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## 12<sup>TH</sup> INTERNATIONAL CONFERENCE ON APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY AND STATISTICS IN ECONOMY AND EDUCATION ICAICTSEE - 2022

December 2 – 3<sup>rd</sup>, 2022 University of National and World Economy Sofia, Bulgaria

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Dear Colleagues,

On behalf of the Conference Committees I have the honor and pleasure to thank you all for your true participation in the work of the **12**<sup>th</sup> **International Conference on Application of Information and Communication Technology and Statistics in Economy and Education** (ICAICTSEE-2022), http://icaictsee.unwe.bg/, which took place on December 2–3<sup>rd</sup>, 2022 at the University of National and World Economy (UNWE), Sofia, Bulgaria.

**ICAICTSEE** shares experience with the **Recent Trends in Biomedical Technology Conference**, co-organized by the School of Electronics Engineering, Vellore Institute of Technology, Vellore, India.

I would like specially to express my gratitude to all of the program committee members for their genuine support without which it would never had happened.

Due to the current state of scientific development in all spheres of human activity, the constant knowledge and skill actualization of the academia and researchers in the field of Information and Communication Technology (ICT) is an obligatory necessity, especially when the world is in a global economic and financial crisis. The definition of long-term scientific research tasks in this area has a strategic importance, which is even truer for young researchers, lecturers and Ph.D. students.

The conference aims were conducting analysis of the current problems and presenting results of the ICT application in different areas of economy, education and related areas of scientific knowledge; outlining the existing possibilities for the application of modern ICT tools, methods, methodologies and information systems in economy and education; discussing advanced and emerging research trends with a long-term importance in the field of ICT application in economy and education.

The conference has established an academic environment that fosters the dialogue and exchange of ideas between different levels of academic and research communities.

The conference outcome is 26 published research papers, the explosion of fresh ideas and the establishment of new professional relations.

Dimiter G. Velev ICAICTSEE-2022 Chair

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## Threats Model for the Security of Personal Data During Their Processing

#### Serghei Ohrimenco<sup>1</sup>, Svetlana Apachita<sup>1</sup>, Eduard Ryzhkov<sup>2</sup>, Lyudmila Rybalchenko<sup>2</sup>

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**Abstract.** The article describes the main steps to form a model of threats to the security of personal data during their processing in information systems. Particular attention is paid to the deliberate actions of the violator, which lead to damage to the interests of the individual, society and the state. The results of the analysis of existing methods and standards are presented, including: ISO 27005-2022, The STRIDE Threat Model, NIST Special Publication 800-37. The hierarchical intruder model is described as one of the sources of threats along with malware carriers and bookmarks, the definition and description of attack channels.

**Keywords:** Information security, Threats model, ISO Standards, Computer attack, Personal data security.

#### 1. Introduction

In European countries, the relevant personal data protection (PD) legislation is used, which defines: principles and criteria for automated data processing; rights and obligations of entities and holders of personal data; issues of cross-border transfer of personal data; liability and sanctions for damage [1, 2, 3].

A separate, completely unresolved problem is the development of a list of data security threats during their processing in PD information systems. Security threats can be caused by intentional or unintentional actions of persons, services, organizations that lead to the damage of the individual, society and the state's interests. In addition, a lot of questions arise regarding the formation of initial threats to PD.

#### 2. Formation of a list of current threats

Threat modeling is an independent scientific and practical direction in information security. Among the many literature sources, it should be highlighted the "classical" work of Adam Shostack "Threat Modeling. Designing for Security" [20], which collects information for threat modeling for the Windows operating system. This is one of the earliest and most famous works, which presents approaches to the description of threats and their modeling. Strategies for Threat Modeling covers a great many ways to approach threat modeling. A list of the main threats has been proposed and their analysis has been carried out, with the following steps identified: Mitigating threats; Eliminating threats: Transferring threats: Accepting the risk.

When analysing the available literature sources [3,9, 11, 15, etc.], a list of actual threats to the security of PD was determined. They should include the following: threats from the

actions of malicious programs (viruses); threats of loss of keys and attributes of access; password detection threats over the network; threats of malware introduction over the network; threats of undeclared capabilities of system software and programmes for processing PD; threats of interception outside the controlled zone; scanning threats; threats of substitution of a trusted object in the network; threats of the introduction of a false object in the PD processing system, and in external networks; denial of service threat; remote application launch threats.

Let's analyse the structure of the threats reflected in the official documents used by information security specialists.

The ISO/IEC 27005:2022 "Information security, cybersecurity and privacy protection — Guidance on managing information security risks" standard describes typical threats, as well as the origin of each threat, including intentional - all deliberate actions are directed at information assets, accidental - actions of personnel that can accidentally damage information assets, natural - incidents that are not based on the actions of personnel. These include: searching for reused or rejected media; disclosure; data from unreliable sources; criminal use of software; location determination; interception of compromising interference signals; remote espionage; eavesdropping; theft of media or documents; equipment theft; equipment failure; malfunctioning equipment; information system saturation; software malfunction; violation of information system maintenance; unauthorized use of equipment; fraudulent copying of software; use of counterfeit or copied software; distortion of data; illegal data processing; error while using; rights abuse; rights falsification; refusal to take action; disruption of staff performance.

The Microsoft methodology "The STRIDE Threat Model" uses an approach to creating secure systems based on threat modeling [14]. This approach is a classification scheme for describing the attacks depending on the type of vulnerabilities used to implement them or the motivation of the offender: identity substitution; falsification of data; the user's refusal to take action; information disclosure; denial of service; privilege position, when an unprivileged user is accessing information.

NIST Special Publication 800-30 is a guide to risk management for information systems and focuses on the risk management processes of the management level of an organization [18]. At the stage of threat identification, only a description of intruders (threat sources) and their probable actions is used, a list of threat classes is formed, which is further ranked according to the degree of probability of implementation. The main focus is on identifying vulnerabilities.

A special consideration should be given to the threat modeling methodology using MITRE. Mitre Att&ck (Adversarial Tactics, Techniques & Common Knowledge) is a knowledge base based on real observations by MITRE, containing a description of the tactics, techniques and methods used by cyber criminals. The main goal of this project is to compile a structured matrix of techniques used by cyber criminals to simplify the task of responding to cyber incidents. The stages of threat modeling include: identification of negative impacts; definition of objects of influence; assessment of the possibility of implementing threats and attacks: a) identification of violators and b) modeling of attack scenarios. Accordingly, the determination of negative impacts includes the analysis of documentation of systems and networks and other input data; definition of negative consequences - that undesirable result which can occur after an attack. Assessing the possibility of implementing threats and attacks includes identifying violators (determining the source of threats and interaction interfaces) and modeling attack scenarios (selecting sources of information about the tactics and techniques of violators and, in fact, modeling attack scenarios).

There is no mathematical formalization in the considered models, i.e. all models are described using verbal lists and instructions, which can lead to the fact that each of the experts

can interpret the same methodology in different ways, moreover, experts often do not have a direct relationship with the organization, which introduces additional inaccuracies in the formation of models of threats.

