speed. This allows for seamless deployment across diverse platforms, catering to a wide range of users.

The chatbot's ability to process and generate natural language responses in bosnian language, while handling diverse content types, underscores its robustness and utility in providing accessible legal assistance. However, continuous improvements, especially in grammar handling, are necessary to further enhance its effectiveness.

## DISCUSSION

Incorporation of machine translation capabilities presents both opportunities and challenges in bridging language barriers and facilitating cross-lingual communication for Bosnian speakers. While machine translation systems offer the potential to facilitate access to information and services in diverse languages, their effectiveness in accurately capturing the nuances of Bosnian semantics and syntax remains a subject

of ongoing research. Ensuring the fidelity and fluency of translated text while preserving the cultural and linguistic context of the original content is paramount for achieving meaningful communication and user satisfaction.

Furthermore, the ethical considerations surrounding language processing and generation in the Bosnian context warrant careful attention to issues such as bias, fairness, and inclusivity. Language models trained on biased or unrepresentative datasets risk perpetuating stereotypes, marginalizing certain demographic groups, and amplifying social inequalities. Therefore, proactive measures, such as bias detection and mitigation techniques, diverse dataset collection, and inclusive model evaluation criteria, are imperative for fostering equitable and socially responsible AI systems that uphold the principles of diversity and inclusivity in language representation and usage.

The correct utilization of the Bosnian language within our AI application presents several notable challenges and considerations. Bosnian, as one of the South Slavic languages, possesses unique linguistic characteristics that demand careful handling to ensure accurate comprehension and generation of text by our system. One of the primary challenges lies in the morphological complexity of Bosnian, characterized by intricate inflectional patterns and rich morphology, which significantly impact natural language processing tasks such as tokenization, stemming, and lemmatization.

Addressing these challenges necessitates a concerted effort to curate comprehensive language resources, refine linguistic processing pipelines, and continually update and adapt our AI models to evolving language norms and usage patterns in the Bosnian-speaking context. Collaborative initiatives involving linguists, computational linguists, and native speakers are crucial for overcoming these hurdles and advancing the state-of-the-art in natural language understanding and generation for the Bosnian language. Through persistent research and innovation, we strive to enhance the linguistic capabilities of our AI application and deliver a more accurate, nuanced, and culturally sensitive conversational experience for users.

Beyond addressing the linguistic complexities of the Bosnian language, our AI application also confronts challenges related to privacy, data security, and user trust. As our system interacts with users and pro-

cesses their queries and inputs, safeguarding sensitive information and ensuring data confidentiality are paramount. Implementing robust encryption protocols, access controls, and data anonymization techniques helps mitigate the risk of unauthorized access or data breaches, fostering user confidence in the privacy and security of their interactions with the AI system.

## CONCLUSION

The scalability and deployment considerations of our AI application extend beyond technical architecture to encompass economic, environmental, and societal impacts. Optimizing resource utilization, minimizing energy consumption, and reducing carbon footprint are essential considerations in designing sustainable and environmentally conscious AI systems. Additionally, fostering equitable access to AI technologies and addressing digital divide issues are imperative for promoting social inclusion and bridging socioeconomic disparities. By adopting a holistic approach that balances technological innovation with ethical, environmental, and societal considerations, we strive to develop AI solutions that contribute to positive societal outcomes and sustainable development goals.

The chatbot leverages models like Mixtral8x7B and NVIDIA AI endpoints, specifically optimized for the Bosnian language. This focus on linguistic nuances ensures that the AI system can accurately understand and respond to legal queries in Bosnian, addressing a critical gap in existing research which often overlooks less widely spoken languages.

The integration of Gradio enhances user interaction by providing an intuitive interface for users to fine-tune their preferences and receive personalized legal advice. This user-centric approach is pivotal in ensuring the system's accessibility and ease of use, particularly for individuals with limited legal knowledge.

## ACKNOWLEDGEMENTS

We would like to extend our sincere appreciation to all those who have contributed to the development and realization of this AI application.

First and foremost, we express our gratitude to Ivan Joković for his unwavering support and encouragement throughout the course of this project. His invaluable insights, guidance, and resources have been instrumental in shaping the direction and vision of our work.

We are deeply thankful to the Mustafa Deljkić, Ana Jozić Agić and company IUD Kolektiv for providing access to computational resources and infrastructure essential for the development and deployment of our AI models. Their technical expertise and collaborative spirit have been indispensable in overcoming various technical challenges and optimizing the performance of our system.

We extend our heartfelt thanks to Zoran Blažević and Alem Bradarić for their generous contribution of linguistic resources, datasets, and exper-

tise, which have greatly enriched the linguistic capabilities and accuracy of our AI application, especially in handling the nuances of the Bosnian language.

Our appreciation also goes to the dedicated team of developers, researchers, and engineers who have worked tirelessly to design, implement, and refine the AI algorithms, interfaces, and functionalities. Their creativity, perseverance, and collaborative efforts have been essential in achieving the milestones and outcomes outlined in this article.

We are grateful to the users and testers who have provided valuable feedback, suggestions, and insights that have informed the iterative development and improvement of our AI application. Their engagement and input have been instrumental in shaping the user experience and usability of our system.

Last but not least, we would like to thank our families, friends, and colleagues for their unwavering support, understanding, and encouragement throughout this journey. Their patience, encouragement, and belief in our work have been a constant source of motivation and inspiration.

## REFERENCES

- [1] Katz, D. M., Bommarito II, M. J., & Blackman, J. (2018). *Legal Analytics: The State of the Art*. Cambridge University Press.
- [2] Python Software Foundation, "Python programming language," Python Software Foundation. [Online]. Available: <https://www.python.org>. [Accessed: February 11, 2024].
- [3] Gradio, "Gradio AI framework," Gradio. [Online]. Available: <https://www.gradio.app>. [Accessed: February 11, 2024].
- [4] Langchain, "Langchain framework," Langchain. [Online]. Available: [https://python.langchain.com/docs/get\\_started/introduction](https://python.langchain.com/docs/get_started/introduction). [Accessed: February 11, 2024].
- [5] Langchain, "Nvidia AI endpoints," Langchain. [Online]. Available: [https://python.langchain.com/docs/integrations/chat/nvidia\\_ai\\_endpoints/](https://python.langchain.com/docs/integrations/chat/nvidia_ai_endpoints/). [Accessed: February 11, 2024].
- [6] NVIDIA, "Nvidia NGC Catalog: GPU-optimized AI, Machine Learning, & HPC Software," NVIDIA. [Online]. Available: <https://catalog.ngc.nvidia.com/>. [Accessed: February 11, 2024].
- [7] NVIDIA, "NVIDIA AI Foundation Models and Endpoints," NVIDIA. [Online]. Available: <https://www.nvidia.com/en-us/deep-learning-ai/solutions/ai-foundation/>. [Accessed: February 11, 2024].
- [8] Facebook AI Research, "Faiss: A library for efficient similarity search," Meta. [Online]. Available: <https://engineering.fb.com/ai-research/faiss-a-library-for-efficient-similarity-search/>. [Accessed: February 11, 2024].

Received: April 30, 2024

Accepted: May 18, 2024

## ABOUT THE AUTHORS



**Admir Agić** is an accomplished IT professional with over 19 years of experience in software development, network administration, and IT services; as the co-founder of Kolektiv EU, he specializes in providing tailored IT solutions, with expertise in web development and network management, while his proven track record includes developing

and implementing custom software solutions across diverse industries, alongside excelling in customer relationship management and negotiation to drive business growth, and he is also an independent teacher, emphasizing STEM education in robotic engineering; holding a B.Sc. in Mechanical Engineering and Cisco CCNA certified engineer, he has further enhanced his skills through education in network management, and his proficiency extends to AI development, machine learning algorithms, natural language processing, and generative AI models, showcasing collaborative efforts with diverse teams to deploy intricate AI systems, with his expertise in AI model training methodologies and rigorous research underscoring his value in enhancing AI system performance.



**Boško Jević** is a highly accomplished IT professional with a strong academic and professional background. He is currently in the final year of his doctoral studies at the University of Vitez, where he has demonstrated his dedication to advancing his knowledge and expertise in the field of information technologies. Boško holds a Bachelor's degree from the

University of East Sarajevo, where he graduated from the Faculty of Traffic and Transport Engineering. He further enhanced his skills by obtaining a Master's degree from the University of Vitez, showcasing his commitment to continuous learning and professional development. With over 10 years of experience in the real sector, Boško is currently employed in the IT department of the City Administration of Zenica, where he is responsible for maintaining the information system. His expertise and dedication have been recognized, as he was appointed to the position of Senior Assistant in 2017, within the scientific field of Computer Science. Boško's academic contributions are equally impressive. He has authored numerous scientific and professional papers, which have been published in various journals and conference proceedings, demonstrating his ability to conduct rigorous research and share his findings with the broader academic community. Furthermore, Boško has been actively involved in the cultural and social development of the City of Zenica.

## FOR CITATION

Admir Agić, Boško Jević, Use of AI applications in providing free legal assistance to citizens of BiH, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:29-36, (UDC: 007.52:791.221.8), (DOI: 10.7251/JIT2401029A, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004



# DIGITAL IDENTIFICATION FROM SMART CARD TO DIGITAL WALLET –EU LEGAL FRAMEWORK AND SITUATION IN BOSNIA AND HERZEGOVINA

**Siniša Macan**

*Ministry of Interior of Republic of Srpska, BiH - sinisa.macan@mup.vladars.rs*

**Review paper**

<https://doi.org/10.7251/JIT2401037M>

UDC: 005.591.6:330.341(497.6)

**Abstract:** Information technologies and the entirely new digital world are experiencing significant development in the second and third decades of the twenty-first century. This development has led to the need to realize the concept of legal regulation of cyberspace, especially in the segment of digital identification. Digital identification is necessary to ensure security as well as the protection of personal data. Additionally, digital identification must guarantee the reliability and trust of signatories in the technologies used. The regulations adopted in previous years implied the existence of a PKI infrastructure and the storage of the private key by the signatory. However, the development of technologies and the widespread use of mobile and smart devices have generated the need for remote signing, cloud-based signing, and the creation of digital wallet techniques. It is precisely in this segment that the regulations have been amended. The paper presents EU regulations in this area and the situation in Bosnia and Herzegovina. It is particularly emphasized that the use of reliable legally grounded digital identification has not yet begun to be implemented in Bosnia and Herzegovina, and that it is necessary to establish practices and systems based on legal regulations that are aligned with the EU, as well as with the legal framework in Bosnia and Herzegovina.

**Keywords:** Digital identity, eID, digital wallet, eIDAS, eIDAS 2.0

## INTRODUCTION

The real world and the digital world are closely integrated in the 21st century. The widespread use of digital devices, along with technological advancements, has completely blurred the boundaries between the physical, or real world on one side, and the digital world on the other. A vast number of human social activities, as well as trade, exchange of goods and services, and capital, have gained a completely new dimension with the development of information and communication technologies. Today, we don't just talk about technologies, but about an entirely new, information society. A society that operates in the real world and what is called cyberspace. In the last decade, the volume of retail through electronic commerce has increased by 3.2 times. The global volume of e-commerce in 2014 amounted to 1,336 billion US dollars, while in 2020 it increased to 4,280 billion US dollars, with a projected growth trend until 2023 to approximately 5,900 billion dollars. At the same time, statistics show that there are around 4.5 billion inter-

net users worldwide, while approximately 3.8 billion people use social networks[1].

The cause of this state and these indicators are digital technologies that play a key role in almost every aspect of human life. Smartphones, portable devices, smart homes and vehicles, and a large number of other digital innovations have transformed the way people communicate, work, travel, shop, and even the way people socialize and engage in social interactions. The business world uses digital platforms for marketing, sales, and customer engagement, while industries such as healthcare, finance, and education embrace digital solutions to improve efficiency, accessibility, and the quality of services.

In the real, or physical world, rules of behavior have been introduced through the legal system and regulatory framework, as well as through moral and other societal norms. Data related to commodity exchange, as well as the number of Internet and social media users, unequivocally generate the need for appropriate attempts at regulation in cyberspace. This need is par-



ticularly pronounced in the adequate identification of individuals present in cyberspace, i.e., in the domain of establishing identity and access to the global network when conducting various types of transactions.

It is extremely important to establish a clear relationship between the real identity and the identity that an individual present in cyberspace when conducting electronic business, as well as when participating in global networks or various digital transactions. This type of identity is called digital identity.

Digital services that promote electronic business and commerce are one of the priorities of the European Union. Legislation related to digital identities, information security, and personal data protection is being significantly transformed in the European Union. The development of legislation is based on scientific and technological development, which is one of the foundations of the Treaty on the Functioning of the European Union.

In cyberspace, computer systems, mobile systems, a large number of sensors collecting data for so-called “smart systems,” and large amounts of data are processed using artificial intelligence. “Cyberspace is a non-physical space where, according to current applicable legislation, there are no national borders and new rules are established based on the technical capabilities of computer systems.” [2] “Cyberspace is a new type of space consisting of the Internet, World Wide Web,, i.e., basic infrastructure and information about the Internet and WWW, after the known and traditional four types of space: land, sea (ocean), airspace (atmospheric space, or internal space), and space. Cyberspace is actually the fifth space in which modern man lives, works, plays, and does business.” [3]. Within cyberspace, and especially when conducting digital transactions that require reliability and security, mechanisms for verifying the identity of individuals must be provided.

Since 1999, when the first directive dealing with digital signatures was adopted, systems for digital identification have been established and used in member states, with problems of consistency and interoperability of systems arising between member states. The reform of regulations continued when Regulation (EU) No 910/2014 on electronic identification and trust services for electronic transactions in the internal market (eIDAS) was adopted in 2014. Regulation eIDAS primarily established a legal ba-

sis for the establishment of an electronic identification and trust services system that would be unified and recognized equally in all European Union member states. Procedures were defined to ensure that through the accreditation process, the goal of ensuring that each trust service provider or certification body meets technical requirements in accordance with standards and recommendations is achieved. The accreditation process is carried out in a unified manner, guaranteeing uniform conditions throughout the territory of the European Union. Regulation 910/14 defines specific security levels, based on which the legal force of the electronic identification trust service, i.e., digital signature, is determined.

The development and widespread use of digital devices have led to the need for more precise definition of conditions for server signing, as well as for the use of digital means of identification, so Regulation (EU) 2024/1183 of the European Parliament and of the Council of 11 April 2024 amending Regulation (EU) No 910/2014 as regards establishing the European Digital Identity Framework, or eIDAS 2 regulation, was adopted in 2024. This regulation establishes an electronic wallet system, which enables the establishment of electronic documents in the electronic wallet in a reliable manner using trusted cryptographic mechanisms known only to the wallet owner. In addition, eIDAS regulation was related with Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive).

The Republic of Srpska, as well as Bosnia and Herzegovina, are in the process of integration with the European Union. The Stabilization and Association Agreement between the European Union, or its member states, on one side, and Bosnia and Herzegovina, on the other side, was signed in Luxembourg on June 16, 2008. The agreement entered into force on June 1, 2015. The Stabilization and Association Agreement is legally binding in Bosnia and Herzegovina and in the Republic of Srpska, so there is an obligation to harmonize regulations in BiH with the regulations of the European Union. The Republic of Srpska, as well as Bosnia and Herzegovina, have a legal obligation to harmonize their legislation with the legislation of the

European Union. This paper discusses the eIDAS and eIDAS 2 regulations, and presents the situation in the Republic of Srpska.

## DIGITAL IDENTITY, GENERALY

Digital identification, or digital ID, is the process of electronically verifying and authenticating the identity of individuals or entities in transactions and interactions that take place in cyberspace. In today's world, digital identification plays a crucial role in facilitating a wide range of online activities, including accessing digital services, conducting e-commerce, as well as participating in social networks and interacting with public administration.

As stated in the introductory chapter, digital identification systems are increasingly subject to legal regulation. They typically involve the use of unique identifiers, such as usernames, email addresses, or identification numbers, along with authentication mechanisms to verify the identity of users. These mechanisms can include passwords, Personal Identification Numbers - PINs, biometric data (such as fingerprints or facial recognition), cryptographic keys, or two-factor authentication (2FA), among others.

One of the key advantages of digital identification is its convenience and accessibility. Unlike traditional forms of identification, such as physical ID cards or passports, digital IDs can be easily accessed and used from any internet-enabled device, providing users with greater flexibility and mobility in their online interactions. This convenience is particularly important in situations where quick and secure access to digital services is essential, such as online banking, e-government services, or remote work environments.

Additionally, digital identification offers enhanced security and fraud prevention capabilities compared to traditional forms of identification. Advanced authentication methods, such as biometric authentication or cryptographic keys, can significantly reduce the risk of identity theft, phishing attacks, and unauthorized access to sensitive information. Furthermore, digital identification systems often incorporate encryption and other security measures to protect user data and privacy.

Digital identification also enables seamless and secure transactions and interactions across borders. In an increasingly globalized world, where individuals and companies routinely engage in international

activities, the ability to verify identities in different jurisdictions is essential. Digital identification systems that adhere to international standards and interoperability protocols can facilitate cross-border trust and enable smooth international transactions.

Moreover, digital identification has the potential to promote financial inclusion and empower marginalized populations. In many parts of the world, a significant portion of the population lacks access to formal identification documents, which can hinder their ability to access financial services, healthcare, education, and other essential resources. Digital identification systems, especially those based on mobile technologies, offer a cost-effective and scalable solution to address this issue by providing individuals with a secure and verifiable means of identification.

However, despite its numerous advantages, digital identification also raises significant concerns regarding privacy, data security, and digital rights. One of the main concerns is the potential for misuse or improper use of personal data collected through digital identification systems. Inadequate safeguards and weak data protection measures can expose individuals to privacy violations, surveillance, identity theft, and other forms of abuse.

Furthermore, the centralized nature of many digital identification systems raises concerns about data security and the risk of single points of failure. Centralized databases containing sensitive personal information are attractive targets for hackers and cybercriminals, who may exploit vulnerabilities in the system to gain unauthorized access to user data. Additionally, the proliferation of digital identification systems raises questions about the concentration of power and control in the hands of governments or private entities that operate these systems.

Another challenge associated with digital identification is the issue of the digital divide and unequal access to technology. While digital identification has the potential to empower individuals and enhance their participation in the digital economy, disparities in access to technology, internet connectivity, and digital literacy can exacerbate existing inequalities and marginalize disadvantaged populations. Efforts to promote digital inclusion and bridge the digital divide are crucial to ensure that all individuals have equal opportunities to benefit from digital identification.

In response to these challenges, policymakers,

technologists, and civil society organizations are exploring ways to design and implement digital identification systems that prioritize privacy, security, and user empowerment. Principles such as privacy by design, data minimization, user consent, transparency, and accountability are increasingly being integrated into the design and governance of digital identification systems to mitigate risks and protect user rights.

Moreover, decentralized identity technologies, such as self-sovereign identity (SSI) systems based on blockchain or distributed ledger technology (DLT), offer promising alternatives to centralized digital identification systems. By giving individuals greater control over their personal data and reducing reliance on intermediaries, decentralized identity solutions can enhance privacy, security, and user autonomy in digital interactions.

In conclusion, digital identification is a key enabler of the digital economy and society, offering numerous benefits in terms of convenience, security, and inclusivity. However, realizing the full potential of digital identification requires addressing significant challenges related to privacy, security, and digital rights. By adopting principles of privacy, security, and user empowerment, as well as leveraging emerging technologies such as decentralized identity, stakeholders can create digital identification systems that are secure, reliable, and respectful of individual rights and freedoms.

## EU REGULATION

eIDAS Regulation (Regulation (EU) No 910/2014) is a fundamental piece of legislation in the European Union (EU) that aims to establish a framework for electronic identification and trust services for electronic transactions in the internal market. The regulation provides a legal foundation for secure and seamless electronic interactions between businesses, citizens, and public authorities across EU member states.

The eIDAS Regulation, which stands for “electronic Identification, Authentication, and trust Services,” is a significant piece of legislation in the European Union (EU) aimed at facilitating secure and seamless electronic transactions across member states. Enacted in 2014, eIDAS replaced the previous Electronic Signature Directive (1999/93/EC) and established a comprehensive legal framework for electronic identification and trust services within the EU. This article provides a detailed examination of the eIDAS Regulation, its objec-

tives, key provisions, implementation challenges, and the implications for businesses and individuals.

The primary objectives of the eIDAS Regulation are to enhance trust and security in electronic transactions, promote the use of electronic identification (eID) and electronic signatures, and facilitate cross-border recognition of electronic trust services within the EU. By establishing uniform standards and legal requirements for electronic identification and trust services, eIDAS aims to create a digital single market where businesses and citizens can engage in electronic transactions with confidence and convenience.

## Key Provisions of eIDAS

**Electronic Identification (eID):** eIDAS defines electronic identification as the process of uniquely identifying individuals or legal entities in electronic transactions. Member states are required to establish and maintain electronic identification schemes that meet specified criteria, including security, reliability, and interoperability. Qualified electronic identification (QeID) schemes, which comply with additional requirements, are granted a higher level of legal recognition across the EU.

**Electronic Signatures:** eIDAS recognizes various types of electronic signatures, including simple electronic signatures, advanced electronic signatures (AdES), and qualified electronic signatures (QES). AdES and QES are subject to specific requirements regarding authenticity, integrity, and non-repudiation. QES, in particular, provides the highest level of legal certainty and is equivalent to a handwritten signature under EU law.

**Trust Services:** eIDAS establishes a framework for electronic trust services, such as electronic seals, electronic time stamps, electronic registered delivery services (ERDS), and website authentication certificates. Trust service providers (TSPs) must adhere to strict requirements concerning security, liability, and transparency. Qualified trust service providers (QTSPs) undergo a rigorous certification process to ensure compliance with eIDAS standards.

**Cross-Border Recognition:** One of the key objectives of eIDAS is to enable seamless cross-border recognition of electronic identification and trust services within the EU. Member states are required to recognize electronic signatures, electronic seals, electronic documents, and other trust services issued

by qualified providers in other EU countries. This facilitates the expansion of digital business activities across borders and reduces administrative barriers for citizens and businesses operating in the EU.

### Implementation Challenges

While eIDAS represents a significant step towards harmonizing electronic identification and trust services across the EU, its implementation has posed several challenges for member states and stakeholders. Some of the key challenges include:

**Technical interoperability:** Ensuring seamless interoperability between different national eID schemes and trust service infrastructures remains a complex task, requiring standardization and compatibility efforts.

**Legal harmonization:** Achieving uniform interpretation and application of eIDAS provisions across member states' legal systems requires ongoing coordination and cooperation among national authorities and judicial bodies.

**User acceptance:** Encouraging widespread adoption of electronic identification and trust services among citizens, businesses, and public administrations requires awareness-raising campaigns, user-friendly interfaces, and effective communication strategies.

**Security and privacy concerns:** Addressing concerns related to data security, privacy protection, and cybersecurity threats is essential to maintaining trust in electronic transactions and preventing fraud or misuse of electronic identities and signatures.

### Implications for Businesses and Individuals

The eIDAS Regulation has significant implications for businesses, governments, and individuals operating within the EU. For businesses, eIDAS offers opportunities to streamline administrative processes, reduce costs, and expand market reach by leveraging electronic identification and trust services. Qualified trust service providers can offer innovative solutions for electronic authentication, document signing, and secure communication, enhancing business efficiency and competitiveness. For individuals, eIDAS provides greater convenience and accessibility in accessing digital services, conducting online transactions, and interacting with public authorities across borders. By enabling secure and reliable electronic identification

and signature solutions, eIDAS empowers citizens to participate more actively in the digital economy and exercise their rights in a digitalized society.