### 3. Cyber threats and attacks

Cyber security is the combination of policies and practices to prevent and monitor computers, networks, programs and data from unauthorized access or attacks that are aimed for exploitation. The major areas that are included in Cyber securities are presented in Table 1

Areas of Cybersecurity	Characteristics
Application Security	Application security is the process of developing, adding, and testing security features within applications to prevent security vulnerabilities against threats such as unauthorized access and modification.
Information Security	Information security protects sensitive information from unauthorized activities, including inspection, modification, recording, and any disruption or destruction. The goal is to ensure the safety and privacy of critical data such as customer account details, financial data or intellectual property.
Email Security	Email security is a term for describing different procedures and techniques for protecting email accounts, content, and communication against unauthorized access, loss or compromise. Email is often used to spread malware, spam and phishing attacks. Attackers use deceptive messages to entice recipients to part with sensitive information, open attachments or click on hyperlinks that install malware on the victim's device. Email is also a common entry point for attackers looking to gain a foothold in an enterprise network and obtain valuable company data.
Mobile Device security	Mobile Device Security is the protection of sensitive information transmitted by your smartphones, tablets, laptops, and other mobile devices. Mobile device security aims to: $\checkmark$ Protect sensitive data stored on portable devices $\checkmark$ Prevent unauthorized users from using mobile devices to access the enterprise network.
Web Security	Web security refers to protecting networks and computer systems from damage to or the theft of software, hardware, or data. It includes protecting computer systems from misdirecting or disrupting the services they are designed to provide.
Wireless Security	Wireless security is the prevention of unauthorized access or damage to computers or data using wireless networks, which include Wi-Fi networks.

Table 1. Areas of Cybersecurity

The Computer Security Incident Response Team (CSIRT) considers the types of cyber attacks in the following order:

- Malware;
- Phishing;
- Man in the Middle Attack;
- Dos/DDos;
- SQL Injection;
- Zero-Day Exploit;
- Cross Site Scripting;
- Business Email Compromise.

It should be noted that cyber attacks are used not only for tactical but also for strategic purposes. In particular, actions are being taken to weaken public opinion, incite fear, and so on. Such actions lead to the disruption of the functioning of state institutions, the creation of information noise, create the preconditions for cyber espionage, cyber sabotage, as well as the implementation of influence operations. The Table 2 summarizes cyberattack tools and their impact.

Instrument of Attack	Purpose	<b>Protective Measure</b>
defacement attacks	intimidation/threatening creating confusion disrupting information flow	Website software update. When outsourcing a website, make sure the provider diligently implements cybersecurity measures. If defaced, use alternative information channels if possible, such as social media. Main targets: media, state institutions (mediators of crisis information), website providers
denial-of-service attacks	disrupting information flow intimidation	Protection against denial-of- service attacks
social media posts	damage to reputation (reduce help from allies and intelligence sharing)	Think carefully about what information you share and with whom. Make sure your shared information is kept secure, and the recipient keeps the shared information in an environment where cybersecurity best practices are implemented
data encrypting malware	disrupting the functioning of the state intimidation	Back up data properly

Table 2. Cyberattack tools

destructive malware	disrupting the functioning of the state intimidation	Keep your software updated. Implement cybersecurity best practices. Back up data properly
cyber intelligence (phishing, brute force attacks, exploitation of security vulnerabilities)	information gathering leaking stolen information out of context, combined with fabricated information	Keep your software updated. Implement cybersecurity best practices. Get cyber hygiene training

Source: Estonia Foreign Intelligence Service Report 2023. P.16. ISSN: 2613-3288

The list of cyber attacks and their characteristics is given in Table 3.

Attack types	Characteristics
Denial of Service Attacks	These attacks are mainly used to unavailable some resources like a web server to users. These attacks are very common today. They used overload to resource with illegitimate requests for service. The resource cannot process the flood of requests and either slows or crashes.
Brute Force Attacks	These attacks try to kick down the front door. It's a trial-and error attempt to guess a system's password. One in four network attacks is a brute- force attempt. This attack used automated software to guess hundreds or thousands of password combinations.
Browser Attacks	These attacks target end users who are browsing the internet. The attacks may encourage them to unwittingly download malware. These attacks used fake software update or application. Websites are also force to download malware. The best ways to avoid browser-based network attacks is to regularly update web browsers.
Shellshock Attacks	These attacks are refers to vulnerabilities found in Bash, a common command-line shell for Linux and UNIX systems. Since many systems are never updated, the vulnerabilities are still present across the Web. The problem is so widespread that Shellshock is the target of all networks
SSL Attack	These attacks are intercept data that is sent over an encrypted connection. These attacks successfully access to the unencrypted

Table 3. Cybersecurity attacks

	information. These attacks are also very common today.
Backdoor Attacks	These attacks are used to bypasses normal authentication to allow remote access. These attacks are added in software by design. They are added in the Programs or created by altering an existing program. Backdoors is less common types.
Botnet attacks	These attacks are hijackers. They are computers that are controlled remotely by one or more malicious actors. Attackers use botnets for malicious activity, or rent the botnet to perform malicious activity for others. Millions of computers can be caught in a botnet's snare.

Sourse: Narmatha C. (2020). Advancements, Merits & Demerits of Cyber Security: A Critical Study. 2020 International Conference on Computing and Information Technology (ICCIT-1441). DOI:10.1109/ICCIT-144147971.2020.9213774; Jitendra Jain, Parashu Ram Pal (2017). A Recent Study over Cyber Security and its Elements. International Journal of Advanced Research in Computer Science. 8 (3), March-April 2017, 791-793, ISSN: 0976-5697

#### 4. Conclusion

The presented material does not claim to solve the complex problem of modeling threats to the security of personal data. Subsequent work should be related to determining the level of risk and managing risks in specific situations of the personal data processing process.

Risk is defined as the product of threats, vulnerabilities, and impact, divided by mitigations. Each of these components is defined here [21, 22].

1. Threats: Your organization needs to consider any sources of intentional threats that could have a potentially negative impact on its assets. These intentional threats include insiders, cybercriminals, and nation- states.

2. Vulnerabilities: Threats rely on vulnerabilities to undermine an organization's cybersecurity, so it is crucial that the most significant vulnerabilities are identified and considered. Vulnerabilities could take the form of poor business processes, poorly educated employees, or outdated software.

3. Impact: Your organization must take the potential impact of a cyberattack into account. Assessing the potential impact of a cyberattack involves understanding the effects that various threat scenarios could lead to. For example, an organization could assess the potential impact that a distributed denial- of-service attack (an attack that restricts available bandwidth by flooding networks with unmanageable amounts of data) could have on its system, and how a critical failure of that system would affect critical business operations.

4. Mitigations: As your organization takes steps to reduce threats, vulnerabilities, and their impact, it is important to account for these as part of your risk posture. Some mitigation activities are focused on addressing just one aspect of risk, whereas other mitigations are systemic and address each risk consideration across an organization.