The eIDAS Regulation represents a significant milestone in the development of a harmonized legal framework for electronic identification and trust services within the European Union. By establishing common standards, promoting interoperability, and fostering trust in electronic transactions, eIDAS aims to facilitate the digital transformation of businesses and public services, enhance cross-border cooperation, and empower citizens in the digital age. While challenges remain in terms of technical implementation, legal harmonization, and user acceptance, eIDAS lays the foundation for a more secure, efficient, and inclusive digital single market in Europe

### eIDAS 2

In recent years, there have been discussions and proposals for an updated version of the eIDAS regulation, often referred to as "eIDAS 2." While eIDAS has laid a solid groundwork for electronic identification and trust services, technological advancements, evolving digital needs, and emerging security threats have prompted calls for revisions and enhancements to ensure the regulation remains relevant and effective in the rapidly changing digital landscape.

eIDAS 2 is envisioned as a comprehensive update to the existing regulation, aiming to address existing shortcomings, incorporate new technological developments, and strengthen the trust framework for electronic transactions. The proposed amendments and additions under eIDAS 2 are expected to shape the future of digital identity management and electronic trust services within the EU.

One of the key aspects of eIDAS 2 is the expansion of the scope of the regulation to cover a broader range of electronic services and transactions. This includes provisions for electronic signatures, electronic seals, electronic time stamps, electronic documents, electronic registered delivery services, website authentication, and electronic identification (eID) schemes. By encompassing a wider array of digital services, eIDAS 2 seeks to facilitate greater interoperability and cross-border acceptance of electronic transactions within the EU.

Furthermore, eIDAS 2 aims to address interoperability challenges that hinder seamless cross-border



recognition of electronic identities and trust services. Interoperability is crucial for enabling citizens and businesses to use their electronic identities and trust services across different member states without encountering unnecessary barriers. To achieve this goal, eIDAS 2 may introduce standardized protocols, technical specifications, and interoperability frameworks to ensure compatibility and harmonization of electronic identification systems and trust services across the EU.

Additionally, eIDAS 2 is expected to place a stronger emphasis on security and privacy aspects of electronic identification and trust services. With the increasing prevalence of cyber threats and data breaches, ensuring the confidentiality, integrity, and authenticity of electronic transactions is paramount. eIDAS 2 may introduce stricter security requirements, robust authentication mechanisms, encryption standards, and data protection measures to enhance the overall trustworthiness and resilience of electronic systems and services.

Moreover, eIDAS 2 may introduce provisions to foster innovation and adoption of emerging technologies in the field of electronic identification and trust services. This includes support for technologies such as blockchain, biometrics, artificial intelligence, and machine learning, which have the potential to revolutionize the way electronic identities are managed and verified. By embracing innovation, eIDAS 2 aims to future-proof the regulation and ensure its relevance in the rapidly evolving digital landscape.

Another key aspect of eIDAS 2 is the reinforcement of legal certainty and cross-border recognition of electronic signatures and other trust services. Cross-border recognition is essential for promoting cross-border trade, e-commerce, and digital collaboration within the EU. eIDAS 2 may introduce mechanisms to streamline the mutual recognition of electronic signatures and trust services across member states, thereby reducing administrative burdens and legal uncertainties associated with cross-border electronic transactions.

Furthermore, eIDAS 2 may introduce provisions to strengthen consumer protection and user rights in the context of electronic identification and trust services. This includes transparency requirements, user consent mechanisms, recourse mechanisms, and liability frameworks to ensure that consumers are adequately informed and empowered when us-

ing electronic services. By safeguarding consumer rights, eIDAS 2 aims to build trust and confidence in electronic transactions and foster greater uptake of digital services among citizens and businesses.

In conclusion, eIDAS 2 represents a significant milestone in the ongoing evolution of electronic identification and trust services within the EU. By addressing key challenges, embracing technological innovation, and strengthening the legal and technical framework for electronic transactions, eIDAS 2 aims to facilitate secure, seamless, and trusted electronic interactions across member states. As digitalization continues to reshape the economy and society, eIDAS 2 is poised to play a central role in unlocking the full potential of the digital single market and driving Europe's digital transformation agenda forward.

### Personal data protection

In the digital landscape, two fundamental regulations play a pivotal role in shaping the way data is handled and identities are verified: the General Data Protection Regulation (GDPR) and the Electronic Identification, Authentication and Trust Services Regulation (eIDAS). While they serve distinct purposes, these regulations are closely intertwined, working together to safeguard individuals' privacy, ensure data security, and foster trust in digital interactions.

The General Data Protection Regulation (GDPR), implemented in May 2018, is a comprehensive data protection framework applicable to all entities processing personal data of individuals residing in the European Union (EU). It aims to harmonize data protection laws across EU member states, empower individuals with greater control over their personal data, and establish accountability and transparency requirements for organizations handling such data.

Key principles of GDPR include:

- Lawfulness, Fairness, and Transparency: Data processing must be lawful, fair, and transparent to the data subjects.
- Purpose Limitation: Personal data must be collected for specified, explicit, and legitimate purposes and not further processed in a manner incompatible with those purposes.
- Data Minimization: Data controllers must ensure that personal data processed is adequate, relevant, and limited to what is necessary.
- Accuracy: Personal data must be accurate and,



where necessary, kept up to date.

- Storage Limitation: Personal data must be kept in a form that permits identification of data subjects for no longer than is necessary.
- Integrity and Confidentiality: Personal data must be processed in a manner that ensures appropriate security, including protection against unauthorized or unlawful processing and accidental loss, destruction, or damage.

Non-compliance with GDPR can result in severe penalties, including fines of up to €20 million or 4% of the annual global turnover, whichever is higher.

While GDPR focuses primarily on data protection and privacy, and eIDAS centers on electronic identification and trust services, the two regulations intersect in several areas:

- Data Protection in eIDAS Transactions: eIDAS mandates that trust service providers adhere to stringent security measures to protect personal data processed during electronic transactions. These security requirements align closely with GDPR's principles of data protection by design and default.
- Legal Validity of Electronic Signatures: eIDAS establishes a legal framework for electronic signatures, including qualified electronic signatures, which hold the same legal validity as handwritten signatures. GDPR recognizes the use of electronic signatures for obtaining consent and executing contracts, provided they meet the criteria outlined in eIDAS.
- Authentication and Authorization: Both regulations emphasize the importance of ensuring secure authentication and authorization mechanisms to protect individuals' personal data. eIDAS provides the framework for electronic identification, while GDPR sets forth requirements for obtaining explicit consent and implementing appropriate security measures.
- Cross-border Data Transfers: eIDAS facilitates cross-border recognition of electronic identification and trust services, enabling seamless digital interactions between EU member states. GDPR's provisions on international data transfers apply to personal data exchanged during such transactions, ensuring that data protection standards are upheld regardless of geographical boundaries.

In today's digital era, the harmonious implementation of GDPR and eIDAS as well as eIDAS 2.0 is crucial for fostering trust, ensuring data protection, and facilitating secure electronic transactions within the EU. By adhering to the principles outlined in both regulations and leveraging the synergies between them, organizations can navigate the complexities of digital identity management while safeguarding individuals' privacy rights and promoting digital innovation and growth.

## LEGAL FRAMEWORK IN BOSNIA AND HERZEGOVINA

The legislation of Bosnia and Herzegovina, although incompetent for the area of digital signatures and certificates, adopted the Law on Electronic Signature of Bosnia and Herzegovina in 2006 ("Official Gazette of BiH" No. 91/06). The Law on Electronic Signature of Bosnia and Herzegovina is harmonized with Directive 1999/93/EC on a Community framework for electronic signatures. The BiH Law is not harmonized with Regulation No. 910/14 on electronic identification and trust services for electronic transactions on the internal market (hereinafter: eIDAS).

The BiH Law is in force and fully applied with unfavorable solutions for Republika Srpska. According to this law, the Office for Supervision and Accreditation of Certifiers has been established within the Ministry of Communications and Transport, which fully performs its function in accordance with this Law. The accreditation procedure is conducted, and a Register of Certifiers is maintained, which currently includes three legal entities (Halcom D.D. Ljubljana, registered on October 3, 2019, the Indirect Taxation Authority based in Banja Luka, registered on May 12, 2021, and the Agency for Identification Documents, Records, and Data Exchange of Bosnia and Herzegovina, based in Banja Luka, registered on April 15, 2022). The Ministry of Communications and Transport of Bosnia and Herzegovina is recognized as the Supervisory Authority on behalf of Bosnia and Herzegovina in the Forum of European Supervisory Authorities for Trust Service Providers (FESA), as well as competent to maintain the list of trust service providers. Trust service providers and digital identity providers registered in the registers maintained by the Supervisory Authority of BiH are visible beyond the borders of Bosnia and Herzegovina, i.e., on the EU market.

In the parliamentary procedure at the BiH level, there was a proposal for the Law on Electronic Ident-

tification and Trust Services for Electronic Transactions of Bosnia and Herzegovina No. 01.02-02-1-667/19, dated March 26, 2019, which was rejected. It is undeniable that the issue of digital identification needs to be regulated, but solely in accordance with constitutional competencies.

At the level of the Federation of Bosnia and Herzegovina, a regulation on electronic signatures has not been adopted, but the Law on Electronic Document ("Official Gazette of FBiH" 55/13) has been adopted.

### LEGAL FRAMEWORK IN REPUBLIC OF SRPSKA

The area of digital identification and the application of digital identities in Republika Srpska is regulated by the following legal regulations:

- Law on Electronic Signature of Republika Srpska ("Official Gazette of Republika Srpska", No. 106/15 and 83/19), with corresponding subordinate regulations.
- Law on Electronic Document ("Official Gazette of Republika Srpska", No. 106/15).
- Law on Electronic Business of Republika Srpska ("Official Gazette of Republika Srpska", No. 59/09 and 33/16).
- Law on the Agency for Information and Communication Technologies ("Official Gazette of Republika Srpska" No. 102/23).

According to the above, the legal framework in Republika Srpska enables the immediate use of trust services of digital identification, defines schemes of digital identification, and allows legal entities, especially the business community, to use current qualified or unqualified digital certificates. E-government, as a significant actor in overall electronic business, can currently provide trust services according to identification schemes.

Key procedures related to trust services are:

- Procedure for prescribing conditions for the operation of CA bodies.
- Accreditation procedure and compliance verification of CA bodies.
- Maintenance of the CA body register, which is publicly available.
- Supervision procedure over the work of CA bodies.

Establishment of identification schemes and registers of service providers of various identification schemes.

In Republika Srpska, the Regulation on Special

Conditions that CA bodies must meet ("Official Gazette of Republika Srpska" No. 78/16 and 108/19) prescribes the conditions that CA bodies must meet.

The accreditation procedure in Republika Srpska is regulated according to Article 22 of the Law on Digital Signature, which allows any legal entity intending to issue qualified digital certificates to carry out this activity based on a permit from the relevant ministry. A request for a permit to operate as a certification body is submitted to the Ministry of Administration and Local Self-Government. Based on the request, the Minister forms a Commission for Compliance Verification. After the procedure, the qualified certification body is entered in the register of certification bodies of Republika Srpska, which is publicly available. This procedure is not harmonized with the eIDAS regulation and is not transparent enough.

Related to the previous regulations of Republika Srpska, the use of electronic signatures and qualified electronic signatures is defined, and two types of records are kept, which opens the possibility for the application of eIDAS identification schemes and the current beginning of the application of the Law on Electronic Signature in certain areas. In the records of unqualified bodies maintained by the Ministry of Scientific and Technological Development and Higher Education on May 2024, three legal entities are registered: Ministry of Administration and Local Self-Government of Republika Srpska, the Tax Administration of Republika Srpska, and Sberbank a.d. Banja Luka. The MF Bank is also registered, but this information is not publicly available in the register.

According to Article 34, supervision over the implementation of the Law is carried out by the Republic Administration for Inspection Affairs.

Republic of Srpska as well as Bosnia and Herzegovina legally not recognized requirements from eIDAS 2 regulation.

### CONCLUSION

The state of digital identification in the Republic of Srpska presents a multifaceted landscape, shaped by various factors including regulatory frameworks, technological infrastructure, adoption rates, challenges, and ongoing initiatives. This analysis provides an overview of the current state of digital identification in Republic of Srpska, highlighting key aspects and potential pathways for improvement.

Republic of Srpska has established a legal framework for digital identification, primarily governed by laws related to electronic signatures, electronic documents, and electronic business. The Law on Electronic Signature of Republic of Srpska, in line with national legislation, provides a foundation for electronic authentication and signature mechanisms. Additionally, regulations pertaining to electronic documents and electronic business further support digital identification practices within Republic of Srpska. In 2023, the Republic of Srpska finally adopted the Law on the Agency for Information and Communication Technologies, thereby establishing an institution responsible for digital identification as well as information security.

The technological infrastructure supporting digital identification in Republic of Srpska is evolving, with efforts to modernize and enhance existing systems. Public Key Infrastructure (PKI) systems are utilized for secure authentication and digital signatures, facilitating electronic transactions and communications. However, there may be gaps in the coverage and interoperability of digital identification systems across different sectors and entities within RS.

The adoption of digital identification solutions in Republic of Srpska varies across different segments of society and industries. While government agencies and certain sectors may have implemented digital identification mechanisms, there may be disparities in adoption rates among businesses, organizations, and individuals. Factors influencing adoption include awareness, accessibility, ease of use, and trust in digital technologies.

Several challenges exist in advancing digital identification in Republic of Srpska:

- Regulatory Compliance: Ensuring compliance with national and international regulations, including EU standards such as the eIDAS Regulation, poses a challenge. Harmonizing RS's legal framework with evolving regulatory requirements necessitates continuous updates and amendments to existing laws and regulations.
- Infrastructure Development: Enhancing the technological infrastructure for digital identification, including PKI systems, authentication mechanisms, and interoperable platforms, requires investments in infrastructure development and technology upgrades. This entails addressing infrastructure gaps, ensuring scalability, and fostering interoperability across systems.
- Data Privacy and Security: Addressing concerns related to data privacy, security vulnerabilities, and identity theft is essential for building trust and confidence in digital identification systems. Implementing robust data protection measures, encryption protocols, and cybersecurity standards is crucial to safeguarding personal information and mitigating risks.
- Awareness and Education: Promoting awareness and understanding of digital identification among stakeholders, including citizens, businesses, and government agencies, is vital for increasing adoption rates and fostering trust in digital technologies. Educational initiatives, training programs, and outreach campaigns can help raise awareness about the benefits and functionalities of digital identification.

To address these challenges and improve the state of digital identification in Republic of Srpska, several strategies can be considered:

- Regulatory Reforms: Enhance the legal framework for digital identification by aligning with international standards and best practices, including the eIDAS and eIDAS 2 Regulation. This involves revising existing laws, adopting new regulations, and ensuring compliance with evolving regulatory requirements.
- Infrastructure Investments: Invest in upgrading and modernizing the technological infrastructure for digital identification, including PKI systems, authentication protocols, and interoperable platforms. This requires strategic investments in infrastructure projects, technology upgrades, and capacity building initiatives.
- Data Protection Measures: Strengthen data privacy and security measures to protect personal information and mitigate cybersecurity risks. This includes implementing robust encryption standards, adopting cybersecurity best practices, and conducting regular audits and assessments to identify and address vulnerabilities.
- Awareness Campaigns: Launch targeted awareness campaigns to educate stakeholders about the benefits, functionalities, and security features of digital identification. This involves disseminating informative materials, organizing workshops and seminars, and engaging with

key stakeholders to address concerns and misconceptions.

- Intersectoral Collaboration: Foster collaboration and cooperation among government agencies, regulatory bodies, industry associations, academia, and civil society organizations to develop coordinated approaches and share best practices. This includes establishing intersectoral working groups, promoting information exchange, and fostering a culture of collaboration and innovation.

By implementing these strategies and fostering a conducive environment for digital innovation and transformation, the Republic of Srpska can enhance its digital identification capabilities, promote economic growth, and improve the delivery of public services in the digital age.

## REFERENCES

- [1] Macan, S, Sajber pravo i pravni aspekti sajber prostora, Pan-evropski univerzitet Apeiron, Banja Luka, 2022
- [2] Macan, S, Specificity of design of information systems for identification of citizens, master thesis, FON, Belgrade, 2006
- [3] Macan, S and Nogo, S, Use of biometric data and their mutual exchange in ID systems in BIH, Vol.11. Jahorina: Infoteh, 2012.
- [4] Parliamentary Assembly of Bosnia and Herzegovina, Law on Protection of Personal Data („Official Gazette of Bosnia and Herzegovina“ 49/06, 76/11 and 89/11)
- [5] Nash, A.: PKI – Implementing and Managing E-Security. Berkeley, California, USA: RSA Press, 2001
- [6] Nogo, S., & Macan, S. eServices Platform. Beograd: SMART eGovernment 2009.
- [7] Parliamentary Assembly of Bosnia and Herzegovina Law on Electronic Signature of Bosnia and Herzegovina. Sarajevo: Official Gazette of Bosnia and Herzegovina No. 91/06, 2006
- [8] Sinisa, M. Registers for Identification of Citizens, Protecting of Human Rights and Efficient Public Administration. Banja Luka: Disertation, 2018
- [9] Regulation (EU) No 910/2014 on electronic identification and trust services for electronic transactions in the internal market (eIDAS), 2014
- [10] Cohen, J. E., Cyberspace As/And Space, Georgetown University Law Center, 2007
- [11] Windley, P. J. Understanding Digital Identity Management. The Windley Group, 2003
- [12] Song, YY, Cybercryptography: Applicable Cryptography for Cyberspace Security, ISBN 978-3-319-72534-5, Springer Nature Switzerland, <https://doi.org/10.1007/978-3-319-72536-9>, 2019
- [13] Dijck, J. V., Jacobs, B., Electronic identity services as sociotechnical and political-economic constructs, Vol. 22(5) 896–914, New media and sociati, Sage, DOI: 10.1177/1461444819872537, 2020
- [14] Macan, S. (Juli 2020). Procjena usklađenosti u postupku primjene zakona o digitalnom potpisu Republike Srpske i usaglašenost sa eIDAS regulativom. Banja Luka: Godišnjak Fakulteta pravnih nauka, broj 10, UDC: 340.132.6:349.412, pp. 241-255.
- [15] Regulation (EU) 2024/1183 of the European Parliament and of the Council of 11 April 2024 amending Regulation (EU) No 910/2014 as regards establishing the European Digital Identity Framework.
- [16] Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive)
- [17] Digitalna identifikacija i nivoi bezbednosti elektronskih potpisa, ITEO 2022, XIV međunarodni naučno-stručni skup Informacione tehnologije za e-obrazovanje, Panevropski univerzitet “APEIRON”, Banja Luka, godina 2022.
- [18] [www.europe.eu](http://www.europe.eu)

Received: May 9, 2024  
Accepted: May 16, 2024

## ABOUT THE AUTHORS



**Siniša Macan**, assistant professor is an advisor in the ICT Department of the Ministry of Interior of the Republic of Srpska, with extensive experience in top and mid-level management positions in the ICT field. He graduated from the Faculty of Organizational Sciences at the University of Belgrade. He earned his Master's degree in Technical Sciences – Information Systems in 2006 from the same faculty at the University of Belgrade, and defended his doctoral dissertation in 2018 in Banja Luka. From 2006 to 2009, he was the director of the CIPS Directorate, and from 2009 to 2015, he was the first director and proposer for the establishment of IDDEEA, the agency responsible for ID documents and record keeping. His work at IDDEEA was crucial in obtaining visa-free travel with Schengen Agreement countries. He is currently a member of the Board of Directors of the ICT Agency of the Republic of Srpska and teaches Cyber Law as an assistant professor. He has participated in the following projects: the CIPS project (establishment of the citizen registry system, personal documents, and driver's licenses in Bosnia and Herzegovina), the passport and electronic passport system, passive voter registration in Bosnia and Herzegovina, the data transmission network for public security authorities, the vehicle registration system, etc. In 2011, the European Movement in Bosnia and Herzegovina awarded him the title “The Most European of Bosnia and Herzegovina for 2011.”

## FOR CITATION

Siniša Macan, Digital Identification from Smart Card to Digital Wallet –Eu Legal Framework and Situation in Bosnia and Herzegovina, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:37-46, (UDC: 005.591.6:330.341(497.6)), (DOI: 10.7251/JIT2401037M, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004



# FRAMEWORK OF DIGITAL TRANSFORMATION READINESS AT A MAJOR COMPANY

Krunoslav Ris<sup>1</sup>, Tomislav Radoš<sup>2</sup>

<sup>1</sup>Lumen Spei, Osijek, Croatia, krunoslav.ris@gmail.com, <https://orcid.org/0000-0001-7447-9817>

<sup>2</sup>Hrvatska Gospodarska Komora, Zagreb, Croatia, trados@hgk.hr, <https://orcid.org/0009-0003-2801-4092>

Review paper

<https://doi.org/10.7251/JIT2401047R>

UDC: 339.138:005.591.6

**Abstract:** Modern business, based on modern technologies, require strategy initiative that incorporates different forms of digital technologies across all areas of the organisation, with aim to identify ways to improve operational efficiency and faster commercialisation of products or services. Digital transformation is becoming important strategy for each organisation to meet these objectives. This study presents an in-depth evaluation of a company's readiness for digital transformation. Employing a methodical approach that includes extensive stakeholder interviews and a meticulously designed digital readiness survey, this research identifies critical areas where technological enhancement and strategic digital deployment could significantly improve organizational efficiency and competitiveness on a global scale. The paper outlines a framework tailored to guide enterprises through their digital transformation journeys effectively, facilitating better operational efficiencies and sustainable growth.

**Keywords:** Digital Transformation Strategy, Organizational Readiness, Operational Efficiency, Competitive Strategy, Change Management, Innovation Culture

## INTRODUCTION

In today's rapidly evolving digital landscape, companies across various sectors are increasingly recognizing the imperative need for digital transformation. This transformation is not merely about technology adoption but involves a comprehensive rethinking of business operations, customer interactions, and competitive strategies. Digital transformation can profoundly impact a company's efficiency, customer experience, and market positioning.

The development of a robust Digital Transformation Framework is crucial for guiding this complex transition. Based on insights gathered from multiple successful case studies over the past five years, including notable examples from industries such as e-commerce and customer relationship management, this paper proposes a generalized framework aimed at guiding organizations through their digital overhaul. Noteworthy instances such as Amazon's expansion into cloud services and Salesforce's evolution from software product to a platform-as-a-service model illustrate the transformative power of well-strategized digital initiatives [1].

This framework is distilled from the digital transformation journeys of ten different companies, reflecting a variety of industries that have successfully navigated the shift. It provides a structured approach to digital transformation, emphasizing the importance of leadership, the selection of appropriate technologies, and the cultivation of an innovative organizational culture. By adopting this framework, companies can not only enhance their operational efficiencies and customer engagement but also ensure that these changes lead to sustainable growth and competitive advantage [1][2].

The study aims to deliver a thorough understanding of the company's readiness for digital transformation, pinpointing strategic areas for intervention. The ultimate aim is to empower the organization to navigate its digital transition effectively, ensuring that it not only adapts to the demands of a digital economy but also thrives in it.

## METHODS AND MATERIALS

The research aims to deliver a thorough understanding of the company's readiness for digital



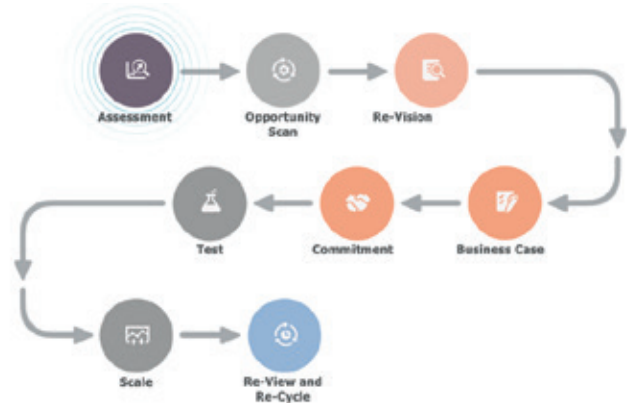
transformation, pinpointing strategic areas for intervention. The ultimate aim is to empower the organization to navigate its digital transition effectively, ensuring that it not only adapts to the demands of a digital economy but also thrives in it.