## References

- The EU General Data Protection Regulation (GDPR). (2020). Oxford University Press. ISBN 978– 0-19-882649-1
- EU General Data Protection Regulation (GDPR). An implementation and compliance guide. Fourth edition (2020). IT Governance Privacy Team. ISBN: 978-1-78778-249-5
- 3. Damian A. Tamburri (2019). Design Principles for the General Data Protection Regulation (GDPR): a Formal Concept Analysis and its Evaluation. https://doi.org/10.1016/j.is.2019.101469
- Michael T. Raggo (2016). Mobile Data Loss. Threats and Countermeasures. Elsevier Inc. ISBN: 978-0-12-802864-3
- Bolun, I.; Ghetmancenco, S. Efficiency indices of investment in IT projects with equal lives. Journal of Social Sciences 2022, 5 (3), pp. 105-120. https://doi.org/10.52326/jss.utm.2022.5(3).08.
- Shreya Paliwal, Purvi Khodwe, Aditi Nandi (2021). Cyber Attacks and Cyber Security: Basics and Framework. International Journal for Research in Applied Science & Engineering Technology (IJRASET). vol. 9, no IV Apr 2021. ISSN: 2321-9653 https://doi.org/10.22214/ijraset.2021.33593
- Narmatha C. (2020). Advancements, Merits & Demerits of Cyber Security: A Critical Study. 2020 International Conference on Computing and Information Technology (ICCIT-1441). DOI:10.1109/ICCIT-144147971.2020.9213774
- Jain J., Parashu Ram Pal (2017). A Recent Study over Cyber Security and its Elements. Int. J. of Advanced Research in Computer Science. 8 (3), March-April 2017, 791-793. ISSN No. 0976-5697
- Custers B., A. M. Sears, F. Dechesne, I. Georgieva, T. Tani, S. van der Hof (2019). EU Personal Data Protection in Policy and Practice. ISBN 978-94-6265-282-8 https://doi.org/10.1007/978-94-6265-282-8
- Schnädelbach H., D. Kirk (2019). People, Personal Data and the Built Environment. Springer Nature Switzerland. ISBN 978-3-319-70875-1 https://doi.org/10.1007/978-3-319-70875-1
- Singh, A., J. Anurag, Study of Cyber Attacks on Cyber-Physical System (April 28, 2018). Proceedings of 3rd International Conference on Internet of Things and Connected Technologies (ICIoTCT), Malaviya National Institute of Technology, Jaipur (India), March 26-27, 2018, SSRN: https://ssrn.com/abstract=3170288 or http://dx.doi.org/10.2139/ssrn.3170288 ISSN: 1556-5068
- David J. Hand (2020). Title: Dark data: why what you don't know matters. Princeton University Press. ISBN 9780691198859
- 13. Brian Nafziger (2017). Data Mining in the Dark: Darknet Intelligence Automation. The SANS Institute. https://www.sans.org/white-papers/38175/.
- 14. STRIDE Threat Modeling: What You Need to Know. https://www.softwaresecured.com/stride-threat-modeling/
- 15. Threat Modeling Process. https://owasp.org/www-community/Threat\_Modeling\_Process.
- Gazizov T.T., Mytnik A.A., Butakov A.N. Generic Model of Security Threats for Personal Data in regard of Information Systems Dedicated to Academic Planning. https://journal.tusur.ru/storage/44705/09.pdf?1465961925
- 17. Security Development Lifecycle. https://www.microsoft.com/en-us/securityengineering/sdl
- NIST Special Publication 800-30 Rev.1, Guide for Conducting Risk Assessments. https://csrc.nist.gov/publications/detail/sp/800-30/rev-1/final
- 19. ATT&CK Matrix for Enterprise. https://attack.mitre.org/
- Shostack A. (2014). Threat Modeling/ Designing for Security. John Wiley & Sons. ISBN: 978-1-118-81005-7
- Gregory Falco, Eric Rosenbach (2022). Confronting Cyber Risk. An Embedded Endurance Strategy for Cybersecurity. Oxford University Press. ISBN 9780197526569 DOI: 10.1093/oso/ 9780197526545.001.0001
- Denning, D. E. (2015). "Assessing Cyber War." In Assessing War: The Challenge of Measuring Success and Failure, L. J. Blanken., H. Rothstein, and J. J. Lepore, eds., pp. 266–284. Washington, DC: Georgetown University Press. ISBN 978-1-62616-247-1

## Aspects of the Exchange of Classified Information between Organizational Structures in Crisis Situations

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Abstract. The report presents an analysis of the national and international regulatory framework related to the exchange of classified information in the management of the forces and resources of the state and local administration bodies in the event of incidents, disasters, accidents and catastrophes. Mechanisms and tools for managing classified information within organizational structures are examined. The analysis covers legal frameworks, organizational policies, technological safeguards and personnel training essential to maintaining the confidentiality, integrity and availability of classified information.

Keywords: Classified Information, Crisis Situations, Technology.

#### 1. Introduction

The management of classified information is a critical aspect of organizational operations, especially in sectors such as government, defense, and private enterprises dealing with sensitive data. Effective information activity encompasses a range of processes and protocols designed to safeguard classified information from unauthorized access, disclosure, modification, or destruction.

The policy of the Republic of Bulgaria on the protection of classified information is implemented in accordance with the directives on interoperability with NATO and the EU, which requires the creation of new laws and regulations related to the security of sensitive information.

The term "classified information" was first introduced by the Classified Information Protection Act (CIPA). By its very nature, this is information constituting state secrets, official secrets and foreign classified information. The need to protect classified information arises from its importance for the national security of the Republic of Bulgaria. It protects facts and circumstances, free access to which could harm the interests of the State as a whole.

Restricting access to classified information aims to minimise risks, prevent threats or damage to the interests of the Republic of Bulgaria relating to sovereignty, independence, territorial integrity, defence, constitutional order, foreign policy and international relations.

#### 2. Organizational Structures and Information Activities Related to the Processing of Classified Information

A national protection system is being established for the provision and exchange of classified information in the country. It is related to:

- a set of competent authorities and measures;

- the implementation of specific information, analysis and control activities;
- the possibility of integrating information from organisational units;
- assessments and forecasts of the quality of protection of classified information;
- assessment of the current state of quality of the system;
- risk assessment and forecast;
- the timely identification of negative processes;
- forecasting;
- prevention of harmful processes;
- determining the degree of effectiveness of the measures implemented.

The Classified Information Protection Act (CIPA) [1] establishes a new regulatory framework in line with NATO and EU policy and standards. The legislative experience of a number of European and NATO countries has been used in developing the legal framework.

The CIPA introduces new concepts and categories, such as classified information, 'physical security', 'personal security', 'information security' and others, which are defined in additional provisions of the law and are in line with NATO standards.

The main laws and regulations governing the protection of classified information in the field of document security are: the Constitution of the Republic of Bulgaria; the Law on Access to Public Information [2]; the Law on Protection of Personal Data; The Classified Information Protection Act [1] and regulations.