The comprehensive roadmap for the research is composed of following steps:

- **Assessment of Current Digital Maturity:** To evaluate the existing level of digital integration within the organization across various departments and to determine how deeply digital technologies are embedded in the company's operations, providing a baseline for measuring future progress.
- **Identifying Key Barriers and Enablers:** To uncover the critical obstacles and facilitators affecting the company's digital transformation initiatives and to understand factors allowing the company to strategically address barriers and leverage enablers, smoothing the path for a successful transformation.
- **Evaluation of Stakeholder Perceptions and Engagement:** To gather insights from a broad range of stakeholders (senior executives, middle management, IT staff, and frontline employees) regarding their views on digital transformation to meet employee expectations and company culture, ensuring widespread support and minimizing resistance.
- **Developing tailored Digital Transformation Framework:** To create a robust framework that guides the organization through the complexities of digital change with a structured approach to digital transformation, highlighting key areas such as leadership roles, technology adoption, and innovation culture, thereby facilitating effective management of the transformation process.
- **Establishing Baselines for Future Evaluations:** To set benchmarks and performance metrics that can be used to evaluate the success of digital transformation efforts over time enabling the company to track progress, make informed adjustments to strategies, and measure the impact of changes on operational efficiency and market competitiveness.

To accurately capture the complexities of digital transformation, our methodology incorporates

a blend of established industrial best practices for qualitative research. This ensures a comprehensive understanding of the underlying processes, cultural shifts, and technological integration essential for successful transformation.



*Figure 1: Digital Transformation Company or Processes Roadmap*

**Qualitative research** in digital transformation focuses on understanding the human elements, organizational culture, and change management processes that quantitative data alone cannot fully capture. In the context of this research, we recommend use of: 1) in depth interviews, 2) case studies, 3) participant observation and focus groups, 4) documents analysis and 5) digital readiness survey.

**In-depth Interviews:** Conducting detailed interviews should target a broad spectrum of stakeholders, from C-suite executives to frontline employees, provides diverse perspectives on the digital transformation journey. Each of these stakeholders can provide a unique perspective that is vital for a holistic understanding of digital transformation's implications and ensuring that the transformation strategy is comprehensive, actionable, and has the buy-in from all parts of the organization. These interviews help identify success factors, barriers, and the overall impact of digital strategies on daily operations [3]. The recommended number of interviews for a qualitative study can vary widely depending on the scope of the project, the complexity of the transformation, the size of the company, and the richness of the data required. There is no one-size-fits-all answer, but there are some general guidelines that can be followed: consider the purpose of the study when estimating number of interviews; 12-20 interviews should be conducted

to avoid saturation effect; divers the stakeholders and aim for “quality-over-quantity” principle; take into account available resources such as time, budget and personnel, but also project timeline and previous studies and their results. As a rule of thumb, for a medium to large-scale digital transformation project, aiming for around 15-30 interviews might be a good starting point, adjusting as needed based on the factors mentioned above. However, the key is to ensure that the sample of interviews represents the diverse perspectives within the organization and provides enough data to inform the transformation strategy effectively.

**Case Studies:** Analyzing case studies of organizations that have undergone digital transformation offers practical insights and lessons learned helping to understand the strategic, tactical, and operational elements that contribute to the success or failure of digital initiatives [4].

**Participant Observation and Focus groups:** Engaging directly in the environments where digital transformation occurs allows researchers to observe firsthand the implementation of digital tools and the subsequent cultural shifts. This method is particularly useful for capturing real-time reactions and adaptations by the workforce [5]. Organizing focus groups with employees from various departments can uncover collective insights about the digital transformation experience, including shared challenges and the effectiveness of communication across the organization [6].

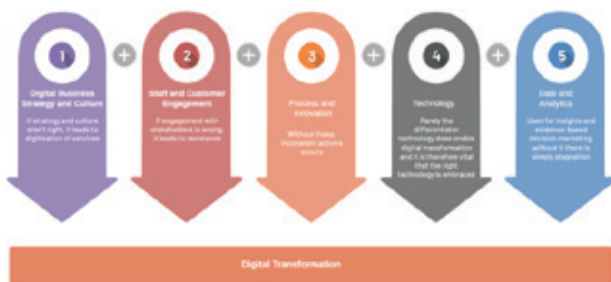


Figure 2: Five Steps Digital Transformation Company Process

**Document Analysis :**Reviewing internal documents, such as project plans, training materials, and digital strategy documents, provides a backdrop against which the qualitative findings can be assessed. This helps in validating the alignment of stated goals with actual practices and outcomes. When we are

talking about documentation, to conduct a successful digital transformation project, we split necessary documentation in to the two groups: 1) a must have documentation (such as technology roadmaps, governance model, communication plan, performance metrics and post-implementation review) and 2) a good to have documentation (such as risk management and stakeholders analysis, business case for digital initiatives, IEEE standards for software requirements and change management plan).

**Digital Readiness Survey with Gap analysis:** To gauge digital maturity across different organizational facets, a Digital Readiness Survey can be structured with a focus on specific domains of digital proficiency, including information and data literacy, communication and collaboration, and digital safety and security. The survey should consist of a balanced mix of multiple-choice questions (MCQs) and dichotomous items (yes/no, true/false) to accurately measure the competencies and readiness of individuals in a digital context [14]. When creating the survey, consider these key topics for your questions:

- Digital Mindset and Culture: Assessing openness to change and innovation.
- Leadership and Vision: Understanding the digital direction set by leaders.
- Technology Adoption: Evaluating the current use and future plans for technology.
- Skills and Training: Identifying gaps in digital skills and training needs.
- Digital Infrastructure: Examining the adequacy of current digital tools and platforms.

As for the number of respondents, a minimum of 30-50 responses could be sufficient for smaller organizations, while larger ones should seek a wider sample, often going into the hundreds, to ensure variability and reliability in the data collected.

A well-designed survey typically includes 70-90 questions covering various aspects of digital readiness without causing respondent fatigue. Questions will determinate Factor of Digital transformation.

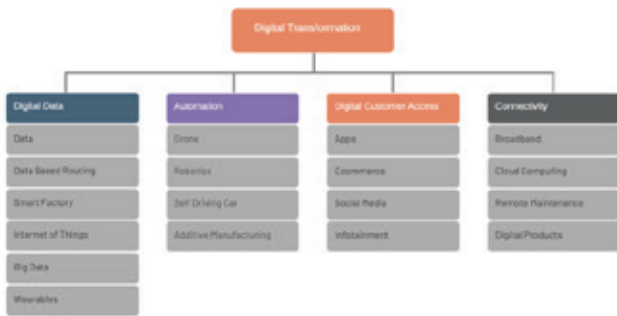


Figure 3: Factor of Digital Transformation

It's also recommended to use response scales when appropriate, as they can capture the intensity of attitudes more effectively than binary yes/no answers [13].

When analyzing data from Digital Readiness Surveys, following established best practices ensures that you extract meaningful insights and that your analytical framework can be repeated and refined over time. To perform Digital Readiness Survey, it is important to properly deal with the data through high-level processes of :1) Data Cleaning ( ensuring completeness and consistency, and identifying statistical outliers), 2) Data Analysis (using descriptive tools, cross tabulation, gap analysis and frequency distribution) and 3) Data Interpretation (using review of open-ended responses, as well as correlation and regression analysis)

To maintain the validity of your survey results and analyses over time, it is crucial to apply these best practices (e.g, from IBM or Americal Statistical Association) consistently, refining your approach as necessary based on outcomes and new insights gained from each survey iteration.

The above steps and considerations draw on established best practices from sources like Qualtrics, which emphasizes the importance of context, statistical validation, and benchmarking in survey data analysis (Qualtrics). Meanwhile, GetThematic [16] provides additional insights into coding open-ended responses and complements survey data with qualitative research (Thematic). Lastly, SurveyLab [15] offers a step-by-step guide to the data analysis process and suggests best practices for survey design.

To ensure our digital transformation aligns with best practices, the Digital Readiness Survey will include elements based on ISO/IEC 27001 [17] for cybersecurity, NIST'[18]s cybersecurity framework,

and COBIT [19] for governance. The survey has been enhanced to assess these standards' specific compliance points, allowing us to measure our digital maturity against recognized benchmarks.

The methodology for the Gap Analysis presented herein involves a comparative approach across five key domains pertinent to digital transformation. For each domain, the 'Current State' column describes the organization's existing conditions or capabilities. The 'Desired State' column articulates the optimal conditions or capabilities that align with the organization's strategic objectives for digital transformation. The 'Gap' column explicitly outlines the deficiencies or differences between the current and desired states. Finally, the 'Action Items' column provides a set of strategic actions necessary to bridge the identified gaps.

This structured approach enables a clear understanding of the required changes and facilitates the development of a targeted action plan to transition effectively to a digitally mature enterprise. Each gap identified through this analysis underscores an opportunity for growth and is matched with actionable steps to achieve the desired digital competencies and infrastructure. The subsequent table (Table 1) encapsulates the findings from the Gap Analysis, providing a concise roadmap from the present state to the envisioned future state of digital readiness.

Table 1. Gap Analysis findings

Area of Assessment	Current State	Desired State	Gap	Action Items
Digital Strategy Alignment	No formal digital strategy	Clearly defined digital strategy	Lack of clear direction for digital initiatives	Develop a comprehensive digital strategy
Employee Digital Skills	Basic digital skills in workforce	Advanced digital skills across workforce	Need for digital training and upskilling	Implement a digital literacy training program
IT Infrastructure	Aging servers, limited cloud use	Modern infrastructure with cloud services	Upgrade to current IT systems required	Invest in new hardware and cloud solutions
Use of Data Analytics	Data collected, not systematically analyzed	Data analytics driving decision-making	Analytics capability to be built and integrated	Hire data science team, invest in analytics tools
Customer Digital Engagement	Traditional marketing, low social media engagement	High customer engagement across digital platforms	Develop a digital marketing and engagement plan	Create a social media presence, online campaigns

For the **quantitative analysis**, responses from the survey can be statistically analyzed to derive scores that represent the digital maturity levels of the different departments and the organization as a whole. These scores can be used to identify areas of strength

and potential improvement, informing targeted interventions for digital upskilling and strategic planning for technology investments. When conducting such surveys, consulting existing frameworks like the Digital Competence Framework for Citizens [14] can offer valuable guidelines and established metrics to measure digital competence effectively [15].

## RESULTS

Upon rigorous evaluation through our digital readiness assessment framework, the ensuing section delineates pivotal findings. It encompasses a diagnostic examination of the organization's extant digital tool deployment, a critical appraisal of digital capability gaps, and the formulation of strategic recommendations to orchestrate a comprehensive digital transformation.

### Evaluation of Current Digital Utilization

The investigation into current digital tool utilization elucidates a spectrum of efficacy and integration levels. It was observed that / if legacy systems persist within the operational framework, engendering inefficiencies and fragmentation of data resources. If A rudimentary adoption of cloud computing solutions and collaborative platforms was noted, facilitating a modicum of operational fluidity and data interchange. Nonetheless, a pronounced underutilization of these digital resources signifies a substantial deviation from potential technological empowerment.

### Identification of Improvement Domains

Sequential to the aforementioned utilization review, if the gap analysis procedure has surfaced critical deficits in the organization's digital proficiency:

- Information Technology Infrastructure: The prevailing infrastructure is marked by obsolescence, lacking the requisite flexibility and scalability demanded by contemporary digital exigencies.
- Digital Skills Among Employees: A heterogeneity in employee digital acumen is discerned, underscoring the exigency for extensive upskilling to adeptly navigate and exploit digital apparatus.
- Cohesion in Digital Strategy Deployment: There is an apparent disjunction between digital strategy formulation and its operational

amalgamation, which could potentially impede digital-induced innovation and process refinement.

### Strategic Imperatives for Digital Transformation

Consequent to the digital readiness assessment, the subsequent strategic imperatives need to be advocated:

- Modernization of IT Infrastructure: A strategic capital allocation toward advanced IT infrastructure is imperative. This includes infrastructure with inherent support for cloud-based technology, advanced data analytics, and mobile capabilities, to promote agility and scale.
- Digital Competency Enhancement: Instituting an all-encompassing educational paradigm aimed at elevating digital proficiency across the organizational spectrum is essential.
- Comprehensive Digital Strategy Formulation: A recommendation is posited for the articulation of an integrative digital strategy that mirrors and advances the enterprise's strategic objectives. This entails the establishment of explicit goals, delineation of progression benchmarks, and the adoption of evaluative metrics to monitor advancement. The strategy should engender a culture predicated on innovation and perpetual improvement.

The articulation of these findings and the consequent strategic prescriptions provide a substantive framework to facilitate the organization's trajectory towards heightened digital maturity and to harness digital innovation for future enterprise fortification and market competitiveness.

Our analysis reveals that while cybersecurity practices needs to be largely in compliance with NIST standards, if there are significant gaps in IT governance when compared to COBIT recommendations, they need to be mitigated. These findings are critical as they highlight areas needing urgent attention to enhance our digital security and governance practices.

## DISCUSSION

This section scrutinizes the implications of the findings derived from the digital readiness assessments, concentrating on the strategic alignment and



the financial and resource implications of implementing a digital transformation strategy.

### Strategic Alignment

The essence of strategic alignment in digital transformation cannot be overstated. If the empirical evidence suggests a pronounced misalignment between current digital initiatives and the overarching strategic objectives of the organization. Digital transformation is not merely a technological upgrade but a strategic realignment that necessitates the congruence of digital endeavors with business goals. This alignment ensures that digital initiatives reinforce and are integral to the organization’s strategic vision, thereby fostering sustainable competitive advantage and value creation.

A paradigm shift is required from perceiving digital tools as isolated solutions to viewing them as integral components of the strategic fabric. This shift demands meticulous planning, executive sponsorship, and a governance structure that orchestrates the symbiosis between digital strategies and business objectives.

### Budget and Resource Allocation

The discourse on budget and resource allocation unveils the constraints that encumber the execution of a digital transformation. Budgetary limitations are a significant hurdle, with the assessment highlighting the inadequacy of current funding in addressing the identified gaps in digital readiness. Resource allocation is similarly challenged, not only in financial terms but also regarding human capital and technological resources.

corded with the digital readiness objectives. The plan should provide for the acquisition of modern IT infrastructure, upskilling of the workforce, and integration of a cohesive digital strategy. Moreover, resource allocation should transcend monetary aspects to include the allocation of human capital, ensuring that personnel with the requisite skillsets are deployed to champion digital initiatives.

In addressing these constraints, the organization should contemplate innovative funding mechanisms, such as phased investment, partnerships, or exploring alternative revenue streams to subsidize the transformation. The reallocation of existing resources, optimization of current investments, and a focused approach to digital expenditure will be paramount in circumnavigating the budgetary and resource limitations.

In summation, the strategic alignment and budgetary considerations form the bedrock upon which successful digital transformation is built. It is through the meticulous integration of these elements into the organizational framework that digital transformation initiatives can be realized, leading to the attainment of enhanced efficiency, market agility, and sustained growth.

### CONCLUSION

In conclusion, the systematic assessment of the organization’s readiness for digital transformation has illuminated critical insights and identified strategic imperatives crucial for fostering an environment conducive to innovation and growth. The findings have underscored the necessity of a robust digital infrastructure, a digitally literate workforce, and the integration of digital initiatives with the strategic objectives of the organization.

The current digital utilization within the organization exhibits a foundational framework upon which further advancements can be constructed. However, it is clear that there is a substantial need for the modernization of IT infrastructure, enhancement of digital competencies among employees, and the establishment of a comprehensive digital strategy that aligns with and advances the organization’s goals.

Strategic alignment has emerged as a pivotal theme, necessitating that digital initiatives be seamlessly woven into the fabric of the organization’s strategic planning. The need for alignment underscores



Figure 4: How to prepare for DX?

For an efficacious digital transformation, it is imperative to devise a structured financial plan that ac-



that digital transformation should not be perceived as a standalone IT project but as a strategic imperative that permeates every facet of the organization, necessitating commitment and coordination at all levels.

The discussion on budget and resource allocation has brought to the fore the constraints that the organization faces in actualizing its digital ambitions. It is evident that overcoming these limitations will require not only a reevaluation of budgetary commitments but also a cultural shift towards an innovative funding approach and resource optimization.

The strategic recommendations presented aim to bridge the identified gaps and facilitate a transition towards a digitally mature enterprise capable of leveraging technology for enhanced efficiency, customer engagement, and market competitiveness. A concerted effort towards these recommendations will be instrumental in propelling the organization towards a future where digital transformation is not just an aspiration but a tangible reality, driving business success in an increasingly digital-centric world.

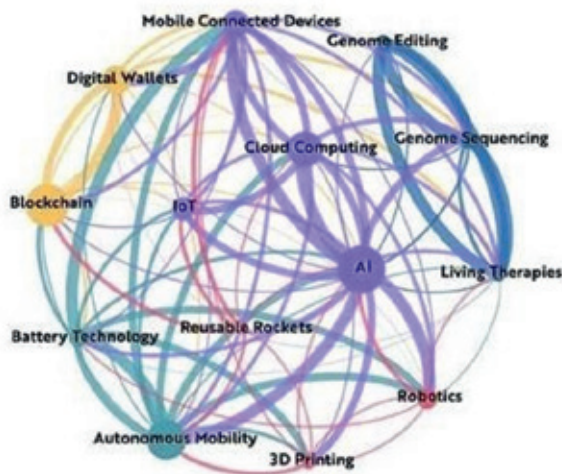


Figure 5: Transformative technologies in 2024

REFERENCES

[1] Businesstechweekly.com. (2023). Implementing a Digital Transformation Framework: Best Practices and Strategies. Retrieved from <https://businesstechweekly.com/articles/digital-transformation-framework-best-practices-strategies> accessed on 15.04.2024.

[2] Toptal.com. (2023). How Digital Transformations Succeed. <https://toptal.com/insights/digital-transformation-success> accessed on 15.04.2024.

[3] Sage Publications. (2023). Doing Qualitative Research in a Digital World. Retrieved from Sage Publications <https://sagepub.com/qualitative-research-digital-world> accessed on 15.04.2024.

[4] Springer. (2023). Digital Transformation in Industry: Realizing the Opportunities of a Digitalized World. Retrieved from Springer <https://springer.com/digital-transformation-industry> accessed on 16.04.2024.

[5] Journals Sage. (2023). Qualitative Research in the Digital Era: Challenges and Opportunities. Retrieved from SAGE Journals <https://journals.sagepub.com/qualitative-research-digital-era> accessed on 17.04.2024.

[6] Nature. (2023). Interviews and Focus Groups in Qualitative Research: An Update for the Digital Age. Retrieved from Nature <https://nature.com/articles/interviews-focus-groups-digital-age> accessed on 17.04.2024.

[7] Project Management Institute (PMI) - PMBOK® Guide: This guide provides a comprehensive framework for managing projects, including detailed discussions on documentation like project charters, business cases, and risk management plans. It's a critical resource for understanding the project management process standardized across industries. <https://pmi.org/pmbok-guide-standards> accessed on 17.04.2024.

[8] Harvard Business Review - Articles on Digital Transformation: HBR offers a range of articles discussing the strategies and outcomes of digital transformation, often highlighting the importance of a solid business case and effective change management documentation. <https://hbr.org/focus/digital-transformation> accessed on 17.04.2024.

[9] Prosci - Change Management Methodology: Prosci is renowned for its research and methodologies in change management, providing extensive guidance on how to plan for and implement change, including tools for stakeholder analysis and communication plans. <https://prosci.com/change-management> accessed on 17.04.2024.

[10] IEEE - Standards for Software Requirements: As a leader in setting international standards for technology and engineering, IEEE provides guidelines for documenting software requirements, a crucial aspect of digital transformation projects involving new technologies. <https://ieee.org/standards/software-requirements> accessed on 18.04.2024.

[11] Forrester - Technology Roadmaps: Forrester Research publishes studies and reports that include technology roadmaps, helping companies plan their technology adoption strategies effectively. <https://forrester.com/technology-roadmaps> Accessed in 18.04.2024.

[12] Gartner - IT Governance Models: Gartner's research on IT governance provides insights into how organizations can structure their governance documents to oversee digital transformation effectively. <https://gartner.com/it-governance-models> Accessed on 18.04.2024.

[13] Qualtrics General information and methodologies for surveys <https://qualtrics.com/> accessed on 18.04.2024.

[14] Mettl Blog - Insights on various professional assessments; <https://mettl.com/blog> accessed on 18.04.2024.

[15] Survey Lab - Detailed guide on survey design and analysis; <https://surveylab.com/> accessed 18.04.2024.

[16] GetThematic - Insights on coding open-ended responses; <https://getthematic.com/> accessed on 19.04.2024.

[17] ISO/IEC Standards: Available for purchase at ISO's official website. These standards will provide a basis for IT management and security practices; <https://iso.org/standards> access on 19.04.2024.

- [18] NIST Cybersecurity Framework: Freely accessible from the NIST website. This framework is essential for assessing cybersecurity practices. <https://nist.gov/cyberframework> accessed on 19.04.2024.
- [19] COBIT Framework: Information and documentation available from ISACA. COBIT provides a comprehensive

framework for IT governance that can be aligned with digital transformation initiatives. <https://isaca.org/cobit> accessed on 19.04.2024.

Received: April 29, 2024

Accepted: May 14, 2024

## ABOUT THE AUTHORS



**Dr. Krunoslav Ris**, CEO of Lumen Spei Ltd. Was born on September 14<sup>th</sup> 1981 in Vinkovci, Republic of Croatia. He graduated, obtained his master's degree, and earned his PhD from Pan-European University Apeiron Banja Luka. The topic of his doctoral dissertation was "IMPLICATIONS OF IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN THE

BANKING BUSINESS IN RELATION TO THE HUMAN FACTOR".

Krunoslav Ris wrote three books about Digital Transformation; "Digital Transformation Cheat Sheet: Book for managers and executives", "Digital Transformation Handbook" and "5G and the Next-Gen Consumer Banking Services".

Krunoslav currently working as a Digital Transformation Consultant for Enterprise Clients, and he is attending as a speaker, lecturer on the DX Conferences Worldwide.



**Dr. Tomislav Radoš**, Associate Professor and Vice President of the Croatian Chamber of Economy, was born on April 2, 1971, in Požega, Republic of Croatia. He graduated, obtained his master's degree, and earned his PhD from the Faculty of Economics, University of Zagreb. The topic of his doctoral dissertation was: "The Relationship between

Strategy and Business Performance of Croatian Companies". In 2019, he was appointed as an associate professor at the University of Sjever, where he teaches at the graduate and postgraduate levels.

He assumed the position of Vice President of the Croatian Chamber of Economy after serving as the Assistant Minister of Economy of the Republic of Croatia, where he led a working group and was the lead author of the Industrial Strategy of Croatia for the period 2014–2020. From 2007 to 2014, he was the founder and CEO of companies specializing in investments in renewable energy sources and providing consultancy services in the areas of strategic management and finance. Prior to that, he served as the CEO of AutoZubak and began his career in the banking sector as a risk management department manager.

## FOR CITATION

Krunoslav Ris, Tomislav Radoš, Framework of Digital Transformation Readiness at a Major Company, *JITA – Journal of Information Technology and Applications, Banja Luka*, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:47-54, (UDC: 339.138:005.591.6), (DOI: 10.7251/JIT2401047R, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# DIGITAL TRANSFORMATION AS A STARTER OF THE CREATION OF NEW ECONOMIC BUSINESS MODELS

Nataša Đalić<sup>1</sup>, Živko Erceg<sup>2</sup>

<sup>1</sup>University of East Sarajevo Faculty of Transport and Traffic Engineering, Dobo, Bosnia and Herzegovina, [djalic.natasa@gmail.com](mailto:djalic.natasa@gmail.com)

<sup>2</sup>University of East Sarajevo Faculty of Transport and Traffic Engineering, Dobo, Bosnia and Herzegovina, [zivkoerceg@gmail.com](mailto:zivkoerceg@gmail.com)

Review paper

<https://doi.org/10.7251/JIT2401055DJ>

UDC: 330.341:005.591.6

**Abstract:** Digital transformation refers to major changes occurring in all sectors of the economy and society, as a result of the introduction and integration of digital technologies into every segment of human life. The subject of research work is the contribution of the process of digitization and digital transformation to the improvement of the business processes of companies in Bosnia and Herzegovina. One of the sources of competitive advantage of modern companies is digital technology, which, due to the accelerated development of information and communication technologies, is changing the way of functioning and adapting to a more innovative way of doing business. The problem of research work manifests itself through the question of whether the application of digital technology and digitization affects the business operations of companies and the choice of their business strategy, and whether digital transformation can represent the strategic determination of companies in Bosnia and Herzegovina in modern business conditions. The goal of the research is to investigate the meaning, characteristics, and role and functions of digitization and digital transformation in the business of the company. The paper will present a comparative analysis of the digitization process of business in Bosnia and Herzegovina with the European Union.

**Keywords:** digitization, digital transformation, digital economy, new economic business models

## INTRODUCTION

Digital opportunities, scopes and limitations, and accelerated technological development, lead to a global digital transformation of society. The application of modern technological achievements changes almost all spheres of human life, the way he works, communicates, buys and spends his free time.

Business transformation is an extremely complex initiative that primarily aims to improve the company's operations through all its functions. The newest and most current model of the modern business concept or form of business is digital business. Its basic feature is manifested in solid support of digital technology, i.e. digitization of business processes at all levels within the company.

What is crucial in the context of digital business, which is based on the described digitalization, is based on data and information. According to Celik, digitalization through this concept means the reorientation of interactions, communications, business functions and business models into digital models

that often come down to a mix of digital and physical content, integrated marketing or smart production with a mix of autonomous, semi-autonomous and manual operations [2].

The connection between digitization and digital business is manifested in the fact that digitization actually represents the direction or movement towards digital business, and this process is often described as digital transformation. Krsmanovic states, the above-mentioned process represents a systematic process of intensive application of digital technology and resources with the aim of converting them into new revenues, business models and ways or forms of business [8].

Digital transformation, with its immediate impact on awareness, ideas, paradigm shift and way of doing business, led to the creation and expansion of the digital economy, as a completely new and previously unknown model of digital business.

Digital transformation has produced profound changes in the way we do business and live, which are reflected in several of the most significant points

of the digital economy (innovation and technological progress, through the growth of the startup ecosystem, through the global market and availability, Freelancing and the gig economy, platform business models, new revenue models and digital security and privacy).

All these changes represent great challenges, but also opportunities for companies and individuals who are ready to adapt and take advantage of the potential of the digital economy. This transformation is not only technical, but has deep cultural and social implications that shape our daily lives and the future of business. In the international economy or modern practice, this transformation occurs at the moment when a company decides in a relatively short period of time to fundamentally change business processes, strategies, activities, hierarchical and organizational structure, all with the aim of optimally connecting these elements and achieving better business results.

### REVIEW OF CURRENT LITERATURE

According to the author [2], the process of digital transformation represents one of the most comprehensive transformations of the business environment that took place in the last hundred years, as a result of which its potentials, which were used within the framework of new digital innovations, represent a significant challenge for all industrial branches, as well as national economies.

Contemporary business is a term that over time, and during the past three decades, began to be used in economic thought and profession, as a term that indicates numerous changes in today's business, compared to the traditional one. They are, for the most part, the result of dynamic technological development and its intensive support for everyday business processes. Technology is a commonly known and often used term, both in science and in practice. Krsmanovic states, while it once represented an innovation and an exception, today it is increasingly an essential resource in the international economy and global society [9]. The unprecedented and accelerated development of technology has influenced the establishment and strengthening of virtual communication, as well as the digitization of business and people's daily lives.

According to the author [10] who defines the digital economy as an economy based on digital technologies, including digital communication networks and other related information technologies.

In the digital economy, organizations use digital tools to automate processes, analyze data, connect with customers and expand their business to the global market. Also, digital communication networks enable fast and efficient exchange of information between different actors in the economy. This definition emphasizes the key components of the digital economy, emphasizing the importance of digital technologies and communication networks in shaping the modern business environment.

Digital and information communication technology is a product of scientific and technological progress, as well as general development during the second half of the 20th century. Considering their importance in modern business, it is pointed out that they increasingly exceed the level of revolution, and are maintained through economic, sociological and cultural effects and implications, states Krsmanovic [10].

According to Drucker, technology in general, which initially refers to digital technology, contributes to modern business in various ways. It is based on data and information, advanced knowledge, understanding and critical thinking [4]. Djalic and the group of authors point out, in order to clarify the meaning of the concept of digital business in the simplest and at the same time complete way, it is important to define the original concept of digitization. It is a complex term that refers to enabling, improving and transforming business, functions, models, processes and activities or, in one word, business using digital technologies and using digitized data [5]. What is crucial in the context of digital business, which is based on the described digitalization, is based on data and information. In this context, digitization means the reorientation of interactions, communications, business functions and business models into digital models that are often reduced to a mix of digital and physical content, integrated marketing or smart manufacturing with a mix of autonomous, semi-autonomous and manual operations, Celika claims [2].

The connection between digitalization and digital business is manifested in the fact that digitalization actually represents the direction or movement towards digital business. This process is often described as digital transformation. It represents a systematic process of intensive application of digital technology and resources with the aim of converting them into new revenues, business models and ways or forms of business, highlights Krsmanovic [8].



Digitization and digital business are interrelated concepts that together shape the way organizations work and provide value to their customers. Digitization represents a fundamental change in the way organizations handle information and business processes, while digital business means a step further in utilizing these digital resources to improve business in a broader sense.

Together, these two concepts form the basis for adaptability and competitive advantage in today's digital ecosystem. Organizations that are able to effectively use digital resources have a greater chance of success in the modern business environment.

According to Kotler, digitization as a process is carried out through the application of digital technologies, directly or indirectly, and as a rule has an impact on the creation of value and competitiveness, the organizational design (structure) of the company, human resources, production processes or services, the reward and promotion system and the profiling of the development strategy [7].

A group of authors [14] believes that digital transformation can be defined as a change in the way a company uses digital technologies to develop a new digital business model, and helps create new value for the company.

Digital transformation enables human beings and autonomous devices to collaborate using information technology (IT), which is enabled by big data, cloud computing, and mobile technologies and social networks, states Anthony [1].

## **DIGITAL TRANSFORMATION AS A SOURCE OF BUSINESS GROWTH AND DEVELOPMENT**

Digital transformation has become a key factor for the growth and development of companies in today's technologically advanced environment.

Digital transformation, with its direct impact on ideas, behavior and change of paradigm, focus and way of doing business, undoubtedly led to the creation and expansion of the digital economy, as a completely new and previously unknown model of market business.

The trend of adopting digital transformation strategies in the corporate segment encourages all companies to focus more strongly on improving their business. Based on research findings, analysis, as well as visible indicators that the process of applying modern

technologies brings with it, the conclusion emerges that digitization brings not only numerous but also profound changes, both in business and in other segments of social life.

According to Kotler, the digital transformation of business is accompanied by a new way of thinking, approaching problems and solving them. In this regard, experts estimate that the key to successful digitization includes: new strategy, improvement of user experience, digital marketing, modern CRM system, development of a new management and business model, and innovative organizational design. Its effects are reflected in the increase in profitability, growth and development of companies in various production and service sectors, which most often in practice can also mean the redefinition of current business models [7].

The process of digitization and digital transformation has a significant impact on economic effects in the company, and it manifests itself in several ways:

- The implementation of digital technologies enables the automation of routine tasks and processes, which reduces the time needed to perform business processes, and the aforementioned results in an increase in efficiency and productivity in the company.

- Digital transformation enables businesses to collect, analyze and use data in a way that facilitates informed decision-making. This can lead to a better understanding of the market, customer needs and industry trends.

- Through the implementation of digital technologies, companies can improve the quality of their products or services, increasing customer satisfaction and increasing competitive advantage.

- Digital platforms enable communication with customers in real time. This enables a faster response to questions, complaints or requests, which increases customer satisfaction.

- Digital platforms enable communication with customers in real time. This enables a faster response to questions, complaints or requests, which increases customer satisfaction.

- Digitization enables better monitoring and management of resources, including human resources, materials and financial flows. This can lead to more efficient use of resources and reduced costs.

- Companies that are leaders in the process of digital transformation usually have an advantage over the competition. This may include better utilization

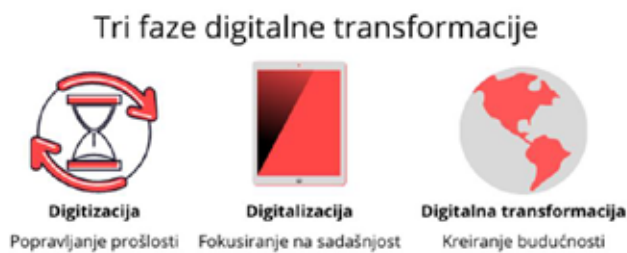
of technological solutions, faster response to market changes and innovative approaches.

- Digitization enables flexible work arrangements, including remote work. This can improve employee satisfaction and help attract talent.

- Digital transformation enables companies to more easily access the global market and expand their business beyond local borders.

- Through digitization, businesses can implement sustainable practices, including reducing the consumption of paper, energy and resources.

All these advantages together contribute to strengthening the company's competitive position on the market and create a foundation for long-term success. However, it is very important to emphasize that successful digital transformation requires careful planning, investments in employee training and constant adaptation to changes in the technological environment.



*Figure 1. Phases of digital transformation*

Digital transformation is by its nature multidisciplinary, as it includes changes in strategy, organization, information technologies, supply chains and marketing. In this regard, business success requires an increased understanding of how companies can gain a sustainable competitive advantage by transforming their business, what strategies they should adopt to improve their business, and how to change their organizational structure to support the new strategy.

According to a group of authors [14], three external factors can be identified that drive the need for digital transformation. First of all, with the advent of the World Wide Web and its adoption worldwide, the need for an increasing number of supporting technologies (e.g. broadband Internet, smartphones, Web 2.0, cloud computing, speech recognition, online payment systems and cryptocurrencies) was expressed, and what has strengthened the development of e-commerce. It is estimated that the ubiquity of big data and the

emergence of new digital technologies such as artificial intelligence, blockchain, the Internet of Things and robotics will have far-reaching consequences for business. Although not all of these technologies may be as powerful as expected, the arrival of new digital technologies clearly signals the need for companies to digitally transform their operations. In addition, these new technologies can also affect the company's cost structure by replacing humans with robots, virtual agents or optimizing logistics flows and reducing supply chain costs using artificial intelligence and blockchain.

New digital technologies contribute to a drastic change in competition. Not only has the competition become global, but the intensity of the competition has also been changed by large information-rich companies (eg Amazon, Alphabet, Apple and Facebook from the USA or Alibaba and JD from China) that have begun to dominate numerous industries.

Also, consumer behavior is changing in response to the digital revolution. Market figures show that consumers are shifting their shopping to online stores. With the help of new search tools and social media, consumers have become more connected, informed, empowered and active. Digital technologies allow consumers to co-create value by designing and customizing products, performing distribution activities, and helping other customers by sharing product reviews. Mobile devices have become an important factor in the behavior of today's consumers. Consumers are also heavily reliant on apps and new technologies based on artificial intelligence. These new digital technologies are likely to structurally change consumer behavior and, consequently, the use of new digital technologies can easily become the new norm and defy traditional business rules. If companies cannot adapt to these changes, they become less attractive to customers and are likely to be replaced by companies that use such technologies.

Digital change within an organization can be divided into three phases, from relatively simple to more complex change, which include: digitization, digitalization and, finally, digital transformation, states the group of authors [15]. In recent times, almost all companies in most industrial branches have been most affected by the technological environment due to digitization, which represents the transformation of physical into virtual content, as well as due to digitalization, which represents the processing of digitized content, states

the group of authors [15]. This transformation is a consequence of the process of digitization and conversion of physical resources, information and processes into virtual form, as well as digitization that includes the processing and processing of digital content. These two processes bring numerous changes and new opportunities, but also challenges for business.

Thus, digitization is the encoding of analog information into information in a digital format in such a way that computers can store, process and transmit such information, states the group of authors [14]. Examples refer to the use of digital forms in appropriate processes, the use of digital surveys or the use of digital applications for internal financial transactions. Typically, digitization mostly digitizes the documentation process, but does not add value to the business.

Digitization describes how digital technologies can be used to change existing business processes. Through digitalization, companies apply digital technologies with the aim of optimizing existing business processes by enabling more efficient coordination

between processes and/or creating additional user value through improving the user experience. Thus, digitization is not only focused on cost savings, but also includes process improvements that can improve customer experiences. Digital transformation is the most extensive phase and describes changes in the entire company that lead to the development of a new business model. Companies compete and can achieve a competitive advantage through their business models, which are defined by the way the company creates and adds value to customers, which aims to make a profit, states the group of authors [13].

Digital transformation affects the entire company and its ways of doing business and goes beyond digitization - the change of simple organizational processes and tasks. Processes are being rearranged to change the company's business logic and the ways in which value is added. The use of IT is transformative and leads to fundamental changes in existing business processes, routines and capabilities, and enables entry into new or exit from current markets. The great

**Table 1.** Trends in digital transformation

Technology	Description	Positive influences	Negative influences
Implantable technologies	Devices implemented in the body, such as a pacemaker	Useful for health checks or locating missing children	A threat to privacy and data security
Wearable Internet	Technologies in mobile phones designed to fit into clothing and accessories	Self-sufficiency and better decision-making	Threat to privacy and data security, addiction
Internet of things	Connecting everything to the Internet through sensors and appropriate applications	Increase in productivity, improved quality of life, safety (food, autonomous vehicles, airplanes, etc.), creation of new companies, connection with the environment	Privacy concerns, loss of traditional jobs, security threats
Smart cities	Energy management, material flows, logistics and traffic with the help of sensors and data platforms	Increased productivity, improved quality of life, lower crime rates, increased mobility, better access to education	Privacy concerns, risk of system collapse, cyber attacks
Big data	Manage and use massive amounts of data for automated decision-making when building and customizing services in real time	Better and faster decision-making, cost savings, new job categories	Job loss, privacy concerns, questionable data trust, questionable data ownership
Driverless cars	Threat to privacy and data security, dependency	Improved safety, less impact on the environment, improved mobility of the elderly and infirm	Job loss, cyber attacks, less income from public transport
Robotics	Application of robots in design, construction and other operations	Hard work of people replaced by robots	Job loss, liability, dependence on machines
Blockchain	A distributed trust mechanism designed to track transactions	Increased transparency, disintermediation of financial resources	People's trust, fear of unrealistic thinking about finances
Sharing economy	Exchange of physical goods, property or services	Increased access to resources, better use of assets	More labor contracts, reduction of gray economy, abuse of trust
3D printing	Creating physical objects by printing a drawing or model layer by layer	Accelerated product development, growing demand for designer products, more personalized products	Job loss, piracy, uncontrolled production of body parts, opportunity to print items such as weapons which pose a danger

advantage of using digital technology is in achieving a competitive advantage by transforming the company and using existing core competencies or developing new ones.

According to the group of authors, new development trends of digital transformation include the implementation of new digital technologies under the common name Industry 4.0 or the fourth industrial revolution [11]. The rate of technological development in Industry 4.0 is exponential and, therefore, predicting the challenges and even the benefits is much more difficult than what the world has experienced in previous industrial revolutions. The fourth industrial revolution is also bringing a shift in the way technology, communications, data and analytics affect the way we live, work and relate to each other.

A group of authors [11] provided an overview of certain new trends in digital transformation along with their positive and negative impacts (Table 1).

All the mentioned technologies have the potential to increase productivity and bring digital transformation to the organization, whether they are presented or used separately, or in combination, and the only chal-

lenge is the right choice of technology.

The context of digital transformation in Bosnia and Herzegovina is reflected through the State regulation and legal frameworks as well as through the competences and legal framework.

An analysis of the available secondary data according to the DTS approach is presented in Figure 3. The analysis focuses on the current trends in the integration of digital technologies and the factors that enable it.

When it comes to the digital infrastructure indicator, Bosnia and Herzegovina is at the bottom of the table compared to other European countries. According to DTS 2018, drivers of digital transformation include:

- Digital infrastructure,
- Supply and demand of digital skills,
- Entrepreneurial culture,
- Investments and access to finance,
- e-leadership.

Based on the mentioned enablers, DTS 2018 calculates the Digital Transformation Enablers Index (DTEI), which was developed by linear combination of each of the DT enablers indices. DTEI enables the ranking of EU countries.

Table 2. Methodological approach to presenting secondary data

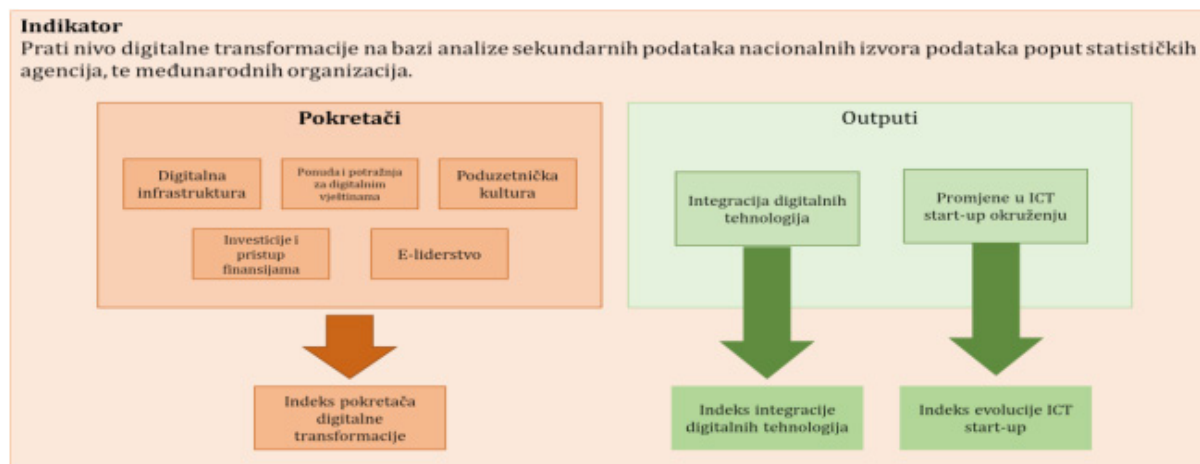


Table 3. Indicators of the digital infrastructure dimension

Indikator	Izvor podataka
Preduzeća koja koriste DSL ili drugu fiksnu širokopojasnu vezu	Eurostat
Propusnost Interneta	Global Competitiveness Index
Postotak preduzeća koja imaju ERP softverski paket za razmjenu informacija između različitih funkcionalnih područja	Eurostat
Postotak preduzeća koja koriste upravljanje odnosima s klijentima	Eurostat



The availability of digital infrastructure is a driver of digital transformation, and consists of the indicators presented (Table 3.)

Political fragmentation affects the coordination and implementation of national projects, including those in the field of information technology. Different governments have different priorities, which can lead to misalignment or duplication in digital initiatives.

Bosnia and Herzegovina lags behind some of its European neighbors in terms of digital infrastructure development. Infrastructure modernization and Internet access are key to the success of digital initiatives.

The European integration process could encourage the development and adoption of digital initiatives. EU funds and programs can provide the necessary funds and expertise for the development of the digital economy.

## RESEARCH RESULTS

Bosnia and Herzegovina as a developing country has a lot of room for progress in terms of technology and digitization. The technological progress of companies in Bosnia and Herzegovina varies significantly, ranging from the fact that some companies almost do not use digital technologies to those that are at a higher level of digital business transformation.

It is evident that there are differences in the level of digital transformation depending on the sector in which companies operate. Companies engaged in production as the main drivers of digital transformation represent business needs for solving problems in production. The size of the company also somewhat determines the level of digital transformation of the business. However, it is interesting that medium-sized companies (from 50 to 249 employees) have a higher rate of technology adoption. The internationalization of business is also a significant indicator of the focus on the adoption of digital technologies in business. Organizations that have entered the European and international markets with their products have a greater degree of regulation of business processes, harmonization according to international business standards, which consequently requires digital transformation that enables digital records of business events, easy proof of business facts during internal and external audits.

On the basis of research carried out using a comparative analysis of the process of digitalization of business in the European Union and Bosnia and Her-

zegovina, it can be assessed that the level of digital transformation in Bosnia and Herzegovina is low to moderate. Businesses face different challenges in all areas that are defined as drivers of digital transformation: digital infrastructure, supply and demand of digital skills, entrepreneurial culture, investment and access to finance and e-leadership. According to most indicators, Bosnia and Herzegovina (BiH) is below the average of the European Union (EU), at the bottom of the table. Taking into account the complexity of the organization of Bosnia and Herzegovina, governments at different levels are trying to define measures to achieve digital transformation of the country, but the results are barely visible. The projects of international institutions and organizations that are very active in this field have a significant impact on improving the state of digital transformation. In Bosnia and Herzegovina, there are several examples of successful digital transformation (DKS) initiatives that can serve as a model or inspiration for similar projects within the country and beyond (health information system, digital academy, online e-commerce platform).

The level of digital transformation in any country is complex and depends on many factors including politics, education, economic stability and others. It is important that governments, businesses and educational institutions work together to create an environment that encourages digital transformation and enables businesses to realize its potential.

When it comes to the indicator of digital infrastructure, BiH, in comparison with other European countries, is at the back of the table.

In terms of supply and demand for digital skills, BiH is far behind the countries of the region when it comes to talent competitiveness. In addition, BiH is at the bottom of the table that ranks countries according to the percentage of employment of ICT experts, as well as the percentage of companies that have provided employees with portable devices that enable a mobile connection to the Internet for business use.

The assessment of entrepreneurial culture shows that although entrepreneurship is considered an attractive profession, very few people intend to become or become entrepreneurs. The reasons for this can be found in many factors, starting from macroeconomics, those related to the process of establishing a company, and ending with the business environment itself, as well as personal characteristics of people. The conclu-

sion regarding investments and access to finance when it comes to BiH is that it is relatively easy to get a loan (especially compared to other countries in the region). However, when it comes to investing in research and development, the availability of venture capital, and raising money on the stock market, BiH is worse positioned than most neighboring countries. It is interesting that the total tax rate (share of commercial profit) is much lower than in developed European economies.

When it comes to the e-leadership indicator, Bosnia and Herzegovina is in the lower part of the table. According to the data related to the percentage of companies that trained ICT/IT experts to develop/upgrade their ICT skills and the percentage of companies that provide their employees with portable devices for mobile internet connection, BiH is not at the very bottom. However, Bosnia and Herzegovina is the worst ranked country in terms of the percentage of companies with a workforce with higher education. Overall, the evaluation of the digital infrastructure in BiH is unfavorable in many aspects, which is directly reflected in the level of digital transformation.

The vast majority of companies in Bosnia and Herzegovina are equipped with a fixed broadband connection. BiH companies can benefit from easy access to loans. A large number of people consider starting a business as a desirable career choice, so the promotion and support of entrepreneurship could significantly improve many aspects of the economy. A solid e-leadership rating is more a consequence of skills acquired in academia than on-the-job training provided by companies. The amount of taxes and mandatory contributions that the company pays in the second year of operation, expressed as a share of commercial profit, is quite favorable, so it could be used to attract investments, while creating a more stimulating business environment (in terms of starting a business, etc.). An increasing number of companies are turning to e-commerce, which opens up the possibility of expanding the market.