Regulations for the application of CIPA [3]; Mutual agreements on the security and protection of information, etc. Certain aspects are also regulated in other normative acts [4, 5].

The State Commission for Information Security (SCIS) is a state body that implements the policy of the Republic of Bulgaria for the protection of classified information.

The authorities for the protection of classified information carry out their information activity through the creation of information funds, processing of information, maintenance of information funds and storage of information in the information funds. The information activity is subject to the requirements for:

- Legality;
- Objectivity, accuracy, completeness;
- Strict compliance with legal deadlines;
- Protection of classified information;
- Ensuring coordination and interaction in information exchange;
- Protection of personal data and rights of citizens;
- Ability to integrate and create a single information system.

The information activity is related to:

- collection;
- processing;
- systematization;
- storage;
- use;
- providing information;
- informational analytical activity;
- prognostic activity;
- providing information.

Data is collected through:

- voluntary provision by individuals and legal entities;
- from state bodies and organizations;

• from foreign countries and organizations received according to the order of international exchange;

• from other sources of information.

The provision and exchange of classified information of the Republic of Bulgaria with other countries or organizations is carried out on the basis of a decision to provide or exchange classified information.

The procedure for providing the classified information includes

- Agreement concluded;
- Decision of the SCIS after establishing the presence of:
  - security clearance of the persons to whom it is granted;
  - conditions for reliable protection of classified information.

The head of the organizational unit, in which foreign classified information is stored and exchanged, organizes a registry in the field of international relations, under the direction of the SCIS.

The Republic of Bulgaria provides or exchanges classified information with countries or international organizations with which it has entered into force international treaties for the protection of classified information. If the international agreement does not specify which is the applicable law for matters not settled by it, the law of the country - source of the information - shall be applied. When there is no international treaty for the protection of classified information with another country or international organization in force, the Republic of Bulgaria provides or exchanges classified information with them only in cases related to the protection of its national security. In relation to classified information exchanged or provided to the Republic of Bulgaria by an international organization of which the Republic of Bulgaria is a member, the principles, norms and procedures for the protection of classified information operating within the framework of this international organization shall apply, if such an obligation arises for the Republic Bulgaria from its membership in the international organization.

The security of classified information is built using sub-components by types of security. These are physical security, documentary security, personal security, cryptographic security, security of communication and information systems, as well as industrial security.

Personal security is a system of principles and measures applied by the competent authorities in the relevant order to individuals in order to guarantee their reliability with a view to protecting classified information.

Measures for the protection of classified information in the field of personal security guarantee access to classified information only to persons whose official duties or specifically assigned task require such access, subject to the "need to know" principle. The implementation of the measures for the protection of classified information is carried out through a study of the reliability of persons, issuance of access authorization to the corresponding level of classification, withdrawal, termination and refusal of issuance of access authorization, as well as training in the field of protection of classified information. In the organizational unit, a register is kept for the conducted training of the persons admitted to work with classified information.

Employees of the organizational unit authorized to access classified information must comply with the rules for working with classified information.

Employees of the organizational unit are prohibited from:

• to disclose information classified as an official secret;

•to transmit such information by communication or communication means without appropriate protection measures, as well as to record classified information on unregistered media;

• to export materials containing classified information outside the organizational unit and in violation of the order established for this purpose;

• to leave materials containing classified information in the work room (desks, cabinets, etc.) after working hours, if it does not comply with the relevant measures for the protection of the information;

• reproduce, photograph and destroy materials containing classified information, in violation of the established order.

The physical security of classified information includes a system of organizational, physical and technical measures to prevent unauthorized access to materials, documents, equipment and facilities classified as official secrets. The system of measures includes the protection of the buildings, premises and facilities in which classified information is created, processed and stored and the control of access to them.

The necessary methods and means for physical security are determined depending on the level of classification and the amount of classified information, on the number and level of access of workers and employees and on the degree of threat of damaging actions.

Physical access control measures allow to control and, if necessary, restrict the entry and exit of employees and visitors. Fire protection is a part of physical protection.

The supporting infrastructure can include electricity, water and heat supply systems and communication means. They should have the same requirements for accessibility and integrity as for communication and information systems (CIS). In order to ensure integrity, it is necessary to protect the equipment from theft and damage.

All materials and technical means that are used to protect classified information must meet the requirements for stability and indestructibility, corresponding to the level of information security classification, certified by the State Information Security Agency (SCIS). The system of measures, methods and means for physical security, the conditions and the procedure for their use are determined by a regulation of the Council of Ministers.

Document security consists of a system of measures, methods and means for protecting classified information in the creation, processing and storage of documents, as well as in the organization and operation of registries for classified information.

Document security relates to all organizational unit documents containing classified information that are created, processed and stored and/or transferred to the CIS. They are identified, marked and controlled in an appropriate manner. The output of documents containing classified information from a certified CIS is carried out in accordance with the requirements in the security zones. Transfer of documents containing classified information from one CIS to another is carried out only if the recipient is certified for the classification level of the received information. Portable computer devices used to create, process and store classified information are considered carriers of such information. The system of measures, methods and tools for documentary security, the conditions and order for their use are determined by the regulations for the application of the CIPA.

Industrial security is a system of principles and measures that are applied to applicants, natural and legal persons, when entering into or executing a contract related to access to classified information, with the aim of protecting against unauthorized access.

The cryptographic security of information is achieved by planning and implementing a complex of organizational and technical measures related to the application of cryptographic methods and the use of cryptographic means to protect classified information.

CIS security is a system of principles and measures to protect against unregulated access to classified information, marked with the security label "For official use", which is processed, stored and transferred in CIS. The mandatory general security conditions of CIS cover computer, communication, cryptographic, physical and personal security, the security of the information itself on any electronic medium, as well as protection from parasitic electromagnetic radiation.

The activity of information security is associated with the development of security policy, security programs, analysis and risk management.

An information security policy and information security itself depends on human resources, processes and technologies. Ignoring any one of these elements is commensurate with ignoring information security as a whole. Human resources follow processes and use technology to protect information resources.

An information security policy can be understood as a set of management decisions regarding the protection of classified information and the resources connected to it. From a practical point of view, security policy can be divided into three levels.

Toward the first top level of security policy are decisions that pertain to the entire organization.

The intermediate level includes separate aspects of information protection.

The security policy at the lowest level is specific to the software. In contrast to the previous two levels, it should be much more detailed.

#### 3. Conclusion

In conclusion, it can be summarized that the security of information in communication and information systems and their systematization from an organizational point of view is of research interest. The goal is to develop a comprehensive plan for the protection of information in the organization. The functioning of communication and information systems in crisis conditions is associated with vulnerabilities, threats and attacks against users included in the networks, threats against communication and information means, as well as against information circulating among the structures of the organization, as well as between organizations exchanging information in crisis conditions. They are the subject of future research.

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#### References

- 1. Zakon za zashtita na klasifitsiranata informatsia, obn. DV, br.45/30.04.2002 g., popr. DV, br. 5/2003, izm. DV, br.31/2003.
- Zakon za dostap do obshtestvena informatsia, Obn. DV. br.55 ot7 Yuli 2000g., izm. DV. br.17 ot 26 Fevruari 2019 g..
- 3. Pravilnik za prilagane na zakona za zashtita na klasifitsiranata informatsia. Priet s PMS № 276 ot 02.12.2002 g., izm. i dop. DV. br.79 ot 8 Septemvri 2020g.
- 4. Zakon za kibersigurnost, Obn. DV. br.94 ot 13 noemvri 2018 g.
- Obsht reglament otnosno zashtita na lichnite danni (Reglament (ES) 2016/679) na Evropeyskia parlament i na Saveta ot 27 april 2016 godina, prilaga se pryako vav vsichki darzhavi-chlenki ot 25 may 2018 g., https://www.cpdp.bg/?p=element&aid=991

## Challenges in Choosing the Type of Intrusion Detection and Prevention System to Increase the Level of Cybersecurity in the Organization

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**Abstract.** Intrusion Detection and Prevention Systems (IDPS) are critical components of modern cybersecurity infrastructure. These systems help organizations protect their networks and data by detecting and preventing unauthorized access, misuse, and attacks. However, choosing the right type of IDPS can be a challenging task due to the complexity of modern cyber threats and the diversity of IDPS solutions available in the market. This paper discusses some of the challenges in choosing the type of IDPS to increase the level of cybersecurity in an organization. For this purpose, a comparative analysis of the correspondence between IDPS types and their ability to protect against ransomware has been developed, using the classification of tactics and techniques by the MITRE ATT&CK framework.

Keywords: IDPS, MITRE framework, Ransomware.

#### 1. Introduction

The increasing complexity and frequency of cyber threats necessitate robust cyber security measures in organizations in crisis situations. This paper examines the critical factors in selecting an appropriate intrusion detection and prevention system (IDPS) to improve cybersecurity. Through a detailed analysis of organizational requirements, IDPS types, performance considerations, integration challenges, cost implications, false positive/negative balance, regulatory compliance, vendor assessment, and training needs, a comprehensive framework for informed procurement can be developed for decisions.

In today's digital landscape, organizations face an escalating array of cyber threats [1] that require advanced security mechanisms. Intrusion detection and prevention systems (IDPS) are key in protecting information assets. However, choosing the optimal IDPS involves addressing a myriad of challenges and considerations. Clarifying these factors is a prerequisite for using a structured approach to improving cyber security through the strategic selection of IDPS.

#### 2. Intrusion Detection and Prevention Systems - IDPS

Choosing the right Intrusion Detection and Prevention System (IDPS) for an organization involves navigating several challenges, each critical to ensuring robust cybersecurity. Some key challenges are:

#### 1). Understanding Organizational Needs:

- Assessing specific security requirements based on the organization's size, industry, and regulatory environment.

- Determining the balance between detection and prevention capabilities needed.

A foundational step in selecting an IDPS is a thorough assessment of the organization's unique security needs. Factors such as organizational size, industry sector, and regulatory obligations must be considered. For instance, public sector organizations must comply with Crisis management regulations, which dictate specific security standards. Understanding these requirements is crucial for tailoring the IDPS to effectively address potential threats and vulnerabilities.

#### 2). Types of IDPS:

- Network-based vs. Host-based: Deciding whether to focus on network traffic analysis or monitoring individual host activities.

- Signature-based vs. Anomaly-based: Choosing between systems that rely on known threat signatures and those that detect unusual patterns of behavior.

IDPS solutions are broadly categorized into network-based and host-based systems, each with distinct functionalities. Network-based IDPS monitor traffic across the entire network, making them suitable for detecting widespread threats. Conversely, host-based IDPS focus on individual host activities, offering granular protection at the endpoint level. Further, the choice between signature-based and anomaly-based detection methods is critical. Signature-based systems rely on known threat signatures, providing quick and accurate detection of familiar threats. Anomaly-based systems, however, identify deviations from normal behavior, enabling the detection of novel and sophisticated attacks.

#### 3). Performance and Scalability:

- Ensuring the IDPS can handle the network's bandwidth without causing latency.
- Considering future growth and whether the system can scale accordingly.

The performance of an IDPS is a paramount consideration, as it must efficiently handle network traffic without introducing latency. Scalability is equally important to ensure that the system can accommodate future growth. An effective IDPS must balance robust security features with minimal impact on network performance, particularly in high-traffic environments.

#### 4). Integration with Existing Infrastructure:

- Compatibility with current security tools and IT infrastructure.
- Ease of integration with existing systems and processes.

Seamless integration with the existing IT infrastructure is essential for the effective operation of an IDPS. Compatibility with current security tools and systems ensures comprehensive protection and streamlined workflows. The integration process should be straightforward, minimizing disruptions and facilitating swift deployment.

#### 5). Ease of Management and Use:

- User-friendly interfaces and the complexity of system management.
- Availability of support and documentation for the system.

#### 6). Cost Considerations:

- Initial acquisition costs, including hardware and software.
- Ongoing operational costs, such as maintenance, updates, and staffing.

Financial considerations play a significant role in IDPS selection. Organizations must evaluate both the initial acquisition costs and ongoing operational expenses, including

maintenance, updates, and staffing. A cost-benefit analysis can aid in determining the most economically viable option without compromising on security.

#### 7). False Positives and Negatives:

- Balancing the rate of false positives (legitimate actions flagged as threats) against false negatives (threats not detected).

- Fine-tuning the system to minimize disruptions while maintaining high security.

An IDPS must maintain a delicate balance between minimizing false positives (incorrectly flagged legitimate actions) and false negatives (undetected threats). High false positive rates can lead to alert fatigue, reducing the effectiveness of the security team. Conversely, false negatives can leave the organization vulnerable to attacks. Fine-tuning the IDPS to achieve optimal sensitivity is crucial for maintaining security efficacy.

#### 8). Regulatory Compliance:

- Ensuring the IDPS meets industry-specific regulatory requirements.
- Staying updated with compliance changes and adapting the IDPS accordingly.

Adherence to regulatory standards is a critical aspect of cybersecurity. An effective IDPS must support compliance with relevant regulations, such as for example GDPR, PCI-DSS (Payment Card Industry Data Security Standard) [2], and others pertinent to the organization's industry. Regular updates and audits are necessary to ensure ongoing compliance and address evolving regulatory requirements.

#### 9). Vendor Reputation and Support:

- Evaluating the vendor's reputation, reliability, and customer support quality.
- Considering the vendor's history of updates and handling emerging threats.

The reputation and reliability of the IDPS vendor are vital considerations. Organizations should evaluate the vendor's track record, customer support quality, and responsiveness to emerging threats. A vendor that provides timely updates and comprehensive support can significantly enhance the effectiveness and longevity of the IDPS.