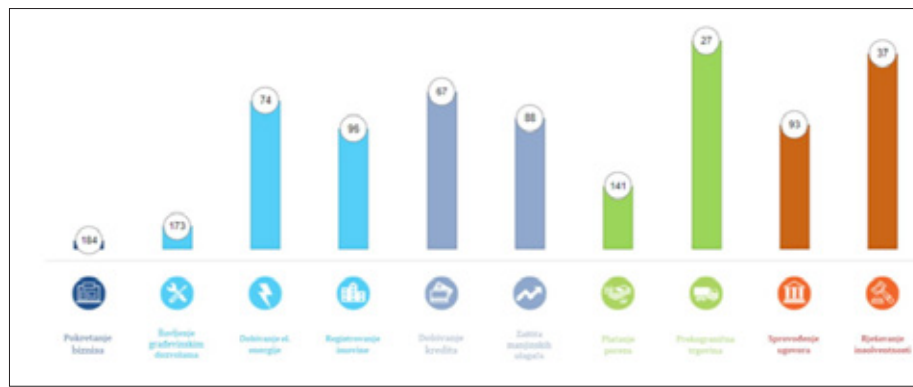
The level of technology adoption and digitization in Bosnia and Herzegovina is low, which consequently affects the country's growth potential. However, the communication and Internet infrastructure is relatively satisfactory, and the ICT sector has a tendency to grow. In this regard, BiH has the opportunity to take advantage of this, as well as the efforts of the EU through the Digital Agenda of the European Union for

the Western Balkans, and improve the presented indicators, and consequently overall social progress.

Bosnia and Herzegovina still faces significant shortcomings in most areas that are drivers of digital transformation. Commercial loans are available, but venture capital, which is very important for the development of entrepreneurship and small and medium enterprises, does not exist in the ecosystem. Furthermore, the low performance of the country in terms of the competitiveness of talents and qualified ICT experts is evident. In addition, BiH is far below the EU average in terms of the number of companies that use an ERP system that enables electronic sharing and processing of information, which is the first step towards the transformation of business to electronic business. The country is poorly positioned on the global competitiveness index, as well as according to the global talent competitiveness index.

In addition, poor results in the field of digital transformation also stem from the insufficient use of digital technologies for business purposes. Despite high DSL and broadband usage, average Internet bandwidth in the country leaves significant room for improvement. All of the above leads to the conclusion that BiH has room for improvement in each of the analyzed areas that are drivers of digital transformation. In this way, the foundation will be created for the improvement of the adoption of digital technologies and the digitization of business, which will result in a more favorable position for BiH when it comes to the integration of digital technologies, but also in the evolution of the IT start-up environment.

It is especially necessary to carry out the necessary improvement activities in the sector of small and medium enterprises, where there is no institutional framework at the state level that would support the development of these enterprises. Consequently, there is a lack of financial instruments for the promotion of innovation within small and medium-sized enterprises. Although the FBiH Government provides some financial support, the measures are mostly ineffective and do not meet the real needs of small and medium-sized enterprises (ITU). In addition, funding is divided between multiple levels of government where coordination and monitoring of implementation and effects are lacking. It is important to note that very little is used of the funds available from EU funds, probably due to the lack of qualified personnel.



**Figure 3.** Ranking of Bosnia and Herzegovina according to topics relevant to business (1-190)

Low performance in terms of supply and demand of digital skills has resulted in low innovation performance of the country. ITU (2018) states in this report that young entrepreneurs too often give up their initial venture and re-enter the regular workforce in large companies, instead of treating their initial failure as a platform for learning, personal development and improvement of the next venture. This speaks precisely to the lack of entrepreneurial culture and the already established fact that young people want to stay in their comfort zones, aiming for a job in the public sector as the best option. In other words, risk aversion is high, so it is necessary to promote entrepreneurial culture on multiple levels. Insufficient workforce with tertiary education, as well as IT personnel, results in poor e-leadership performance.

## RESEARCH DISCUSSION

By means of a comparative analysis that was carried out with several significant aspects, a broader perspective of the state of digital transformation in Bosnia and Herzegovina was obtained.

When it comes to digital infrastructure, BiH's position in terms of the number of companies using DSL or another form of fixed broadband connection is in line with the European average. However, when it comes to Internet bandwidth, BiH is much worse positioned. When it comes to the integration of business processes using the ERP system, BiH is quite low on the table, only ahead of Bulgaria, Romania, Turkey and Hungary. Finally, only Hungary is behind BiH in terms of the number of companies that use CRM to analyze customer data. In conclusion, the digital infrastructure of BiH lags behind the infrastructure of most European countries. According to official data, the situation is comparable to Bulgaria and Romania, while Hungary

is probably in a worse position. According to the UN (2020), BiH belongs to economies in transition in the category of high and middle income, while Bulgaria and Romania belong to developed economies in the category of high and middle income, and Hungary in the category of developed countries with high income.

According to innovation results, when it comes to the supply and demand of digital skills, Bosnia and Herzegovina is at the very bottom of the table, behind Bulgaria, Romania, Hungary, and even neighboring countries. Also, in BiH it is much more difficult to find people with the skills needed to fill a job than in most European countries. Behind BiH are Hungary and Romania. It is interesting that companies in Bosnia and Herzegovina generally have no difficulty in filling the positions of ICT experts, unlike many developed EU countries that are in a worse position (Belgium, the Netherlands, Finland, etc.). However, if the interpretation of this result includes the fact that a far smaller percentage of BiH companies employ IT experts at all, then it is clear that the data on difficulties in finding experts does not indicate the state of the labor market. BiH is below the European average when it comes to the number of employed persons who received a portable device that enables a mobile connection to the Internet for business use, only ahead of Cyprus and Bulgaria. In conclusion, Bosnia and Herzegovina is far behind all countries in the region when it comes to talent competitiveness, which is a very devastating fact. In addition, BiH is at the bottom of the table that ranks countries according to the percentage of employment of ICT experts, as well as the percentage of companies that have provided employees with portable devices that enable a mobile connection to the Internet for business use. All this results in a low level of innovation, and indirectly in overall social progress.

Overall entrepreneurial activity, as well as entrepreneurial intentions in Bosnia and Herzegovina are far behind most European countries. Only the situation regarding the perception of the occupation of entrepreneurs is more positive. However, although entrepreneurship is considered an attractive profession, very few people intend to become or become entrepreneurs. The reasons for this can be found in many factors, starting from macroeconomics, those related to the process of establishing companies, up to the business environment itself, but also personal characteristics of people. It can also be a consequence of the complex administrative environment that makes it difficult to open a new company, and even more difficult to close it if the venture fails.

Investment in research and development, as well as direct investments in the IT sector, are indicators according to which BiH is positioned behind most European countries. On the other hand, the total tax rate expressed as a share of commercial profit positions BiH above many developed countries, and it is easier to get a loan than in many countries. However, the availability of venture capital, as well as access to the stock market, puts BiH again at the bottom of the list, which ultimately determines access to finance as less favorable for business compared to most European countries.

Bulgaria, Romania, Greece, Lithuania, North Macedonia and Turkey are countries that are worse positioned than BiH when it comes to the number of companies that trained IT experts (e-leadership) for the development/upgrade of their IT skills. However, it is last on the list when considering the number of companies with a workforce with higher education. Finally, Bosnia and Herzegovina is close to the average of the overall situation in the EU according to the number of companies that provide their employees with portable devices for mobile internet connection. Bulgaria, Romania, Cyprus, Greece, Slovakia and Italy are behind. In other words, companies in BiH lack highly educated staff, but also trained IT staff. Overall, Bosnia and Herzegovina is in a far worse position than most European countries when it comes to driving digital transformation, and is comparable only to Bulgaria, Romania and Hungary, and in some parameters to Greece and Cyprus.

In the continuation of the paper, several more examples of comparative analysis are presented that can

be significant in interpreting the state of the level of digital transformation, as well as the drivers of digital transformation in Bosnia and Herzegovina.

According to the State Profile of Bosnia and Herzegovina at the World Bank, the political system in BiH is very complex and reflects the provisions of the constitution that were developed to end ethnic conflicts, as well as subsequent changes to the system introduced under the leadership of the international community through the Office of the High Representative. What represents the key economic challenge of BiH is the imbalance of its economic model: public policies and incentives are directed towards the public rather than the private sector, consumption rather than investment, and imports rather than exports. Bosnia and Herzegovina must develop a business environment that will attract private investments intended for SMEs and the growth of large companies. Also, it is very important to work on facilitating native performance and improving productivity, as well as creating the necessary jobs in the private sector. In order to ensure sustainability and future growth, it is necessary to address the imbalance in the economic model.

The business environment in Bosnia and Herzegovina is quite unstable. Based on the report of the World Bank, the ranking of BiH according to topics relevant to business is presented. For example, when it comes to starting a business or establishing a company, the registration procedure consists of 5 steps. In comparison with neighboring countries, Bosnia and Herzegovina is in 184th place out of 190 countries, Montenegro is in 101st position, Croatia is in 114th place. Furthermore, in terms of paying taxes, BiH is in 141st place out of 190 countries, Croatia is on the 49th and Montenegro on the 75th position. Also, BiH is in 70th position out of 190 countries when it comes to cross-border trade, while Montenegro is in 41st place.

According to the Network Readiness Index for 2020 (Portulans Institute), BiH is in the 87th position. When it comes to neighboring countries, Croatia is in 43rd place, while Serbia is in 52nd position. The Network Readiness Index is a report that ranks a total of 134 world economies based on their performance in 60 variables. Recognizing the prevalence of digital technologies in today's networked world, the index is based on four core dimensions: technology, people, governance and performance. This holistic approach means that this index covers issues ranging from fu-



ture technologies such as artificial intelligence and the Internet of Things to the role of the digital economy in achieving the Sustainable Development Goals.

The Global Connectivity Index is a report that ranks 79 countries on the S-curve chart, and maps the transformation into a digital economy. According to ICT investments, ICT maturity and digital performance related to the economy, the S-curve maps countries into three clusters (groups): Starters, Adopters and Front-runners. As of 2019, the CGI research methodology has been expanded to help policymakers understand the growing impact of artificial intelligence on the global economy. When it comes to the Global Connectivity Index for 2020, Bosnia and Herzegovina is not among the 79 leading countries. When it comes to neighboring countries, Croatia is in the 38th position, while Serbia is in the 51st position.

In addition to the above-mentioned global reports, when it comes to the Global Cybersecurity Index 2018 (ITU), Bosnia and Herzegovina is in: 118th position out of a total of 175 countries at the world level in terms of cyber security, and in the 43rd position out of a total of 46 countries at the European level in terms of cyber security. The Global Cyber Security Index (GCI) is a composite index that combines 25 indicators to measure the monitoring and comparison of countries' level of commitment to cyber security in relation to the five pillars of the Global Cyber Security Agenda (GCA). Those pillars make up the five GCI sub-indices.

The advent of digitization makes many traditional manual jobs extremely obsolete, because the demand for new types of skills (especially digital) is created, and thus the market shows the need for retraining the workforce and re-employing surplus workers. Retraining the workforce is both a priority and a challenge in many countries. Countries face the risks that existing jobs will become obsolete, some jobs will undergo a radical redesign (for example, robotics), and new jobs will be created that require specific new skills. It is very important to create a Skills and Retraining Strategy, which is based on the needs of industrial branches, in order to reduce the impact of digital transformation. When drafting the Strategy, it is necessary to pay extra attention, and create educational programs in the areas of artificial intelligence, cyber security, and the like.

The availability of digital infrastructure is the driver of digital transformation. According to the DESI methodology, digital infrastructure includes: internet con-

nection availability, Internet bandwidth, business integration using ERP software packages, and the use of CRM systems. Compared to other European countries, Bosnia and Herzegovina is at the bottom of the table when it comes to the indicator of digital infrastructure. Although it is highly ranked according to the number of companies using the Internet, the bandwidth of Internet connections lags behind most European countries, and a very small percentage of companies use ERP to integrate business processes and CRM to analyze customer data.

The construction of digital infrastructure should be one of the priorities, which is why investments are necessary to finance research, development and commercialization of digital technologies, but also to build digital skills and capabilities of the workforce, and to implement existing and new digital solutions in companies, government institutions and society at large. at all levels.

The COVID-19 pandemic has forced many businesses to go through an accelerated process of digital business transformation. New trends in digital transformation, such as robotics, blockchain, big data, internet of things, and the like, have the potential to drive innovation and improve overall company performance. The European Commission drafted an act proposing strategies for a single digital market and building Europe's digital future, which would accelerate the digital transformation of companies and ensure a fair and competitive digital economy (European Commission). Digital platforms and big data are radically transforming industries. Large amounts of data are generated through equipment, while machines and devices provide various opportunities for the development of new business models and the improvement of products and services (European Commission). Accordingly, digital platforms bring significant economic and social benefits.

Start-up Europe is an initiative of the European Commission to connect high-tech start-ups, scale-ups, investors, accelerators, corporate networks, universities and media. There are various projects and political actions funded by the EU on this issue. The initiative is fully aligned with the European Commission's Strategy for Small and Medium Enterprises (SME)<sup>1</sup> (European Commission). This strategy recognizes the different needs of SMEs. It helps them to further develop, grow, use their market opportunities, be competitive,

resilient and build self-sustainability. The goal is to increase the number of small and medium-sized enterprises engaged in sustainable development, as well as the number of small and medium-sized enterprises that use digital technologies.

Digital technologies, as advanced as they are, are just a tool. They cannot solve problems on their own, but they can enable users to realize ideas that were previously unimaginable. What is very important is that we as users have the ability to put the available tools into operation and thereby contribute to a better future.

Although there was no special focus on public and government institutions, it is clear that the BiH institutions have a long road to digitization. First of all, it is necessary to accelerate innovation in the public sector, made possible through the introduction of interoperable IT and better exchange and use of information. The strategic framework for the reform of public administration in BiH 2018 - 2022 emphasizes the importance of digitization, and establishes clear goals that guide the digitization of public administration services, as well as business. In this regard, the priority of all levels of government would be to create action plans in accordance with this strategic framework.

Based on all the performed comparative analyses, a more detailed insight into the state of digital transformation in Bosnia and Herzegovina can be provided and the key factors influencing its further development can be identified. Also, guidelines can be offered for the development of strategies and initiatives that will improve digital transformation in the country.

The key guidelines, based on certain analyses, which relate to the development of strategies and initiatives are:

- Create a strategy and action plan for digital education that would be aligned with the European Union's plan to support the sustainable and efficient adaptation of the education and training systems of EU member states to the digital age;

- Create a program to strengthen digital skills (digital literacy) in society as a whole with an increased focus on young people in order to strengthen digital skills for early career transition;

- Increase digital literacy and the proliferation of digital skills, in order to fill the gap between demand and supply of ICT professionals;

- Create a Skills and Retraining Strategy, which is based on the needs of industrial branches;

- Support for lifelong learning in order to enable the retraining of citizens (especially the population at risk of unemployment) and equip all citizens with the digital and cognitive skills they need for success in the future business context (dual education, support for short educational cycles - BiH Qualification Framework);

- Encouraging cooperation between government institutions, universities, corporations and small and medium-sized enterprises (eg financing of joint facilities for important infrastructure);

- Creating a plan and program for strengthening the digital infrastructure in Bosnia and Herzegovina.

- Stimulating private investments in digital infrastructure (through, for example, tax breaks on investments in IT);

- Encouraging a safe and reliable Internet environment for users and operators, based on strengthened European and international cooperation in responding to global risks;

- Create a strategy for a single digital market and building Europe's digital future, which would be harmonized with the EU Cyber Security Strategy for the Digital Decade, the Act on Digital Services and the Act on Digital Markets, as well as other acts related to this area;

- Develop a strategy for the development of small and medium-sized enterprises (SMEs) to help them develop and be competitive in the market;

- Establish education programs for owners and managers of small and medium-sized enterprises with the aim of increasing awareness and knowledge about digital technologies in business.

Also, it is important to note that most of the recommendations are intended for relevant government institutions, and for individual companies and institutions that aim to promote digitization in BiH. It is suggested that government institutions of all levels in Bosnia and Herzegovina devote themselves to these issues and start implementing the proposed activities that will stimulate the digitization of companies in Bosnia and Herzegovina, as well as public administration.

Recommendations for digital development in Bosnia and Herzegovina:

- Adoption of a National Strategy for Digital Transformation: Formulation and adoption of a coherent national strategy that will guide digital efforts across the country.

- Incentives for the IT sector: Introducing incentives for domestic and foreign investments in the IT sector, including tax breaks and support for startups.
- Infrastructure projects: Investment in broadband Internet and other critical IT infrastructure across the country to ensure universal availability and affordability.
- Regional cooperation: Encouraging regional cooperation with other countries in the region to exchange knowledge and resources in the field of digital transformation.

These recommendations can help BiH accelerate its digital development, encourage innovation and increase its competitiveness on the international level.

## CONCLUSION

The development of the information society and the digital economy makes adjustments in all segments of human life, especially affecting the way of life, work, connection, and social connection of an increasing part of the population around the planet. When it comes to the digitization of activities within the social and economic environment of people, the positive aspects are reflected in a greater degree of transparency of business activities; then the concept of freedom of speech is improved by reducing and practically preventing censorship of both the media and individuals; increasing the effectiveness and efficiency of the exchange and distribution of information and data between individuals, groups and organizations; and increasing the effectiveness and efficiency of administrative and bureaucratic procedures both for individuals, private companies and public company services.

Based on research findings, analysis, as well as visible indicators that the process of applying modern technologies brings with it, the conclusion emerges that digitization brings not only numerous but also profound changes, both in business and in other segments of social life. The trend of adopting digital transformation strategies in the corporate segment encourages all companies to focus more strongly on improving their business.

It can be seen that digitization includes the concepts of sustainable development. Therefore, it is necessary to consider all aspects of their application, as well as to constantly evaluate business processes in order to determine when and which technologies need to be ap-

plied. Furthermore, with technological solutions that include virtual reality and visualization, the positive side includes more effective and efficient implementation of business processes; more effective and timely business decision-making is enabled; enables people with disabilities to perform tasks that they could not do before the application of technology. Digitization of business and the application of digital technology have a positive effect on the efficiency and profitability of businesses in Bosnia and Herzegovina, as well as society in general. Through dynamic development, the digital economy erases the previous boundaries between the traditional and modern economy, between the resource-based economy and the knowledge economy, i.e. economies based on bits and bytes.

The aim of the research of this paper is to investigate the meaning, characteristics, role and function of digitization and digital transformation in the European Union with reference to business operations within Bosnia and Herzegovina. Through a review of the current literature in the mentioned field, the advantages that digital business brings in modern times have been confirmed, but its crucial role in the present time on the territory of Bosnia and Herzegovina has also been argued. Through this work, the key goal of the digitization process was pointed out, both for the business operations of the company, and for the overall development of Bosnia and Herzegovina, through the application of the development strategy of the European Union, then socially responsible business and sustainable development were defined; the implementation of sustainable development in the company's operations is described, as well as the very importance of digitalization in the innovative processes of companies in the territory of Bosnia and Herzegovina.

Thanks to the advantages of the single digital market, the European economy will once again become competent and successful in the world. The initiative itself promotes technology as a "driver of economic growth and development, creation of new jobs, sustainability and social inclusion across borders and in all European member states."

Digital technologies significantly affect the way of life, work, connections and social interaction of a growing part of the population. Digital transformation refers to profound changes that occur in all sectors of the economy and society, as a result of the introduction and integration of digital technologies into every

aspect of human life. Bosnia and Herzegovina has set digital transformation as one of its priorities in the coming period because it is a prerequisite for raising the competitiveness of the economy, but also for improving a number of other processes that are crucial for Bosnia and Herzegovina on its European path.

In Bosnia and Herzegovina, there is no relevant report that would present the state of digitization of business. The data presented in the paper for BiH indicate that the situation in BiH, when it comes to the digital transformation of business operations, is at a very low level compared to other European countries. Together with Poland, Hungary and Romania, BiH is at the very bottom of the business digitization scale, and from this we can conclude that the digital transformation in the EU indicates a significant digital gap between BiH society and the EU.

## REFERENCES

- [1] Anthony Jnr, B. (2021), "Managing digital transformation of smart cities through enterprise architecture—a review and research agenda", *Enterprise Information Systems*, Taylor & Francis, Vol. 15 No. 3, pp. 299–331.
- [2] Čelik, P., (2019). *Bezbednosne implikacije digitalnog poslovanja*, *Ekonomija- teorija i praksa*, godina XII, broj 4, str. 61-81
- [3] Ćuzović, Đ., Sokolović-Mladenović, S., (2014). *Globalizacija digitalne ekonomije*, *Međunarodna naučna konferencija Univerziteta Singidunum Sinteza 2014.*, str.144
- [4] Drucker, P. (1999). *Management Challenges for the 21st Century*, HarperBusiness, New York.
- [5] Đalić, N., Nikolić, M., Bakator, M., Erceg, Ž. (2021). *Modeling the Influence of Information Systems on Sustainable Business Performance and Competitiveness*. *Sustainability*, 2021, 13(17), 9619. <https://doi.org/10.3390/su13179619>
- [6] Imamović-Čizmić, K.,: *Digitalna ekonomija, novi koncepti takmičenja privrednih subjekata i izazovi za pravo i politiku konkurencije*, *Godišnjak Pravnog fakulteta u Sarajevu*, LXIII – 2020., s. 157–181
- [7] Kotler, P., Kartajaya, H. & Setiawan, I. (2017), *Marketing 4.0*, Hoboken, US, *Moving from Traditional to Digital*, John Wiley & Sons, Inc
- [8] Krsmanović, B. 2013. "Koncept digitalne ekonomije". *Novi ekonomist: časopis za ekonomsku teoriju i praksu*. Br. 15.
- [9] Krsmanović, B., (2013). *Izazovi digitalne ekonomije*, VIII Međunarodni Simpozijum i korporativnom upravljanju, Banja Vrućica
- [10] Krsmanović, B., Polić, S., *Inforacione tehnologije u računovodstvu i reviziji*, Bijeljina, 2008
- [11] Pihir, I., Tomičić-Pupek, K. and Furjan, M.T. (2018), "Digital Transformation Insights and Trends", *Proceedings of the Central European Conference on Information and Intelligent Systems*, pp. 141–150.
- [12] Shallmo, D., & Williams, C. (2017). *Digital Transformation of Business Models - best practice, enablers and roadmap*. *International Journal of Innovation Management*, 21(8), 1-17
- [13] Trkulja, M., Lojić, A. & Lončar, M (2018), *Digitalna globalizacija i marketing mega događaja*, *Poslovne studije 10 (19-20)*, pp. 135 – 151, Banja Luka, Republika Srpska, Bosna i Hercegovina, Univerzitet za poslovne studije Banja Luka,
- [14] Verhoef, P.C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N. and Haenlein, M. (2021), "Digital transformation: A multidisciplinary reflection and research agenda", *Journal of Business Research*, Vol. 122 No. July 2018, pp. 889–901.
- [15] Vučeković, M., Radović-Marković, M., & Marković, D. (2020). *Koncept digitalnog preduzeća i njegove virtualizacije*. *Trendovi u poslovanju*, 8(15), 75-82.

Received: January 19, 2024

Accepted: March 28, 2024

## ABOUT THE AUTHORS



**PhD Nataša Đalić**, assistant professor, is a professor at the Faculty of Traffic in Doboj, University of East Sarajevo, specialized field of Information Science (social aspects).

She defended her doctoral dissertation in 2022 at the Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad. She has published over 50 scientific papers, 4 of which are

on the prestigious SCI list.



**PhD Živko Erceg**, associate professor, is employed at the Faculty of Traffic in Doboj, University of East Sarajevo, specialized field of Management.

At the Faculty of Business Economics in Bijeljina, University of East Sarajevo, a doctoral dissertation was selected in 2015. He is the author of over 40 scientific papers, 3 of which are

on the prestigious SCI list.