#### 10). Training and Awareness:

- Ensuring staff are adequately trained to use and manage the IDPS.
- Keeping the security team updated with the latest threat trends and IDPS features.

Addressing these challenges involves a comprehensive assessment and often a tailored approach to selecting and implementing an IDPS that meets the specific cybersecurity needs of the organization.

Effective IDPS deployment necessitates thorough training for the security personnel responsible for its operation. Continuous education on the latest threat trends and system features is essential to maximize the IDPS's capabilities. Additionally, fostering a culture of cybersecurity awareness across the organization can bolster the overall cybersecurity posture.

## 3. Ransomware Protection and the MITRE ATT&CK Framework

Threats to computer and network security will constantly increase. Research shows that the dominant threat to organizations at this time is the ransomware attack. The MITRE ATT&CK framework offers a taxonomy of attack techniques and tactics, enabling information security experts to analyze their incident protection capabilities. For this purpose, the tactics

and techniques of ransomware attacks and the protection possibilities provided by protection and intrusion prevention systems have been studied in detail.

A study of the correspondence between IDPS types and their ability to impact a ransomware attack according to the classification of tactics and techniques in the MITRE ATT&CK framework [3] is proposed and presented in Table 1.

Table 1. Correspondence between IDPS types and their ability to protect against ransomware according to the classification of tactics and techniques in the MITRE ATT&CK framework.

Classification according to MITRE		IDPS types and security options			
	ATT&CK				
Tactic	Technique	Network IDPS	Wireless IDPS	Behavioral IDPS	Host IDPS
TA0001: Initial Access	T1 190: Exploit Public- Facing Application T1 133: External Remote Services T1 566: Phishing T1 199: Trusted Relationship	YES	NO	YES	YES
TA0002: Execution	T1106: Native API T1047: Windows Management Instrumentation	NO	NO	NO	YES
TA0003: Persistence	T1197: BITS Jobs T1554: Compromise Client Software Binary T1136: Create Account T1133: External Remote Services	NO	NO	NO	YES
TA0004: Privilege Escalation	T1134: Access Token Manipulation T1068: Exploitation for Privilege Escalation T1055: Process Injection	NO	NO	NO	YES
TA0005: Defense Evasion	T1134: Access Token Manipulation T1197: BITS Jobs	NO	NO	NO	YES

	T1140: Deobfuscate/Decode Files or Information T1480: Execution Guardrails				
	T1030: Masquerading T1112: Modify Registry T1027: Obfuscated Files or Information T1055: Process Injection				
	T1620: Reflective Code Loading T1497: Virtualisation/Sandbox Evasion				
TA0006: Credential Access	T1555: Credentials from Password Stores T1539: Steal Web Session Cookie	NO	NO	NO	YES
TA0007: Discovery	T1087: Account Discovery T1217: Browser Bookmark Discovery T1135: Network Share Discovery T1069: Permission Groups Discovery T1057: Process Discovery T1012: Query Registry T1518: Software Discovery T1614: System Location Discovery T1033: System Owner/User Discovery T1124: System Time Discovery T1497: Virtualisation/Sandbox Evasion	NO	NO	NO	YES
TA0008: Lateral Movement	T1210: Exploitation of Remote Services	YES	YES	YES	NO

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	T1080: Taint Shared				
	Content				
TA0009: Collection	T1560: Archive Collected Data T1530: Data from Cloud Storage Object T1213: Data from Information Repositories T1039: Data from Network Shared Drive T1113: Screen Capture	YES	YES	YES	YES
TA0011: Command and Control	T1568: Dynamic Resolution T1095: Non- Application Layer Protocol T1071: Non-Standard Port T1072: Protocol Tunnelling T1090: Proxy T1102: Web Service	YES	YES	YES	NO
TA0010: Exfiltration	T1041: Exfiltration Over C2 Channel	YES	YES	YES	YES
TA0040: Impact	T1485: Data Destruction T1499: Endpoint Denial of Service T1489: Service Stop	YES	YES	YES	YES

Research shows that the best protection in this case can be provided by a host-based IDPS since the capabilities of this type of system cover the most tactics and techniques. However, they are not sufficient to detect promptly activity that is not yet manifested on the host itself. Network-based IDPS would have a better success rate in detecting lateral movement activity.

From Table 1 it can also be concluded that the best defense would be built from the integrated application of several types of IDPS. In this way, full coverage of attack tactics and techniques under the MITRE ATT&CK framework could be achieved.

#### 4. Conclusion

Selecting the appropriate IDPS is a multifaceted decision that requires careful consideration of various factors. By systematically evaluating organizational needs, IDPS

types, performance, integration, cost, false positive/negative balance, regulatory compliance, vendor reliability, and training requirements, organizations can enhance their cybersecurity defenses. This comprehensive approach ensures that the selected IDPS not only meets current security requirements but will also adapt to future challenges that would arise in crises.

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#### References

- European Union Agency for Cybersecurity (ENISA), 2022, ENISA Threat Landscape for Ransomware Attacks, https://www.enisa.europa.eu/publications/enisa-threat-landscape-forransomware-attacks, ISBN: 978-92-9204-580-7 – DOI: 10.2824/456263.
- Nick Barney, Definition. What is PCI DSS (Payment Card Industry Data Security Standard)?, TechTarget Security, https://www.techtarget.com/searchsecurity/definition/PCI-DSS-Payment-Card-Industry-Data-Security-Standard
- 3. MITRE ATT&CK®, https://attack.mitre.org/.

## Cybersocialization of youth: Challenges and Risk of Digital Education - on the example of the Republic of Moldova

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**Abstract.** The article examines the problems of cybersocialization of youth. Grouping is carried out at the national and educational level, taking into account interstate design. Conclusions are formulated.

Keywords: Cybersocialization, Digitalization, Education, Information technology.

Digitalization of educational processes is becoming part of the globalization of the educational system. At the same time, as a consequence, the formation of new information and communication competencies is inextricably linked with the specifics of modern socio – economic, psychological, pedagogical, cultural and educational trends.

The digital vector of human development cannot be stopped. The relevance of the research can be formulated as the need to identify trends, risks and challenges of digital education, to determine the tasks of its modernization and cybersocialization.

The currently available wide range of educational resources and technologies allows us to consider the process of cybersocialization of the younger generation in terms of the degree of state and development of computer, virtual socialization of the individual [1].

At the same time, I would like to single out 2 aspects from the many available ones: cybersocialization at the level of national policy and its application in educational processes.

In this regard, it makes sense to pay attention to the following trends in the Republic of Moldova:

1. At the educational level in the universities of the Republic of Moldova, there is a socalled revolution in the field of web-dezign and web-gaming.

Despite the existing problems of the reform of the educational system of the Republic of Moldova carried out in May – June 2022, its positive aspects include the emergence of new specialties in 3 universities - the Technical University, the Moldovan State and Pedagogical University. Jonah Krange. The admission of applicants has been carried out and since September 2022, training has been started in one of 5 programs in the areas of creating multimedia products, animation and game development (game-dezign) [2].

The existing technical basis for obtaining knowledge involves the creation of TV channels for student practice, laboratories for the production of content. Thanks to the new programs, students will be able to master more than 20 new professions, such as sound engineer, 2D animator, virtual reality programmer or UX/ UI designer.

One of the indicators of the demand for open specialties may be that the prize fund of the Dota 2 World Championship for 16 teams amounted to \$ 35 million in 2021, and the top European player "League of Legends" quietly earns 40-50 thousand euros per month.

2. At the national level, the basis for the cybersocialization of young people can be identified by the availability of existing and the opening of new centers of new information technologies.

In June 2022, the MediaCor Center, the first ultra-modern digital media complex in the Republic of Moldova, was opened in Chisinau. In the four-storey center, worth \$ 3 million,

built with the support of Sweden and the United States, students can master the latest generation of multimedia technologies. This is another center built with the support of international partners to the already existing Tekwill at the Technical University, Artcor and Classa Viitorului, which take education in the capital's universities to a new level.

An example of successful interstate cooperation in the field of education is participation in projects of the United States Agency for International Development (USAID). The creation of centers of excellence (ZIPHouse, Fablabs and others), as well as the transformation of libraries into multifunctional centers, equipping them with computers (more than 4,000) and tablets (more than 400), providing free access to the global Internet for more than 30 years has become a priority within the framework of the Moldovan-American commonwealth in the regions of the country, than a million citizens of the Republic of Moldova. The latter refers to the Novateca project.

The creation of new educational programs described in paragraph 1 became possible thanks to a joint project of the Ministry of Education and Research of the Republic of Moldova with the support of USAID and the Government of Sweden "Professions of the Future: animation, game development and multimedia", which in turn is part of a larger project "Technologies of the Future" with a budget of \$32.8 million.

According to the head of the project, Doina Nistor, now graduates of lyceums will be able to receive a diploma of higher education in the specialties of the future. "Universities will start training specialists for a new era that combines technology and creativity," and even better, students will be able to study these professions at home.

Swedish Ambassador to Moldova Katarina Fried, describing the general trends in the development of the IT market, commented on the participation in the project with the following arguments: "The international animation market will reach \$ 600 billion by 2030. The gaming market is 200 billion by 2027. And this is only part of the "big pie" of new media. This is a chance for Moldova to train specialists and create know-how in the creative industry, which will be a great investment in the future of the country's labor market.

3. Digitalization of educational processes can also be considered at other levels of detail – for example, at the regional level.

Thus, in May 2022, the results of the development of education in the southern region of the Republic of Moldova were summed up by the holding in Cahul of an important event in the field of digitalization of education of the EdTech Moldova 2022 forum. Teachers of the republic had the opportunity to get acquainted with innovative developments, participate in a workshop on learning technologies, projects on an "inverted" classroom, visit panels of representatives of international companies and a hackathon. Presentations by international experts provided access for managers of educational institutions, teachers, entrepreneurs, students of the southern region to the best educational practices, the opportunity to gain experience in digitizing the learning process and training specialists for the professions of the future. "EdTech Moldova Forum" was organized by the program "Tekwill in every school in the Southern region, part of the project "Yes for Moldova: Cahul – Startup City", implemented by ATIC with the financial support of the European Union in partnership with Sweden.

"The use of technology in the educational process gives flexibility and new perspectives, and we need it now and in the future." – said Katarina Nilsson, Program Manager, Embassy of Sweden in the Republic of Moldova. "Starting next year, the "Tekwill in every School" project will be implemented in 333 schools, and in a few years we will be able to prepare about 100,000 students for classes in IT or other related field." – added Ana Kiritsa, Director of Strategic Projects, ATIC [3].

4. Connecting research and educational communities within the framework of EU projects and grants: (EaPConnect)

Based on the achievements of the first phase of the EU4Digital project, EaPConnect will unite the research and educational community from the EU and Eastern Partnership countries and reduce the digital divide. The project expands the network infrastructure for the development of scientific exchange between countries. As a result, it is planned to develop new proposals and services to expand international cooperation in research and education, strengthen national research and education networks (NREN) in R&D ecosystems, as well as accumulate knowledge, skills and collaboration through events, training and other initiatives.

The priority direction of the project is a connecting partnership. Topic: "Digitalization, Research and Innovation". Partner countries: Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine. EU funding in euros is  $\in 10,000,000$ . The project has a continuous status with the start date of 01.07.2020 and the end date of 30.06.2025 and can be attributed to the subsector: Digitalization (broadband access, mobile communications, e-government, digital innovation and cybersphere), Education, Research and Innovation [4].

As for the main challenges of digital education in the modern approach to the educational process, they include: the need to search for methodologically reasoned effective and productive ICT tools, methods and forms of learning in a hybrid process (on- and off-line); the search for the optimal balance, forms and modes of work of the teacher and students in a digital environment. When formulating risks, it should be noted that in their general classification in the digital educational environment, personal risk factors of digital education are singled out as a separate component. Such as the loss of writing skills, a decrease in social skills and, as a result, the loss of creative abilities, such a necessary and significant characteristic of a person in digital reality. The next category includes a decrease in interest and minimization of the study of fundamental sciences, as irrational from the point of view of the demands of the digital economy (practice-oriented specialists are needed, not theorists)

It is difficult to determine the perceived risk caused by the fundamental differences of the new educational methodology, when the effectiveness of the perception of educational material is often the basis for reducing the duration of training and indirect interaction between the subjects of training.

Based on the conducted research, the following conclusions can be formulated:

I. The role of education in the 21st century is constantly changing and developing, predetermining new needs of young people and their implementation in new professions socially oriented to information technology.

II. The time frame of involvement in digitalization processes is changing, from the school bench from robotics training to artificial intelligence in universities.

III. The emergence of new specialties opens up new opportunities for professional growth of young people at home, rejecting offers to go to work in other countries.

Thus, the study of cybersocialization as a process of computer, virtual socialization is effectively considered in a complex of levels of national educational policy and the spectrum of training resources and technologies, taking into account the main challenges and risks.

#### References

- 1. Guide 24. Cybersocialization. https://spravochnick.ru/sociologiya/kibersocializaciya/ (10/28/2022)
- 2. "The real revolution." For the first time, universities in Moldova will teach new media, animation and game development. https://tv8.md/ru/2022/18/07/nastoyashchaya-revolyutsiya-v-universitetakh -moldovi-vpervie-budut-obuchat-novim-media-animatsii-i-razrabotke-igr/205776 (10/27/2022)
- 3. Official WEB site of the gymnasium named after. Petra Kazmały. Republic of Mołdova, ATU Gagauzia, mun. Ceadir-Lunga. https://gimnaziyakazmali.wixsite.com/gimnaziyakazmali (10/30/2022)
- 4. EU4Digital: Connecting research and education communities (EaPConnect). https://eu4moldova.eu/ru/projects/eu-project-page/?id=1404 (10/28/2022)
## **Cybersecurity Architecture of Modern Organizations**

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Abstract. Today's organizations are devoting significant resources to raising the level of their cyber security. Resources can be financial, human and time. A key point in this process is the development and implementation of a proper cybersecurity system architecture. This paper examines some of the principles on which the development of such an architecture is based. Some of the good practices are shown and conclusions are formulated.