## FOR CITATION

Nataša Đalić, Živko Erceg, *Digital Transformation as a Starter of the Creation of new Economic Business Models*, *JITA – Journal of Information Technology and Applications*, Banja Luka, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:55-68, (UDC: 330.341:005.591.6), (DOI: 10.7251/JIT2401055DJ), Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004



# FROM .NET CORE TO .NET 8: A COMPREHENSIVE ANALYSIS OF PERFORMANCE, FEATURES, AND MIGRATION PATHWAYS

Branimir Cvijić<sup>1</sup>, Pero Ranilović<sup>2</sup>

<sup>1</sup>Endava, Banja Luka, RS, BiH, cvijic.branimir@gmail.com

<sup>2</sup>Pan-European University "Apeiron", Banja Luka, RS, BiH, pero.d.ranilovic@apeiron-edu.eu

Review paper

<https://doi.org/10.7251/JIT2401069C>

UDC: 004.432.2C#:004.738-1

**Abstract:** This analysis embarks on a comprehensive exploration of the .NET ecosystem's evolution, with a spotlight on the transition from .NET Core to the unified .NET platform, culminating in the release of .NET 8. It meticulously examines the performance enhancements, feature evolutions, and migration strategies that underscore this transition, providing a lens through which the future trajectory of .NET, including the anticipation of .NET 9, can be discerned. By offering a deep dive into the comparative performance metrics and the introduction of novel features across versions, this paper caters to IT professionals, students, and technology aficionados seeking to grasp the full extent of .NET's capabilities and its strategic direction. The findings aim to not only delineate the technical advancements but also to contextualize the platform's ongoing innovation within the broader software development ecosystem.

**Keywords:** .NET core, Unified .NET platform, Migration strategies, Performance benchmarking

## INTRODUCTION

Before the advent of .NET Core, the .NET Framework dominated Microsoft's development landscape, tailored primarily for Windows applications. As global software development trends shifted towards more agile, scalable, and cross-platform solutions, the need for a more flexible framework became evident. In response, Microsoft introduced .NET Core, fundamentally designed to address these modern computing requirements with support for modular, cross-platform development across Windows, Linux, and macOS. Launched as an open-source framework, .NET Core represented a significant departure from the traditional .NET Framework. [1] The evolution of the .NET ecosystem, particularly the transition from .NET Core to the unified .NET platform, marks a pivotal shift in the landscape of software development. This journey, which extends to the advent of .NET 8, is not merely a series of technological advancements but a comprehensive strategic realignment towards creating an inclusive, performance-optimized, and feature-rich ecosystem. The cornerstone of this evolutionary path was .NET Core 3.1, celebrated as the last Long-Term Sup-

port (LTS) version within the .NET Core series. It established a robust foundation that catalyzed the seamless transition to subsequent versions, each introducing significant enhancements and capabilities.

This paper aims to dissect the intricate progression from .NET Core 3.1 to .NET 8, providing a granular analysis of performance improvements, feature augmentations, and the nuances of migration strategies. By delving into the evolution of the platform, the analysis is tailored to offer IT professionals, students, and technology enthusiasts a detailed comprehension of .NET's expansive capabilities and its trajectory towards future developments. Furthermore, a preliminary overview of .NET 9 is included, offering insights into the continuing innovation within the .NET ecosystem.

A focus on detailed performance benchmarks and feature analysis will underscore the platform's developmental milestones, illuminating the strategic insights gleaned through its evolution. This paper is committed to mapping out .NET's transformative journey, highlighting the technological and strategic milestones that have underpinned its growth and continue to shape its future.

## .NET CORE OVERVIEW

.NET Core has represented a significant shift in the .NET framework's development, aiming to provide a more modular, cross-platform development experience. [1] It was designed from the ground up to support the development of applications for Windows, Linux, and macOS, thereby broadening the .NET ecosystem beyond its traditional Windows-centric roots. The introduction of .NET Core was a response to the evolving needs of the software development community, emphasizing performance, scalability, and the ability to run in diverse environments.

### Genesis and evolution of .NET Core

.NET Core's journey began as a lean and composable framework that sought to address the emerging trends in software development, including cloud-based applications and microservices architectures. It introduced a side-by-side installation feature, allowing different versions of .NET Core to coexist on the same machine and thus enabling greater flexibility in application deployment and maintenance. Over its lifecycle, .NET Core saw rapid iteration and improvement, with each version bringing performance enhancements, expanded API sets, and better tooling.

### Spotlight on .NET Core 3.1

When .NET Core 3.1 was released in December 2019, it was declared the final and most polished version of the .NET Core series. As an LTS version, it was guaranteed support from Microsoft for three years, making it a stable base for developers looking to build high-performance web and cloud applications. .NET Core 3.1 brought several key features and improvements: [2]

- Enhanced Performance: Continuing the .NET Core tradition, 3.1 improved on its predecessors' performance metrics, offering more efficient memory usage, faster algorithms, and optimizations in the core libraries.
- Desktop application support: With the introduction of Windows Forms and WPF (Windows Presentation Foundation) on Windows, .NET Core 3.1 bridged the gap between modern web application development and traditional desktop application development.
- Improved Container Support: Recognizing the importance of containerization and microser-

vices, .NET Core 3.1 enhanced its capabilities to run more efficiently in containers, including smaller image sizes and more customizable runtime images. [3]

- Platform expansion: - It maintained support for a broad array of operating systems, further solidifying .NET Core's position as a versatile, cross-platform framework.

### Transition to the unified .NET platform

.NET Core 3.1 set the stage for the transition to the unified .NET platform, starting with .NET 5. This transition aimed to bring together the best of .NET Core, .NET Framework, Xamarin, and Mono under a single platform, simplifying the .NET landscape and offering a unified path forward for all types of .NET development. The move represented not just an evolutionary step in terms of features and performance but also a unification of the .NET ecosystems, streamlining the development experience across application types and platforms.

### Prelude to AI integration in .NET 8

Looking beyond .NET Core 3.1, the .NET platform continues to evolve, with .NET 8 introducing AI and machine learning capabilities as a testament to the framework's adaptability and forward-thinking design. These integrations signal a future where .NET is not just about building applications but also about incorporating intelligent features and data-driven insights directly into those applications.

### KEY FEATURE EVOLUTION IN THE .NET PLATFORM

Exploring the significant enhancements and new capabilities introduced with each successive version of the .NET platform, from the foundational .NET Core 3.1 through to the innovative .NET 8, reveals a trajectory of continuous improvement and expansion. This journey reflects Microsoft's dedication to addressing the evolving needs of developers and organizations, through the provision of a versatile and powerful framework capable of supporting the development of modern applications. Here's a closer look at how these features have evolved, emphasizing the platform's adaptability and forward-looking approach.

### From .NET Core 3.1 to Unified Platform

Unified platform transition: .NET 5 marked a pivotal milestone, merging .NET Core, .NET Framework,

Xamarin, and Mono into a single, streamlined framework, simplifying the development ecosystem. [4]

### **C# 9 and F# 5 Enhancements**

Introduced significant language features like records in C# for immutable data models and pattern matching improvements, alongside new F# features to enhance functional programming.

Blazor WebAssembly: Facilitated the development of full-stack web applications with C#, running client-side logic in the browser via WebAssembly, thereby broadening the scope of .NET in web development.

### **Progression with .NET 6: Enhancing Productivity and Performance**

Minimal APIs: Introduced to simplify the creation of HTTP APIs, these APIs reduce the boilerplate code necessary for setting up microservices and small web applications.

C# 10 Innovations: Brought global using directives and record structs, among other features, making code more concise and improving developer productivity.

MAUI Preview: .NET Multi-platform App UI (MAUI) previewed, offering a path toward building cross-platform mobile and desktop apps from a single codebase.

### **.NET 7 Connectivity, Cloud Optimization and Code Refinement**

Language Advancements: C# 11 and F# 6 introduced further enhancements, such as list patterns in C# for more expressive code and syntax improvements in F#.

ASP.NET Core and Blazor Improvements: Significant advancements in web development capabilities, including better Blazor components and SignalR client reconnections, underscored .NET's commitment to web technologies.

.NET MAUI official release: Delivered a robust framework for developing native applications across Android, iOS, macOS, and Windows, streamlining cross-platform development.

### **.NET 8, Integrating AI and expanding capabilities**

AI and Machine Learning Integration: Demonstrated .NET's adaptability by incorporating AI tooling and libraries, empowering developers to build intelligent, data-driven applications. [5]

Continuous Enhancements: Ongoing improvements in C# and core platform features focused on elevating developer productivity, optimizing application performance, and enhancing cross-platform support.

Improved Native Interop: Made it easier to integrate with native libraries, critical for applications requiring high performance and direct access to underlying system capabilities.

### **PERFORMANCE ENHANCEMENTS IN .NET CORE**

.NET Core has undergone significant performance optimizations across its lifecycle, with particular focus on JIT Compiler improvements and Garbage Collector (GC) enhancements. These efforts have been crucial in ensuring that .NET Core remains a robust and efficient framework suitable for a wide range of applications, from desktop and web applications to cloud-based services and microservices architectures. The enhancements to the JIT compiler and garbage collector across the .NET Core versions underscore Microsoft's commitment to performance, efficiency, and the modernization of application development. [6]

Besides that, performance trajectory of the .NET Core platform has been marked by continuous advancements aimed at optimizing startup times, memory usage, computational efficiency, and ensuring consistent performance across multiple operating systems. These enhancements have solidified .NET Core's position as a high-performance, efficient framework suitable for a diverse range of applications.

#### **JIT Compiler Enhancements**

- **Optimized Code Generation:**

Across its evolution, .NET Core's JIT compiler has continually improved its code generation strategies. This includes better inlining of methods (where the code of a called method is inserted into the caller's body), which can significantly reduce call overhead and improve execution speed.

- **Tiered Compilation:**

Introduced and refined over time, tiered compilation helps achieve a balance between fast startup times and optimized application performance. Initially, methods are compiled for quick execution, and as they are identified as frequently used ("hot" methods), they are recompiled with optimizations.

- **Dynamic PGO (Profile-Guided Optimization):**

Enhanced in later versions, Dynamic PGO utilizes runtime performance data to optimize code paths, significantly boosting the efficiency of JIT compilation and overall application performance.

### Garbage Collector (GC) Improvements

- Efficiency and Throughput:

The GC has been optimized for high efficiency and throughput, with specific enhancements aimed at reducing pause times. This means applications experience fewer interruptions for GC, leading to smoother performance.

- Container Support:

As .NET Core embraced containerization, the GC received optimizations for running in container environments. This includes scaling to the available resources and constraints within a container, ensuring applications perform well even in memory-limited situations.

- Concurrent Garbage Collection:

Enhancements to concurrent GC operations have minimized the impact on application responsiveness. This allows the GC to reclaim memory in the background, reducing pauses in the application's execution.

### Cross-Platform Performance Consistency

Ensuring consistent performance across diverse operating systems is a cornerstone of .NET Core's design philosophy. The framework's cross-platform capabilities are supported by comprehensive optimizations to the runtime and framework libraries, which are crucial for optimal performance on Windows, Linux, and macOS. These enhancements focus on modularizing system dependencies and improving access to native APIs, ensuring applications perform efficiently across all platforms. [7]

### Real-World Impact and Benchmarks

Benchmark tests across various versions of .NET Core consistently demonstrate improvements in startup times, memory efficiency, and overall performance. These enhancements contribute to a more robust and scalable application performance, meeting and often exceeding modern application performance expectations.

This approach to performance optimization not only maintains .NET Core's competitiveness but also anticipates future challenges in software develop-

ment, preparing the platform with advanced capabilities like Blazor for web assembly and .NET MAUI, and integrating AI tools in .NET 8. These innovations underscore .NET's readiness to embrace emerging technologies and adapt to the evolving landscape of software development.

## PRACTICAL PERFORMANCE ANALYSIS IN THE .NET ECOSYSTEM

### A. Definition of Benchmarking Environment

This section focuses on the practical implementation of performance benchmarking within the .NET ecosystem. Providing accurate results requires a detailed definition of the hardware and software characteristics used in the benchmarking process. This segment provides basic information about the hardware and software configuration to enable precise comparison of performance across different versions of the .NET framework.

The specification of the laptop used for benchmarking is as follows:

- 11th Gen Intel(R) Core(TM) i7-1165G7 @ 2.80GHz 2.80 GHz
- 16GB DDR4 RAM
- SK Hynix PC711 512GB
- Windows 10 Pro

In the benchmarking process, three key versions of the .NET framework were used for performance comparison. Versions .NET Core 3.1, .NET 6.0, .NET 7.0, and .NET 8.0 were analyzed. Each version was carefully selected to explore potential performance differences and any optimizations implemented in newer versions.

BenchmarkDotNet was used as the benchmarking tool, widely accepted and recognized tool in the .NET community for measuring performance. BenchmarkDotNet provides a flexible and reliable framework for conducting benchmark tests, enabling automatic management of many details such as measurement stability, error handling, and precise result comparison. Thanks to its simplicity and power, BenchmarkDotNet is an ideal tool for performing detailed performance analysis in the .NET ecosystem. BenchmarkDotNet has already been adopted by over 19,100 GitHub projects, including .NET Runtime, .NET Compiler, .NET Performance, and many others. [8]



Benchmarking process included the following steps:

*Environment preparation:* System configuration was standardized to ensure test consistency. This involved setting up appropriate versions of the .NET framework and ensuring all relevant software and hardware parameters remained constant throughout all tests.

*Test execution:* Each version of the .NET framework was tested using the same set of tests, which included various types of loads and scenarios to obtain a comprehensive performance picture.

*Results analysis:* Results were collected and analyzed using BenchmarkDotNet, which provides detailed reports including metrics such as execution time, memory consumption, and performance stability.

### Limitations and potential biases

While the methodology was carefully designed, there are certain limitations and potential biases to consider:

*Hardware limitations:* Performance may vary depending on hardware configuration. Although using the same system for all tests reduced variability, results may differ on other systems.

*Software variables:* Operating system versions, drivers, and other software components can affect performance. Testing was conducted on Windows 10 Pro, but different configurations may yield different results.

*Benchmarking tool:* Although BenchmarkDotNet is a reliable tool, every benchmarking tool has its limitations and may introduce certain biases into results. For example, optimizations specific to BenchmarkDotNet may affect real-world application performance.

*External variables:* External factors such as background processes and system state can influence test results, despite efforts to minimize such influences.

### B. Time Comparison of Compute-Intensive Operations

This section explores the time difference between the execution of compute-intensive operations, including computing SHA256 and MD5 hash values, on different versions of .NET Framework: .NET Core 3.1, .NET 6.0, .NET 7.0 and .NET 8.0. The aim is to compare the performance of these operations across different framework versions and identify potential differences in speed between them.

SHA256 (Secure Hash Algorithm 256-bit) and MD5 (Message Digest Algorithm 5) are cryptographic hash algorithms used to generate unique digital signatures or “hash” values from input data. These algorithms apply mathematical functions to input data to generate a unique string of bits representing the digital fingerprint or “hash” of the original data. For testing purposes, a bit array value of 10,000 was used.

```
[SimpleJob(RuntimeMoniker.NetCoreApp31)]
[SimpleJob(RuntimeMoniker.Net60)]
[SimpleJob(RuntimeMoniker.Net70)]
[SimpleJob(RuntimeMoniker.Net80)]
1 reference
public class Md5VsSha256
{
    private const int N = 10000;
    private readonly byte[] data;

    private readonly SHA256 sha256 = SHA256.Create();
    private readonly MD5 md5 = MD5.Create();

    0 references
    public Md5VsSha256()
    {
        data = new byte[N];
        new Random(42).NextBytes(data);
    }

    [Benchmark]
    0 references
    public byte[] Sha256() => sha256.ComputeHash(data);

    [Benchmark]
    0 references
    public byte[] Md5() => md5.ComputeHash(data);
}
```

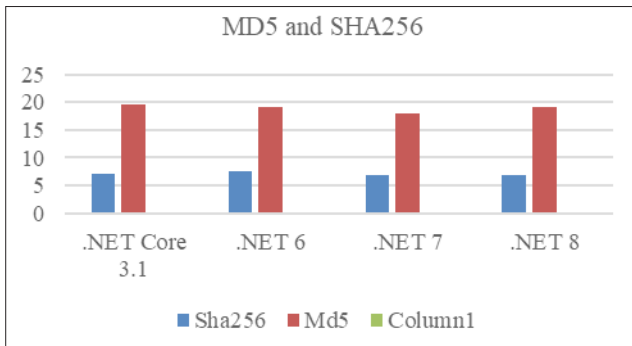
Figure 1. MD5 vs SHA256 benchmark code

When the SHA256 or MD5 algorithm is applied to a dataset, the resulting hash value will be unique for that dataset. Even the slightest change in the input data will produce a completely different hash value.

Table 1. Comprehensive overview of the results of execution of MD5 and SHA256 algorithms on different versions of .NET

Method	Job	Runtime	Mean	Error	StdDev	Median
Sha256	.NET 6.0	.NET 6.0	7.401 µs	0.2467 µs	0.7118 µs	7.447 µs
Md5	.NET 6.0	.NET 6.0	19.447 µs	0.6093 µs	1.7579 µs	19.075 µs
Sha256	.NET 7.0	.NET 7.0	7.138 µs	0.1528 µs	0.4432 µs	6.940 µs
Md5	.NET 7.0	.NET 7.0	17.879 µs	0.3436 µs	0.3375 µs	17.911 µs
Sha256	.NET 8.0	.NET 8.0	6.889 µs	0.1256 µs	0.1880 µs	6.816 µs
Md5	.NET 8.0	.NET 8.0	19.079 µs	0.3755 µs	0.3856 µs	19.167 µs
Sha256	.NET Core 3.1	.NET Core 3.1	7.030 µs	0.1207 µs	0.1983 µs	6.996 µs
Md5	.NET Core 3.1	.NET Core 3.1	20.064 µs	0.6292 µs	1.8254 µs	19.674 µs

Results show that the performance of SHA256 and MD5 algorithms has improved with each new version of the .NET framework. The average execution time of the SHA256 algorithm decreases from .NET 6.0 to .NET 8.0, suggesting continuous performance improvement. A similar trend is observed with the MD5 algorithm. However, in all versions of the .NET framework, the SHA256 algorithm demonstrates faster execution time compared to the MD5 algorithm. This indicates superior performance of the SHA256 algorithm in this specific benchmark test.



Graph 1. Comprehensive overview of the results of execution of MD5 and SHA256 algorithms on different versions of .NET

The standard deviations for both algorithms are low, suggesting consistent performance and reliable results. Overall, the results demonstrate a positive evolution of performance for cryptographic algorithms in the .NET ecosystem over time.

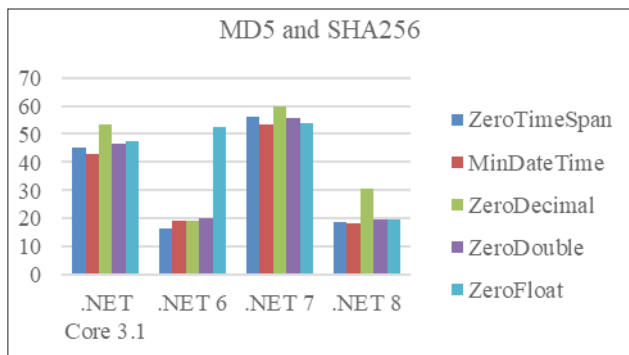
### C. Time Comparison of Asynchronous Operations Execution

In this section of the research, we will focus on the comparative analysis of executing asynchronous operations in different versions of the .NET framework. The asynchronous approach enables efficient management of execution time for operations that require waiting for I/O operations or processing long-running tasks. Through this research, we aim to assess how the performance of asynchronous operations differs between different versions of the .NET framework, as well as to identify any improvements or changes in execution time in newer framework versions. This is important to understand the impact of the evolution of the .NET platform on the efficiency of asynchronous programming and potential opportunities for optimizing coding.

```
[MarkdownExporter, AsciiDocExporter, HtmlExporter, CsvExporter, RPlotExporter]
[SimpleJob(RuntimeMoniker.Net60)]
[SimpleJob(RuntimeMoniker.Net70)]
[SimpleJob(RuntimeMoniker.Net80)]
[MemoryDiagnoser(true)]
<?xml-namespace?>
public class Tests
{
    [Benchmark] public async Task<TimeSpan> ZeroTimeSpan() => TimeSpan.Zero;
    [Benchmark] public async Task<DateTime> MinDateTime() => DateTime.MinValue;
    [Benchmark] public async Task<Guid> EmptyGuid() => Guid.Empty;
    [Benchmark] public async Task<DayOfWeek> Sunday() => DayOfWeek.Sunday;
    [Benchmark] public async Task<decimal> ZeroDecimal() => 0m;
    [Benchmark] public async Task<double> ZeroDouble() => 0;
    [Benchmark] public async Task<float> ZeroFloat() => 0;
    [Benchmark] public async Task<Half> ZeroHalf() => (Half)0f;
    [Benchmark] public async Task<(int, int)> ZeroZeroValueTuple() => (0, 0);
}
```

Figure 2. Async methods for benchmark

Benchmark tests represent asynchronous methods that return different types of data with fixed values (Figure 2.). Each method returns a unique data type with its corresponding fixed value, such as TimeSpan.Zero, DateTime.MinValue, Guid.Empty, DayOfWeek.Sunday, 0m, 0, 0f, (Half)0f, and (0, 0) for the value type Tuple. The goal of these tests is to measure the execution time of asynchronous operations that return constant values. This approach enables the assessment of the efficiency of asynchronous execution for different data types and can provide insights into performance and potential optimizations in working with this data in the .NET ecosystem.



Graph 2. Comprehensive overview of the results of execution async operation

Table 2. Comprehensive overview of the results of execution async operation

Method	Job	Runtime	Mean	Error	StdDev	Median	Gen0	Allocated
ZeroTimeSpan	NET 6.0	NET 6.0	16.71 ns	0.322 ns	0.251 ns	16.65 ns	0.0013	72 B
MinDateTime	NET 6.0	NET 6.0	19.90 ns	0.655 ns	1.900 ns	19.22 ns	0.0013	72 B
EmptyGuid	NET 6.0	NET 6.0	19.73 ns	0.714 ns	2.060 ns	19.40 ns	0.0015	80 B
Sunday	NET 6.0	NET 6.0	15.68 ns	0.264 ns	0.441 ns	15.58 ns	0.0013	72 B
ZeroDecimal	NET 6.0	NET 6.0	19.07 ns	0.319 ns	0.266 ns	19.08 ns	0.0015	80 B
ZeroDouble	NET 6.0	NET 6.0	22.04 ns	2.066 ns	5.862 ns	20.28 ns	0.0013	72 B
ZeroFloat	NET 6.0	NET 6.0	50.35 ns	3.051 ns	8.948 ns	52.36 ns	0.0013	72 B
ZeroZeroValueTuple	NET 6.0	NET 6.0	48.09 ns	1.057 ns	2.858 ns	47.85 ns	0.0013	72 B
ZeroTimeSpan	NET 7.0	NET 7.0	56.11 ns	1.277 ns	3.764 ns	51.99 ns	0.0013	72 B
MinDateTime	NET 7.0	NET 7.0	54.24 ns	1.147 ns	2.769 ns	53.63 ns	0.0013	72 B
EmptyGuid	NET 7.0	NET 7.0	58.58 ns	1.242 ns	3.564 ns	57.68 ns	0.0014	80 B
Sunday	NET 7.0	NET 7.0	54.30 ns	1.431 ns	4.221 ns	53.64 ns	0.0013	72 B
ZeroDecimal	NET 7.0	NET 7.0	59.73 ns	1.257 ns	3.440 ns	59.65 ns	0.0014	80 B
ZeroDouble	NET 7.0	NET 7.0	56.13 ns	1.191 ns	2.908 ns	55.65 ns	0.0013	72 B
ZeroFloat	NET 7.0	NET 7.0	54.54 ns	1.177 ns	3.470 ns	53.94 ns	0.0013	72 B
ZeroZeroValueTuple	NET 7.0	NET 7.0	57.60 ns	1.224 ns	3.340 ns	57.48 ns	0.0013	72 B
ZeroTimeSpan	NET 8.0	NET 8.0	18.97 ns	0.460 ns	1.127 ns	18.54 ns	-	-
MinDateTime	NET 8.0	NET 8.0	18.65 ns	0.433 ns	0.826 ns	18.40 ns	-	-
EmptyGuid	NET 8.0	NET 8.0	21.04 ns	0.501 ns	1.151 ns	20.71 ns	-	-
Sunday	NET 8.0	NET 8.0	18.15 ns	0.374 ns	0.545 ns	18.13 ns	-	-
ZeroDecimal	NET 8.0	NET 8.0	29.73 ns	1.125 ns	3.245 ns	30.51 ns	-	-
ZeroDouble	NET 8.0	NET 8.0	20.03 ns	0.469 ns	1.141 ns	19.71 ns	-	-
ZeroFloat	NET 8.0	NET 8.0	19.59 ns	0.475 ns	0.856 ns	19.55 ns	-	-
ZeroZeroValueTuple	NET 8.0	NET 8.0	27.59 ns	0.614 ns	0.603 ns	27.56 ns	-	-
ZeroTimeSpan	NET Core 3.1	NET Core 3.1	45.44 ns	0.965 ns	1.444 ns	45.32 ns	0.0012	72 B
MinDateTime	NET Core 3.1	NET Core 3.1	43.29 ns	0.725 ns	0.564 ns	42.91 ns	0.0012	72 B
EmptyGuid	NET Core 3.1	NET Core 3.1	55.01 ns	1.140 ns	1.561 ns	55.01 ns	0.0013	80 B
Sunday	NET Core 3.1	NET Core 3.1	46.49 ns	2.005 ns	5.818 ns	47.45 ns	0.0012	72 B
ZeroDecimal	NET Core 3.1	NET Core 3.1	51.17 ns	1.131 ns	2.360 ns	53.21 ns	0.0013	80 B
ZeroDouble	NET Core 3.1	NET Core 3.1	47.21 ns	1.019 ns	2.518 ns	46.79 ns	0.0012	72 B
ZeroFloat	NET Core 3.1	NET Core 3.1	47.66 ns	1.020 ns	2.106 ns	47.47 ns	0.0012	72 B
ZeroZeroValueTuple	NET Core 3.1	NET Core 3.1	47.94 ns	1.020 ns	2.013 ns	47.79 ns	0.0012	72 B

By analyzing the obtained results, we can conclude that the average execution time of asynchronous operations is significantly lower when using the .NET 8.0 version. Let's compare the execution times of the ZeroFloat method across different versions of .NET. When executed on version 8.0, the time obtained was 19.55ns, on version 7.0 it was 53.94ns, on version 6.0 it was 52.36ns, while on version .NET Core 3.1 it was 47.47ns. We see that the difference in time is significant. The situation is similar with other methods used in the measurement. ZeroDecimal method can also be singled out, which had the shortest time when using .NET 6.0 version - 19.08ns, .NET 7.0 version - 59.65ns, .NET 8.0 version - 30.51ns, .NET Core 3.1 - 53.21ns. ZeroDecimal is the method that gave the longest execution time during measurement using .NET 8.0.

### D. Use of GC advancements in .NET 8 version

In .NET 8, the GC (Garbage Collection) server now supports a dynamic heap count. In .NET 8, it is generally off by default but can be enabled by adding the <GarbageCollectionAdaptationMode>1</GarbageCollectionAdaptationMode> property within MS-Build. The employed algorithm can increase and decrease the heap count over time, aiming to maximize its view of throughput while maintaining a balance between that and the overall memory footprint. A scenario demonstrating how the GC operates within .NET 8 is depicted in Figure 3.

```

for (int i = 0; i < 32; i++)
{
    new Thread(() =>
    {
        while (true) Array.ForEach(new byte[1], b => { });
    }).Start();
}
using Process process = Process.GetCurrentProcess();

while (true)
{
    process.Refresh();
    Console.WriteLine($"{process.WorkingSet64:#0}");
    Thread.Sleep(1000);
}
    
```

Figure 3. Threads and GC usage code

The example creates a multitude of threads that continuously allocate, and then repeatedly prints out the working set of memory. In Figures 4a, b, c and d we can see the working sets without the GarbageCol-

lectionAdaptationMode property, while in Figure 4e, the property is set and enabled. There we can observe a significant decrease in the working set.

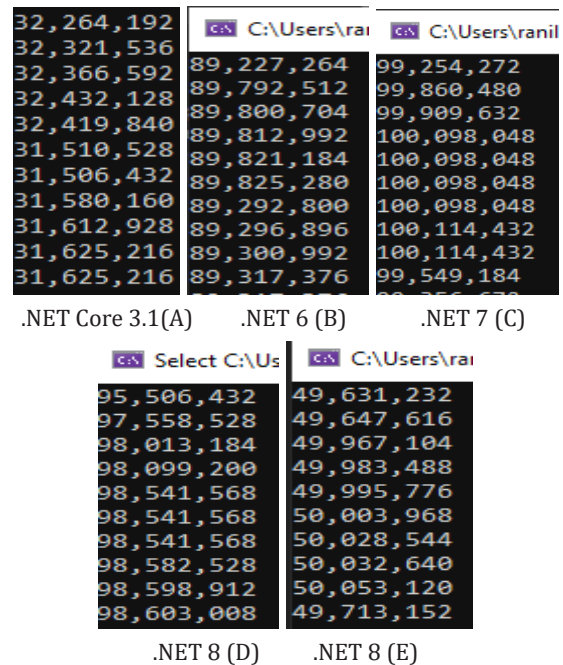


Figure 4. Result of execute code (GC)

In conclusion, activating and configuring the GarbageCollectionAdaptationMode property in .NET 8 significantly reduces the working set of memory. This indicates more efficient memory management and potentially better application performance, especially in situations where the number of heaps dynamically adjusts. Therefore, properly configuring the GarbageCollectionAdaptationMode property can contribute to performance optimization and reduce the resources required for application execution.

Upon analysis of the practical work, it becomes evident that .NET 8 introduces numerous performance enhancements, some of which have not been thoroughly explored. Further investigation into additional practical cases not covered in this study reveals significant differences in the utilization of .NET 8 compared to older versions.

### E. Limitations of the Study

Scope of Tests: Benchmarking was conducted using a specific set of tests and scenarios. This means that certain edge cases or specific workloads that might impact performance in real-world applications were not covered. The tests focused on general



performance rather than specific scenarios that may have different requirements.

*Statistical Analysis:* The number of test iterations and variability in the results were controlled, but a small number of iterations can lead to less reliable conclusions. Increasing the number of test iterations could provide more stable and representative performance data.

*Update Frequency:* The .NET framework is regularly updated, which means the tested versions can quickly become outdated. This can limit the relevance of the results over time, as newer versions with different performance characteristics are released.

## F. Upcoming .NET 9 release

### *Platform for Cloud-Native Development:*

.NET 9 will further improve runtime performance and application monitoring, making applications faster and more stable. With .NET Aspire, cloud application development becomes less complex and more cost-effective. Optimizing applications for Native AOT and trimming will reduce application size and improve execution speed.

### *Tools for Cloud-Native Development:*

Visual Studio and Visual Studio Code will gain support for Native AOT, enabling developers to more easily compile and deploy applications across various platforms. Enhanced integration with Azure Container Apps will simplify scaling applications and managing resources in a cloud environment.

### *Integration with Artificial Intelligence:*

.NET 9 will enable developers to more easily integrate AI functionality into their applications through new libraries and documentation for working with OpenAI and OSS models. Collaboration on projects such as Semantic Kernel and Azure SDK will ensure a rich experience in developing intelligent applications.

### *Backlog and Future Plans:*

The .NET team will regularly update the backlog and release notes, introducing new features and optimizations based on feedback from the community and industry partners. Ongoing experiments may become part of future releases, ensuring the platform's continuous evolution.

## *Impact on the Broader Software Development Landscape:*

These improvements will increase developer productivity, enabling faster development and deployment of applications. Enhancements in performance and scalability will result in more efficient and responsive applications, while advanced security solutions will help protect data and ensure regulatory compliance. Broader support for cross-platform development will lower entry barriers and enable more developers to use .NET for developing diverse applications in various environments.

## G. Potential for Further Research

*Long-term Performance:* Additional research that includes long-term performance and stability of different .NET framework versions could provide deeper insights into the efficiency and reliability of the platform.

*Real-world Scenarios:* Including case studies from the real world and various industrial applications can help understand how specific features and improvements impact performance in real conditions.

*Comparative Analysis:* Further research that includes comparisons with other development platforms and languages can provide a broader context and help assess the relative advantages and disadvantages of the .NET ecosystem.

## CONCLUSION

The journey from .NET Core to .NET 8 represents a remarkable chapter in the evolution of the .NET ecosystem, marked by significant advancements in performance, a broadening of features, and the simplification of migration pathways for developers. Through the analysis of performance improvements, feature enhancements, and migration considerations, this paper has illuminated the strategic and technological evolution that has taken place within the .NET framework, culminating in the release of .NET 8.

.NET Core 3.1 laid the groundwork with its robust foundation, setting a high standard for performance and reliability. From there, each subsequent version of .NET has introduced enhancements and new capabilities, demonstrating Microsoft's commitment to innovation and its responsiveness to the needs of the development community. The integration of AI and machine learning capabilities in .NET 8 is particularly



notable, signaling a forward-looking approach to application development.

Looking ahead, the upcoming release of .NET 9 promises to continue this trajectory of innovation. With the .NET ecosystem now firmly established as a unified platform, future versions are poised to delve deeper into the realms of AI, machine learning, and other cutting-edge technologies. The emphasis on performance optimization, feature richness, and ease of migration will undoubtedly remain central, ensuring that .NET continues to be a leading framework for developers worldwide.

In conclusion, the transition from .NET Core to .NET 8 and beyond exemplifies the dynamic and evolving nature of the .NET ecosystem. This evolution reflects a broader trend in software development towards more efficient, flexible, and intelligent solutions. As the .NET framework continues to advance, it will undoubtedly play a pivotal role in shaping the future of software development, empowering developers to create innovative applications that address the complex challenges of the digital age.

## REFERENCES

[1] Microsoft. (2016). Introducing .NET Core. .NET Blog. Accessed April 15, 2024. [Online]. Available: <https://devblogs.microsoft.com/dotnet/introducing-net-core/>

- [2] Microsoft. (2019). "Announcing .NET Core 3.1". Accessed April 18, 2024. [Online]. Available: <https://devblogs.microsoft.com/dotnet/announcing-net-core-3-1/>.
- [3] Microsoft. (2019). "Performance improvements in .NET Core 3.1". Accessed April 18, 2024. [Online]. Available: <https://docs.microsoft.com/en-us/dotnet/core/whats-new/dotnet-core-3-1>.
- [4] Microsoft. (2020). "The journey to one .NET". Accessed April 18, 2024. [Online]. Available: <https://devblogs.microsoft.com/dotnet/the-journey-to-one-net/>.
- [5] Microsoft. (2022). "Machine Learning with ML.NET". Accessed April 20, 2024. [Online]. Available: <https://dotnet.microsoft.com/en-us/apps/machinelearning-ai/ml-dotnet>.
- [6] Microsoft. (2021). "Performance improvements in .NET 6". Accessed April 18, 2024. [Online]. Available: <https://docs.microsoft.com/en-us/dotnet/core/whats-new/dotnet-6>.
- [7] Microsoft. (2021). "Performance best practices with ASP.NET Core". Accessed April 18, 2024. [Online]. Available: <https://docs.microsoft.com/en-us/aspnet/core/performance/performance-best-practices>.
- [8] BenchmarkDotNet. "Home - BenchmarkDotNet Documentation." BenchmarkDotNet, Accessed March 24, 2024. [Online]. Available: <https://benchmarkdotnet.org/>.
- [9] Akinshin, A. (2018). "Pro .NET Benchmarking: The Art of Performance Measurement." Apress.
- [10] Roth, D., & Price, M. J. (2018). "Migrating to .NET Core: Rebuilding Enterprise Applications." Apress.

Received: May 13, 2024

Accepted: May 24, 2024

## ABOUT THE AUTHORS



**Branimir Cvijić** received the B.Sc. and M.Sc. degrees in computer engineering and informatics from the University of Banja Luka (Banja Luka, Bosnia and Herzegovina) in 2009 and 2014, respectively. He worked in Lanaco d.o.o, Banja Luka, as senior software architect from 2009 to 2021. Since 2021 works in Endava as Software development consultant - Development lead. His specialisation is in software and databases development using enterprise tools. His research interests are Internet of things using enterprise tools for development and integration in different areas of industry.



**Pero Ranilović** was born in the city of Prijedor (Republic of Srpska, BiH). Graduated from high school in Novi Grad. Bachelor's degree in Programming and Software Engineering earned at the Faculty of Information Technology at Pan-European University "APEIRON" in Banja Luka.

Master's degree pursued at the Faculty of Information Technology at Pan-European University "APEIRON" in Banja Luka. Since 2018, he has been employed as a software developer at Lanaco. Employed as a software developer in Lanaco, since 2018. In addition, hired as a teaching assistant at Pan-European University "APEIRON".

## FOR CITATION

Branimir Cvijić, Pero Ranilović, From .NET Core to .NET 8: A Comprehensive Analysis of Performance, Features, and Migration Pathways, *JITA - Journal of Information Technology and Applications*, Banja Luka, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosnia i Hercegovina, JITA 14(2024)1:69-77, (UDC: 004.432.2C#:004.738-.1), (DOI: 10.7251/JIT2401069C, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# COMPARISON OF AGILE AND DEVOPS METHODOLOGIES: ANALYSIS OF EFFICIENCY, FLEXIBILITY, AND APPLICATION IN SOFTWARE DEVELOPMENT

Vladimir Radovanović<sup>1</sup>, Olja Krčadinac<sup>2</sup>, Jasmina Perišić<sup>3</sup>, Marina Milovanović<sup>4</sup>,  
Željko Stanković<sup>5</sup>

<sup>1</sup>*Elektromreža Srbije a.d., Belgrade, Serbia, Kneza Milosa 11, 1112vlada1995@gmail.com, 0009-0001-8363-5903*

<sup>2</sup>*"Union – Nikola Tesla" University, Faculty of Informatics and Computer science, Belgrade, Serbia, Cara Dusana 42-46, okrcadinac@unionnikolatesla.edu.rs, 0000-0002-6299-371X*

<sup>3</sup>*"Union – Nikola Tesla" University, Faculty of Informatics and Computer science, Belgrade, Serbia, Cara Dusana 42-46, jperisic@unionnikolatesla.edu.rs, 0000-0001-7412-7870*

<sup>4</sup>*"Union – Nikola Tesla" University, Faculty of Entrepreneurial Business and Real Estate Management, Belgrade, Serbia, Cara Dusana 42-46, mmilovanovic@unionnikolatesla.edu.rs, 0000-0002-3778-0026*

<sup>5</sup>*Pan-European APEIRON University, Banja Luka, B&H, Vojvode Pere Krece 13, stanz@medianis.net, 0000-0002-9893-9088*

Review paper

<https://doi.org/10.7251/JIT2401078R>

UDC: 004.421.2:519.676

**Abstract:** This paper provides a concise overview of Agile and DevOps methodologies in software engineering. It aims to introduce readers to the fundamental principles of Agile and DevOps, accompanied by brief descriptions and practical examples. The advantages and disadvantages of each methodology are discussed, followed by a comparative analysis highlighting key differences. Understanding these methodologies is crucial in today's IT landscape, as they are commonly employed in various organizations, impacting project management, team collaboration, and product delivery. This paper serves as a valuable resource for individuals seeking a basic understanding of Agile and DevOps methodologies in software engineering.

**Keywords:** Agile methodology, DevOps methodology, software engineering, comparative analysis, software development

## INTRODUCTION

In the realm of software development, Agile and DevOps methodologies stand out as transformative approaches that have revolutionized project management and delivery processes. Agile methodologies, characterized by iterative and collaborative development cycles, have become synonymous with adaptability and responsiveness to changing requirements. On the other hand, DevOps methodologies emphasize the integration of development and operations teams, promoting automation, continuous delivery, and streamlined workflows.

In this study, we delve into the comparison of Agile and DevOps methodologies, focusing on their efficiency, flexibility, and application in software development. Specifically, we hone in on the widely recognized Agile methodologies of SCRUM and Extreme Programming (XP), examining their core principles,

implementation strategies, and real-world impacts. Seventeen researchers convened during a conference to collaboratively formulate a document recognized as the Agile Manifesto (Pacagnella Junior & Da Silva, 2023). The Agile Manifesto as a document for the software development process relies on 4 values and 12 principles. The values are: Individuals and Interaction, Software that Works (Applicable Software), Collaboration with Customers, and Response to Change (Cobb, 2023).

The significance of this comparison lies in the nuanced understanding it offers to organizations seeking to optimize their software development processes. By evaluating the strengths and limitations of Agile and DevOps methodologies, we aim to provide valuable insights that can inform decision-making, enhance project outcomes, and drive innovation in the software engineering domain. There are several

types of agile methodologies, the most important of which are SCRUM, Extreme Programming (XP), Kanban, Feature driven development, Lean software development and others (Tetteh, 2024).

Through a combination of qualitative and quantitative analyses, we dissect the effectiveness of these methodologies, considering factors such as team collaboration, project adaptability, time-to-market, and overall project success rates. Our findings not only contribute to the academic discourse but also offer practical guidance for practitioners and industry leaders navigating the complexities of modern software development.

### EVALUATION METHODS FOR AGILE AND DEVOPS Comparison

For the analysis of data collected in this study, we employed a combination of qualitative and quantitative analytical methods. These methods were chosen to provide a comprehensive understanding of the efficiency and flexibility of Agile and DevOps methodologies in software development. One of the primary analytical methods utilized was qualitative text analysis. This approach involved systematically reviewing and coding textual data obtained from relevant literature. Through thematic analysis, we identified key patterns, themes, and insights related to the implementation and impact of Agile and DevOps methodologies. To facilitate the analysis process, we utilized various tools and software packages. For the analysis of qualitative data in our research, we utilized Python, an open-source programming language that offers various modules and libraries for text processing. By leveraging Python, we had the flexibility to tailor analytical processes to our specific research needs, including text preprocessing, pattern identification, and insights generation from our data.

Almeida et al. highlighted the benefits of combining Agile and DevOps methodologies for handling complex customer requirements. Through qualitative analysis of twelve case studies, it identifies twelve benefits, including process automation, improved team communication, and reduced time to market. The research concludes that while Agile and DevOps have distinct goals, their combined adoption offers significant advantages for organizations. This study is crucial for comparing Agile and DevOps technologies

as it systematically analyzes the benefits of their combined adoption, providing insights into their impact on organizational efficiency and competitiveness (Almeida, Simões, & Lopes, Exploring the benefits of combining devops and agile, 2022).

Masud et al. propose integrating DevOps principles into Agile to create a hybrid DevOps Enabled Agile methodology for software development, addressing collaboration gaps and skill requirements. A pilot project demonstrates how this integration improves speed and quality in software development. This is important for comparing Agile and DevOps technologies as it shows their combined benefits in overcoming implementation limitations and enhancing development processes (Al Masud & et al., 2022). Researchers explore how small software companies with limited resources can adopt agile and DevOps frameworks more effectively. Three best practices based on DevOps were identified, which can be integrated within SCRUM, particularly beneficial for small companies. Through a case study in three small companies, these practices showed improvements in customer support and deployment success, highlighting the importance of integrating DevOps approaches into agile methodologies to enhance software development processes and achieve better product quality (Almeida, Simões, & Lopes, Exploring the benefits of combining devops and agile, 2022).

Jayakody in his research (Jayakody & Wijayanayake, 2021) focuses on analyzing the utilization of the DevOps concept in IT projects, with a specific emphasis on challenges and strategies for success. In relation to the paper describing DevOps as a key component for enhancing performance in software development and operations (Langerman & Leung, 2023), the updated information in our research indicates a continuous increase in the significance of DevOps methodologies within the industry. Recent developments in the Agile and DevOps domains affirm the importance of integrating operations and software development to ensure efficiency and adaptability of organizations. Studies have demonstrated that organizations successfully implementing the DevOps approach have accelerated software delivery and ensured continuous delivery of value to customers. Additionally, evidence from the literature suggests that recent advancements in tools and practices within DevOps methodologies have supported the concepts

described in the cited paper, highlighting their role in enhancing organizational performance. For instance, the emergence of new tools for process automation and infrastructure management has enabled teams to more effectively manage software development and delivery, providing further support for the idea of DevOps as a means to improve performance in software development and operations. By analyzing the literature, we noticed that improved internal communication among teams using Agile and DevOps methodologies often results in greater efficiency in software development. This theme supported previous findings in the literature that highlighted that good communication among team members can significantly improve productivity and reduce the risk of errors in software development. The conclusion of our research confirms that the effectiveness of Agile and DevOps methodologies can be directly related to improved communication between teams.

## RESULTS

The results obtained from the analytical methods were interpreted in conjunction with theoretical frameworks and existing literature on Agile and DevOps methodologies. To ensure the validity and reliability of our findings, we employed strategies such as triangulation of data sources, peer review, and validation through expert feedback.

In the realm of software development methodologies, Agile and DevOps stand out as two prominent approaches that have revolutionized the industry (Maroukian, 2021). Agile methodologies prioritize iterative development, customer collaboration, and responding to change over rigid planning and documentation (Heeager & Nielsen, 2020). This approach has proven highly effective in delivering value to customers through incremental improvements and rapid feedback loops.

On the other hand, DevOps focuses on collaboration between development and operations teams, emphasizing automation and continuous integration (Srivastav, Allam, & Mustyala, 2023). DevOps aims to streamline the software delivery process, reduce manual errors, and accelerate time-to-market by breaking down silos and fostering a culture of shared responsibility.

Agile excels in fostering agility, adaptability, and customer-centricity, while DevOps enhances efficien-

cy, collaboration, and automation across the entire software development lifecycle.

The table below presents a comparison between Agile and DevOps methodologies across various parameters crucial for software development. The parameters were selected through this research based on their significance in understanding the strengths and characteristics of each methodology.

**Table 1.** Comparison of Agile and DevOps Methodologies: Key Parameters

Parameter	Agile	DevOps
Customer Focus	High	High
Iterations	Regular	Continuous
Process Automation	Partial	High
Team Collaboration	Centralized	Integrated
Delivery Speed	Fast	Very Fast
Software Quality	High	Very High
Development-Operations Integration	Partial	Full
Flexibility in Changes	High	Very High
Security Integration	Low	High
Scalability	Moderate	High
Resource Efficiency	Moderate	High

Examining the parameters in the table 1 comparing Agile and DevOps methodologies in software development, we observe significant differences and similarities between these two approaches. For instance, while both methodologies are highly focused on user needs and software quality, DevOps methodology stands out for its capability of continuous software delivery and high degree of process automation. On the other hand, Agile methodology emphasizes regular iterations and centralized team collaboration. Although there is partial integration between development and operations in Agile methodology, DevOps aims for full integration to facilitate continuous software delivery and maintenance.

To quantify the terms *fast* and *high*, we established clear criteria reflecting specific aspects of delivery speed and software quality. For instance, delivery speed was defined as the average time required to deliver a software product or the frequency of software releases within a given timeframe. Fast defined as an average release cycle of 1-2 weeks, while *Very Fast* could defined as an average release cycle of less than 1 week. As for software quality, we quantified



it through various metrics, including the number of bugs or defects identified in the software, customer satisfaction ratings, or adherence to predefined quality standards.

Through this analysis, we conclude that both methodologies have their strengths and weaknesses, but they can complement each other when used together. Integrating DevOps principles within Agile methodology can contribute to more efficient team collaboration, faster software delivery, and improved product quality. Our study suggests that organizations should consider a hybrid approach combining the best aspects of Agile and DevOps methodologies to achieve optimal results in software development. This may involve implementing DevOps principles such as process automation, continuous testing, and security integration within the Agile development framework to support rapid and high-quality software development.

The parameters included in the table were carefully selected based on their relevance to the comparison between Agile and DevOps methodologies in software development. Each parameter was chosen to highlight key characteristics of both methodologies and facilitate a clear comparison between them. For instance, parameters such as “Customer Focus” and “Software Quality” were selected to emphasize the importance of meeting customer needs and ensuring high-quality software products. Conversely, parameters like “Process Automation” and “Delivery Speed” were chosen to underscore the differing approaches between Agile and DevOps methodologies.

The selection of these parameters was guided by the research focus and objectives, aiming to provide meaningful insights that support the study’s conclusions and contribute to a comprehensive understanding of the differences between Agile and DevOps methodologies in the context of software development.

## DISCUSSION

Our comparative analysis between Agile and DevOps methodologies reveals significant differences and similarities across key parameters. While both methodologies prioritize customer focus, iteration, and software quality, DevOps stands out with its emphasis on process automation, delivery speed, and integration between development and operations

teams. Agile, on the other hand, excels in team collaboration and iterative improvements. The findings have important implications for software development practices. Organizations using Agile, DevOps, or a combination of both can benefit from understanding the strengths and challenges of each methodology. Integrating DevOps principles into Agile methodology can lead to enhanced team efficiency and streamlined development processes.

Our research offers practical insights into the implementation of Agile and DevOps methodologies. For example, integrating automation tools and continuous integration practices can improve delivery speed and quality. Furthermore, fostering a culture of collaboration and continuous improvement is essential for success in both methodologies.

While our study provides valuable insights, it is important to acknowledge its limitations. Future research could explore the long-term impact of integrating Agile and DevOps, as well as delve deeper into specific industry contexts or organizational sizes to uncover more nuanced findings. Based on our results, we recommend organizations consider a hybrid approach that combines the strengths of Agile and DevOps. This could involve adopting DevOps principles such as automation, continuous integration, and collaboration within Agile development cycles. Additionally, investing in training and tools to support this integration can lead to improved software delivery and customer satisfaction (Faustino, Adriano, Amaro, Pereira, & da Silva, 2022). Case studies are valuable for gaining deeper insights into specific implementations of Agile and DevOps methodologies in real-world settings. However, it is important to acknowledge that the limited number of case studies may restrict the generalizability of the results to broader populations of organizations. Our study relied on a restricted number of case studies, which may impact the broader applicability across different industries or project sizes.

In light of these limitations, we recommend further research that includes a larger number of case studies or encompasses different industries and project sizes. A larger sample of case studies would provide a broader perspective and contribute to a better understanding of the effects of Agile and DevOps methodologies in various contexts. For instance, future research could explore how industry-specific

characteristics or project sizes influence the success of implementing these methodologies, providing additional insights for organizations planning their implementation.

In the context of growing cybersecurity threats, it is important to consider how Agile and DevOps methodologies can adapt to enhance security and respond to threats (Friman, 2024). This is particularly crucial given the increasing digitization of businesses and the sophistication of attacks that organizations may face. One key way Agile and DevOps methodologies can adapt to strengthen security is by integrating security testing in the early stages of development. Rather than treating security as an afterthought, which can lead to vulnerabilities being discovered late in the development cycle when remediation is more costly and complex, security testing can be integrated into all stages of the development process. This allows teams to identify and address security flaws as early as possible, minimizing the risk of serious security incidents. Additionally, adopting principles of continuous security can be crucial for enhancing security in Agile and DevOps environments. This involves continuously monitoring, assessing, and improving security practices and policies throughout the development cycle. This ensures that security requirements are continually taken into account and implemented, rather than treated as a one-time activity. Furthermore, implementing DevSecOps practices can be an effective way to integrate security considerations throughout the entire development cycle. DevSecOps promotes collaboration between software development, operations, and security teams, enabling them to work together to identify, address, and prevent security threats at all stages of software development and delivery.

Through these approaches, Agile and DevOps methodologies can be effectively adapted to ensure stronger security and resilience against growing cybersecurity threats, providing organizations with the ability to develop and deliver software that is secure and resilient to security challenges.

## CONCLUSION

This research provides a thorough examination and comparison of Agile and DevOps methodologies in software development. Our findings indicate that Agile methodologies excel in iterative improvements,

team collaboration, and customer focus, while DevOps methodologies stand out with their emphasis on automation, continuous integration, and delivery speed. Integrating DevOps principles into Agile frameworks can enhance the efficiency and effectiveness of software development teams, leading to faster delivery times and improved product quality.

Our study highlights the importance of considering the specific needs and contexts of organizations when choosing between Agile and DevOps methodologies. A hybrid approach that combines the best practices of both methodologies can offer significant benefits, including increased flexibility, improved collaboration between teams, and enhanced software development processes.

This research contributes to the existing body of knowledge on Agile and DevOps methodologies and provides practical recommendations for organizations looking to optimize their software development processes. By embracing a holistic approach that leverages the strengths of both Agile and DevOps, organizations can achieve greater success in delivering high-quality software products that meet the evolving needs of their customers.

## REFERENCES

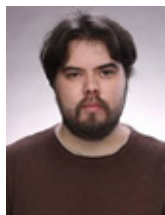
- [1] Al Masud, S., & et al. (2022). DevOps Enabled Agile: Combining Agile and DevOps Methodologies for Software Development. *International Journal of Advanced Computer Science and Applications*, 13(11).
- [2] Almeida, F., Simões, J., & Lopes, S. (2022). Exploring the benefits of combining devops and agile. *Future Internet* 14.2, 63.
- [3] Almeida, F., Simões, J., & Lopes, S. (2022). Exploring the benefits of combining devops and agile. *Future Internet*, 14(2), 63.
- [4] Cobb, C. (2023). *The project manager's guide to mastering Agile: Principles and practices for an adaptive approach*. John Wiley & Sons.
- [5] Faustino, J., Adriano, D., Amaro, R., Pereira, R., & da Silva, M. (2022). DevOps benefits: A systematic literature review. *Software: Practice and Experience*, 52(9), 1905-1926.
- [6] Friman, O. (2024). *Agile and DevSecOps Oriented Vulnerability Detection and Mitigation on Public Cloud*. Aalto University, School of Science.
- [7] Heeger, L., & Nielsen, P. (2020). Meshing agile and plan-driven development in safety-critical software: a case study. *Empirical Software Engineering*, 25(2), 1035-1062.
- [8] Jayakody, J., & Wijayanayake, W. (2021). Challenges for adopting DevOps in information technology projects. In *2021 International Research Conference on Smart Computing and Systems Engineering (SCSE)*, (Vol. 4, pp. 203-210).
- [9] Langerman, J., & Leung, W. (2023). The effect of outsourcing and insourcing on Agile and DevOps. *Journal of Information Technology Teaching Cases*.

- [10] Maroukian, K. (2021). Towards Practice and Principle Adoption through Continuous DevOps Leadership. *J. Softw.*, 16(1), 1-13.
- [11] Pacagnella Junior, A., & Da Silva, V. (2023). 20 Years of the Agile Manifesto: A Literature Review on Agile Project Management. *Management and Production Engineering Review*.
- [12] Srivastav, S., Allam, K., & Mustyala, A. (2023). Software Automation Enhancement through the Implementation of DevOps. *International Journal of Research Publication and Reviews*, 4(6), 2050-2054.
- [13] Tetteh, S. (2024). Empirical Study of Agile Software Development Methodologies: A Comparative Analysis. *Asian Journal of Research in Computer Science*, 17(5), 30-42.

Received: April 10, 2024

Accepted: April 20, 2024

## ABOUT THE AUTHORS



**Vladimir Radovanović** is a Lead Information Security Engineer at Joint Stock Company Elektromreža Srbije. He earned his bachelor degree in Computer Science from University Union Nikola Tesla Beograd. He is currently enrolled in a Master's program in Faculty of Informatics and Computer Science at "Union - Nikola Tesla" University. Before Joint Stock Company Elektromreža Srbije, he was teacher in Gymnasium „Uroš Predić“ Pančevo, where he taught IT subjects. His research focuses on cyber security, information security and teaching. He is author of few research papers.



**Olja Krčadinac** (Latinović, maiden name) is assistant professor at "Union - Nikola Tesla" University - Faculty of Informatics and Computer Science. She earned her Ph.D. in biometric field from University of Belgrade - Faculty of Organizational science, where she conducted groundbreaking research on speaker recognition. In addition to her teaching responsibilities, Olja has authored numerous impactful publications in peer-reviewed journals, contributing valuable insights to the scientific community. Her research focuses on biometric, sensors, IoT and AI, addressing critical issues in AI and making significant contributions to the academic community.



**Jasmina Perišić** graduated and mastered at the Faculty of Organizational Sciences of the University of Belgrade. She defended her doctoral dissertation in the elective field of Electronic Business at the Faculty of Organizational Sciences of the University of Belgrade. Since 2013, she has been employed as an associate professor at the Union "Nikola Tesla" University in Belgrade (Faculty of Informatics and Computing, Faculty of International Politics and Security, Faculty of Economics and Finance, Faculty of Entrepreneurship, Business and Real Estate Management). She has published ten papers in

journals of international importance on the SCI list, twelve papers in journals of international and national importance that are not on the SCI list, over seventy papers at international and domestic conferences, one monograph of national importance and six papers in thematic collections of national importance.



**Marina Milovanović** graduated (2000) and mastered (2005) at the Faculty of Mathematics, University of Belgrade. She received her doctorate at the Faculty of Entrepreneurial Business of Union University (2008) and at the Faculty of Science and Mathematics at the University of Kragujevac (2014) as a Doctor of Science (Economic and Mathematical Sciences). She works as a full-time professor at "Union - Nikola Tesla" University. Currently, her research is focused on performance of the financial mathematics, statistics, teaching mathematics and informatics. Throughout her career, she has authored numerous impactful publications in peer-reviewed journals, contributing valuable insights to the scientific community, projects etc.



**Željko Stanković** received his higher education in Cleveland, Ohio, USA, where he graduated in 1981. The topic of the thesis was "Reversible sound in halls". He defended his master's thesis ("Learning control system (LMS) based on ADL SCORM specifications") in 2006 at the University of Novi Sad, Faculty of Science, Department of Informatics. He defended his doctoral dissertation (Laser perception of defined objects and encapsulation of control and logic elements for an autonomous robotic teaching tool) at Singidunum University, Belgrade, in 2010. He has been programming since 1984, creating programs for his first Commodore 64 computer. He works as a full-time professor at "Union - Nikola Tesla" University. Robotics and bioengineering have been a field of work and interest for many years. He is the holder of the patent right for the teaching tool CD ROBI.

## FOR CITATION

Vladimir Radovanović, Olja Krčadinac, Jasmina Perišić, Marina Milovanović, Željko Stanković, Comparison of Agile and Devops Methodologies: Analysis of Efficiency, Flexibility, and Application in Software Development, *JITA – Journal of Information Technology and Applications*, Banja Luka, Pan-European University APEIRON, Banja Luka, Republika Srpska, Bosna i Hercegovina, JITA 14(2024)1:78-83, (UDC: 004.421.2:519.676), (DOI: 10.7251/JIT2401078R, Volume 14, Number 1, Banja Luka, June (1-88), ISSN 2232-9625 (print), ISSN 2233-0194 (online), UDC 004

# INSTRUCTIONS FOR AUTHORS

The *Journal of Information Technology and Application (JITA)* publishes quality, original papers that contribute to the methodology of IT research as well as good examples of practical applications.

Authors are advised that adherence to the Instructions to Authors will help speed up the refereeing and production stages for most papers.

- Language and presentation
- Length of submissions
- Submission
- Contact details/biographies
- Title of the paper
- Abstract and keywords
- Figures and tables
- Sections
- Footnotes
- Special characters
- Spelling
- References
- Proofs
- PDF offprint
- Copyright and permissions
- Final material
- Correspondence
- Publication ethics

## LANGUAGE AND PRESENTATION

Manuscripts should be written in English. All authors should obtain assistance in the editing of their papers for correct spelling and use of English grammar. Manuscripts should have double spacing, with ample margins and pages should be numbered consecutively. The Editors reserve the right to make changes that may clarify or condense papers where this is considered desirable.

## LENGTH OF SUBMISSIONS

Length of submissions Papers should not normally exceed 15 Journal pages (about 10 000 words). However, in certain circumstances (e.g., review papers) longer papers will be published.

## SUBMISSION

Manuscripts must be submitted through the JITA online submission system.

Please read the instructions carefully before submitting your manuscript and ensure the main article files do not contain any author identifiable information.

Although PDF is acceptable for initial submission original source (i.e. MS Word) files will be required for typesetting etc.

## CONTACT DETAILS/BIOGRAPHIES

A separate file containing the names and addresses of the authors, and the name and full contact details (full postal address, telephone and e-mail) of the author to whom correspondence is to be directed should be uploaded at the time of submission (you should select Contact details/Biographies as the file type). This file is not shown to reviewers. This file should also contain short biographies for each author (75 words maximum each) which will appear at the end of their paper.

The authors' names and addresses must not appear in the body of the manuscript, to preserve anonymity. Manuscripts containing author details of any kind will be returned for correction.

## TITLE OF THE PAPER

The title of the paper should not be longer than 16 words.

## ABSTRACT AND KEYWORDS

The first page of the manuscript should contain a summary of not more than 200 words. This should be self-contained and understandable by the general reader outside the context of the full paper. You should also add 3 to 6 keywords.

## FIGURES AND TABLES

Figures which contain only textual rather than diagrammatic information should be designated Tables. Figures and tables should be numbered consecutively as they appear in the text. All figures and tables should have a caption.

## SECTIONS

Sections and subsections should be clearly differentiated but should not be numbered.

## FOOTNOTES

Papers must be written without the use of footnotes.

## SPECIAL CHARACTERS

Mathematical expressions and Greek or other symbols should be written clearly with ample spacing. Any unusual characters should be indicated on



a separate sheet.

### **SPELLING**

Spelling must be consistent with the Concise Oxford Dictionary.

### **REFERENCES**

References in the text are indicated by the number in square brackets. If a referenced paper has three or more authors the reference should always appear as the first author followed by et al. References are listed alphabetically. All document types, both printed and electronic, are in the same list. References to the same author are listed chronologically, with the oldest on top. Journal titles should not be abbreviated.

- Journal

[1] Avramović Z.Ž. (1995). Method for evaluating the strength of retarding steps on a marshalling yard hump. *European Journal of Operational Research*, 85(1), 504–514.

- Book

[2] Walsham G. (1993). *Interpreting Information Systems in Organizations*. Wiley, Chichester.

- Contributed volume

[3] Huberman A.M. and Miles M.B. (1994). Data Management and analysis methods. In *Handbook of Qualitative Research* (Denzin NK and Lincoln YS, Eds), pp 428-444, Sage, Thousand Oaks, California.

- Conference Paper

[4] Баранов Л.А. (2017). Принципы построения и алгоритмы интеллектуальных автоматических систем управления движения поездов, функционируемых в рамках городских транспортных систем. In G. Radić & Z.Ž. Avramović (Eds.), *Proceedings of a IX International Scientific Conference "Information Technology for e-Education"*, (pp.9-18). Pan-European University APEIRON, Banjaluka, 29–30.9.2017. Republic of Serpska, B&H

- Unpublished reports/theses

[5] Nandhakumar J.J. (1993). The practice of executive information systems development: and in-depth case study. *PhD Thesis*, Department of Engineering, University of Cambridge.

### **PROOFS**

Proofs of papers will be sent to authors for checking. Alterations to diagrams should be avoided where possible. It will not be possible to accept major textual changes at this stage. Proofs must be returned to the publishers within 48 hours of receipt by fax,

first-class post, airmail or courier. Failure to return the proof will result in the paper being delayed.

### **PDF OFFPRINT**

Corresponding authors will receive a PDF of their article. This PDF offprint is provided for personal use. It is the responsibility of the corresponding author to pass the PDF offprint onto co-authors (if relevant) and ensure that they are aware of the conditions pertaining to its use.

The PDF must not be placed on a publicly-available website for general viewing, or otherwise distributed without seeking our permission, as this would contravene our copyright policy and potentially damage the journal's circulation. Please visit <http://www.jita-au.com> to see our latest copyright policy.

### **COPYRIGHT AND PERMISSIONS**

The copyright of all material published in the Journal is held by Pan-European University APEIRON. The author must complete and return the copyright form enclosed with the proofs.

Authors may submit papers which have been published elsewhere in a foreign language, provided permission has been obtained from the original publisher before submission.

Authors wishing to use material previously published in JITA should consult the publisher.

### **FINAL MATERIAL**

All final material must be submitted electronically in its original application format (MS Word is preferred). The file must correspond exactly to the final version of the manuscript.

### **CORRESPONDENCE**

Business correspondence and enquiries relating to advertising, subscriptions, back numbers or reprints should be addressed to the relevant person at:

Pan-European University APEIRON

Journal JITA

Pere Krece 13, P.O.Box 51

78102 Banja Luka

Bisnia and Hercegovina / RS

E-mail: [jita@apeiron-edu.eu](mailto:jita@apeiron-edu.eu)

### **PUBLICATION ETHICS**

We take an active interest in issues and developments relating to publication ethics, such as plagiarism, falsification of data, fabrication of results and other areas of ethical misconduct. Please note that submitted manuscripts may be subject to checks using the corresponding service, in order to detect instances of overlapping and similar text.





---

PUBLISHER: **Pan-European University APEIRON**, Banja Luka  
**College of Information Technology** Banja Luka, Republic of Srpska, BiH  
[www.apeiron-uni.eu](http://www.apeiron-uni.eu)

**Darko Uremović**, Person Responsible for the Publisher  
**Aleksandra Vidović**, PhD, Editor of University Publications

---

#### EDITOR-IN-CHIEF

**Dalibor P. Drljača**, PhD, Pan-European University APEIRON Banja Luka  
College of Information Technology, Pere Krece 13, Banja Luka, RS, BiH  
E-mail: [dalibor.p.drjaca@apeiron-edu.eu](mailto:dalibor.p.drjaca@apeiron-edu.eu)

#### MANAGING EDITOR

**Siniša Tomić**, PhD, Pan-European University APEIRON, BiH  
E-mail: [sinisa.m.tomic@apeiron-edu.eu](mailto:sinisa.m.tomic@apeiron-edu.eu)

#### HONORARY BOARD

**Gordana Radić**, PhD, Pan-European University APEIRON, BiH  
E-mail: [gordana.s.radic@apeiron-edu.eu](mailto:gordana.s.radic@apeiron-edu.eu)

**Dušan Starčević**, PhD, University of Belgrade, Serbia  
E-mail: [starcev@fon.bg.ac.rs](mailto:starcev@fon.bg.ac.rs)

#### TECHNICAL SECRETARY

**Aleksandra Vidović**, PhD, Pan-European University APEIRON, BiH

#### INTERNATIONAL BOARD MEMBERS

**Goran Stojanović**, PhD, University of Novi Sad, Serbia  
**Vlado Delić**, PhD, University of Novi Sad, Serbia  
**Nebojša Bojović**, PhD, University of Belgrade, Serbia  
**Jovan Filipović**, PhD, University of Belgrade, Serbia  
**Maja Gajić Kvašček**, PhD, Vinča institute of Nuclear sciences, Serbia  
**Dragutin Kostić**, PhD, University of Belgrade, Serbia  
**Ljubomir Lazić**, PhD, University UNION Nikola Tesla, Serbia  
**Boško Nikolić**, PhD, University of Belgrade, Serbia  
**Dragica Radosav**, PhD, University of Novi Sad, Serbia  
**Siniša Randić**, PhD, University of Kragujevac, Serbia  
**Negovan Stamenković**, PhD, University of Priština, Serbia  
**Olja Krčadinac**, Univerzitet UNION Nikola Tesla, Serbia  
**Milan Vujanić**, PhD, University of Belgrade, Serbia  
**Milena Vujošević Janičić**, PhD, University of Belgrade, Serbia  
**Mirko Vujošević**, PhD, University of Belgrade, Serbia  
**Damir Zaborski**, PhD, High Railway School - Vocational Studies, Belgrade, Serbia  
**Milenko Čabarkapa**, PhD, Adriatic University, Montenegro  
**Nataša Gospić**, PhD, Adriatic University, Montenegro  
**Milan Marković**, PhD, University Donja Gorica, Montenegro  
**Kristina Jakimovska**, PhD, Cyril and Methodius University in Skopje, N. Macedonia  
**Gjorgji Jovancevski**, PhD, University American College Skopje, N. Macedonia  
**Patricio Bulić**, PhD, University of Ljubljana, Slovenia  
**Leonid A. Baranov**, PhD, Russian University of Transport, Russia  
**Petr F. Bestemyanov**, PhD, , Russia  
**Pavel A. Butyrin**, PhD, National Research University "MEI", Russia  
**Yuri M. Inkov**, PhD, Russian University of Transport, Russia  
**Vladimir N. Malish**, PhD, Lipecky Gosudarstvenny Pedagogichesky Univerzitet, Russia  
**Svetlana A. Kolobova**, PhD, NižegorodskiyGPU, Nižniy Novgorod, Russia  
**Efim N. Rozenberg**, PhD, Research Institute in Railway Transport, Russia  
**Valery T. Domansky**, PhD, Kharkiv National Technical University, Ukraine  
**Dmytro Kozachenko**, PhD, Dnipropetrovsk National University of Railway Transport, Ukraine  
**Valeriy Kuznetsov**, PhD, Dnipropetrovsk National University of Railway Transport, Ukraine  
**Olexandr M. Pshinko**, PhD, Dnipropetrovsk National University of Railway Transport, Ukraine

**Hristo Hristov**, PhD, University of Transport "T.Kableshkov", Bulgaria  
**Mariya Hristova**, PhD, University of Transport "T.Kableshkov", Bulgaria  
**Jelena Mišić**, PhD, Ryerson University, Toronto, Canada  
**Vojislav B. Mišić**, PhD, Ryerson University, Toronto, Canada  
**Ouajdi Corbaa**, PhD, University of Sousse, Tunisia  
**Ahmed Maalel**, PhD, University of Sousse, Tunisia  
**Vladimir Goldenberg**, PhD, University of Applied Sciences, Augsburg, Germany  
**Eva Kovesne Gilicze**, PhD, Budapest University of Technology and Economics, Hungary  
**Sanja Bauk**, PhD, Durban University of Technology, South Africa  
**Maja Đokić**, PhD, Spin on, Barcelona, Spain  
**Dimitris Kanellopoulos**, PhD, University of Patras, Greece  
**Wang Bo**, PhD, Ningbo University of Technology, China  
**Emil Jovanov**, PhD, University of Alabama in Huntsville, USA  
**Milan Janić**, PhD, Delft University of Technology, The Netherlands  
**Zdenek Votruba**, PhD, Czech Technical University in Prague, Czech Republic  
**Makhamadjan Mirakhmedov**, PhD, Tashkent Institute of Railway Engineers, Uzbekistan  
**Nazila Rahimova**, PhD, Azerbaijan State Oil and Industry University, Azerbaijan  
**Gabriela Mogos**, Xi'an Jiaotong-Liverpool University, China

#### DOMESTIC BOARD MEMBERS

**Zdenka Babić**, PhD, University of Banja Luka, BiH  
**Ratko Đuričić**, PhD, University of East Sarajevo, BiH  
**Gordana Jotanović**, PhD, University of East Sarajevo, BiH  
**Esad Jakupović**, PhD, Academy of Sciences and Arts of the Republic of Srpska, BiH  
**Branko Latinović**, PhD, Pan-European University APEIRON, BiH  
**Goran Đukanović**, PhD, Pan-European University APEIRON, BiH  
**Nedim Smailović**, PhD, Pan-European University APEIRON, BiH  
**Željko Stanković**, PhD, Pan-European University APEIRON, BiH  
**Tijana Talić**, PhD, Pan-European University APEIRON, BiH  
**Dražen Marinković**, PhD, Pan-European University APEIRON, BiH  
**Dragutin Jovanović**, PhD, Pan-European University APEIRON, BiH  
**Milan Tešić**, PhD, Pan-European University APEIRON, BiH

#### EDITORIAL COUNCIL

**Siniša Aleksić**, PhD, Director, Pan-European University APEIRON, BiH  
**Sanel Jakupović**, PhD, Rector, Pan-European University APEIRON, BiH

#### TECHNICAL STAFF

**Katarina Držajić Laketić**, PhD, Lector  
**Aleksa Marčeta**, WEB presentation

#### EDITOR ASSISTANTS

**Sretko Bojić**, Pan-European University APEIRON, BiH  
**Marko Milovanović**, Pan-European University APEIRON, BiH