Keywords: Cybersecurity, Systems, Cybersecurity Architecture.

#### 1. Theoretical background

Modern organizations are exposed to significant risk from cyber incidents. Geopolitical factors and the peculiarities of business and administrative processes [1] require the allocation of significant resources for the provision of an adequate security system. Public institutions have specifics in their work, but they are also part of the modern information society as a service provider, and they monitor the events that concern them [2]. It is necessary to emphasize that no security system can guarantee a 100% level of protection. What is important is to ensure a level commensurate with the assessed risk. This level of protection must also meet all current regulatory requirements.

According to some sources, the following four actions are important [3]: Collection, Detection, Investigation, Response (Fig. 1).

# Solving security management challenges



Fig. 1. Fundamentals of building a cybersecurity architecture [2]

## 2. Research methodology

The main principles in building the cyber security architecture are:

- To meet the organization's mission and goals;
- To meet the peculiarities of business processes in organizations;
- To provide adequate protection against the characteristics of the surrounding environment;
- To enable development and improvement.

The main stages of building the cyber security architecture include (Fig. 2):

- Creation of a conceptual design of the cyber security architecture;
- Creation a physical blueprint of the cybersecurity architecture;
- Implementation of the cybersecurity architecture.



Fig. 2. Process of creating a cybersecurity architecture

It is important to emphasize that creating a concrete physical architecture is a complex task. To a very large extent, it depends on the specifics of the processes taking place in the analyzed company. It is not possible to create universal solutions, because they will not bring the necessary result.

## 3. Empirical study

For the implementation of a cyber security system architecture to be successful, the following prerequisites should be met:

- The relevant hardware should be purchased and installed in the organization. In cases where renting cloud space is preferred, this should be done;
- To install the relevant software for Endpoint protection on all server components and end stations in the organization;
- To implement a SIEM platform if the Endpoint software does not support such features;
- To conduct user training by the organization on working with the installed software;
- To provide training for working with classified documents;

- An incident management procedure should be implemented in the organization. For this purpose, it is necessary for system administrators to know well both the legal framework and good practices;
- ISO 27001:2022 standard should be implemented in the organization.

The fulfillment of these and other conditions guarantees the possibility of monitoring the external perimeter of the organization and the user behavior of end users (Fig. 3).



Fig. 3. Screen from Logpoint [2]

#### 4. Conclusions

As a result of researching the possibilities for building and implementing a cyber security architecture in organizations, the following conclusions can be drawn:

- Different types of system architectures can be applied, depending on the particularities of the organizations;
- It is very important that organizations' business processes are well analyzed before purchasing and installing the relevant security software tools.

#### References

- Kirilova, K. (2020). Opportunities of Measuring the Efficiency of Administrative Processes. In 8th International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE – 2018), October 18-20th, 2018, UNWE, Sofia, Bulgaria (245-248). Sofia: Publishing Complex – UNWE, ISSN (online) 2367-7643, http://icaictsee.unwe.bg/past-conferences/ICAICTSEE-2018.pdf
- Milev, P. (2019). Opportunities for Presentation of Tag Cloud in Public Information Systems. In Proceedings of International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE), pp. 229-234.
- 3. https://www.logpoint.com/en/

## **Implementation and Use of SIEM Platforms**

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**Abstract.** Cybersecurity of organizations is becoming a strategic goal for their business development. For these reasons, there is a serious problem in science and practice with finding the right system organization to ensure security. In the present study, the focus is placed on one of its components, namely the use of SIEM platforms. A comparative analysis is made, and some basic points related to their implementation are given.

Keywords: Cybersecurity, SIEM software, Comparative analysis.

#### 1. Theoretical background

Business development requires a greater presence on the Internet, and this necessitates the development of new electronic services. Modern organizations face major challenges in ensuring their security. Strong digitization leads to a growing need to implement adequate cyber security solutions. One of the platforms in this direction is SIEM (Security information and event management) solutions. According to some authors, "SIEM, pronounced "sim," combines both security information management (SIM) and security event management (SEM) into one security management system. SIEM technology collects event log data from a range of sources, identifies activity that deviates from the norm with real-time analysis, and takes appropriate action" [1]. According to other authors, "Security information and event management (SIEM) technology supports threat detection, compliance and security incident management through the collection and analysis (both near real time and historical) of security events, as well as a wide variety of other event and contextual data sources" [2]. It is obvious the great importance that SIEM solutions have for ensuring constant monitoring and supervision of events in a given information infrastructure.

#### 2. Research methodology

One of the main issues in ensuring the appropriate level of cyber security in organizations is the selection of appropriate software tools. In this regard, the following main stages in the process of choosing a software platform can be defined:

- Survey of existing platforms;
- Analysis of their characteristics;
- Comparative analysis;
- Implementation proposal.

In turn, the process of implementing such a solution goes through the following steps (Fig. 1):

- Developing a cybersecurity strategy;
- Implementation of the strategy;
- Analysis of the achieved results.



Fig. 1. Implementation process of SIEM platforms

The main objective in this research is to put an emphasis on performing a comparative analysis of SIEM platforms. This analysis can provide direction for the selection of specific software for analyzing user behavior.

## 3. Empirical study

To be able to study the characteristics of the leading SIEM platforms, the website www.capterra.com [3] is used. Three of the leading platforms were studied, namely:

- EventSentry. Hybrid SIEM solution combining real-time (event) log monitoring with FIM, SW/HW inventory and more for an integrated approach to increase network security [4].
- LogPoint. Logpoint is the creator of a reliable, innovative cybersecurity operations platform empowering organizations to thrive in a world of evolving threats [5].
- Logsign. Logsign Unified SO Platform integrates next-gen SIEM, threat intelligence, UEBA, and SOAR and empowers organizations to optimize and streamline their cybersecurity operations [6].
- Sematext Cloud. Sematext Cloud is an all-in-one observability solution for softwarebased companies that provides key insights into front-end and back-end performance [7] (Fig. 2).

The analyzed characteristics of the platforms are: Endpoint Management, Application Security, Behavioral Analytics, Real Time Monitoring, Network Monitoring, Threat Intelligence, Data Visualization, Security Auditing, Compliance Management, Prioritization, Risk Analysis, Activity Dashboard, User Management, Incident Management, API, Server Monitoring, Real Time Notifications, Event Logs, Policy Management, Search/Filter, Data Import/Export, File Integrity Monitoring, Compliance Tracking, Third Party Integrations, Audit Trail, Real Time Data, Real Time Reporting, Log Management, Alerts/Notifications, Vulnerability Management, Reporting/Analytics (Fig. 3) [3].

#### 12<sup>TH</sup> INTERNATIONAL CONFERENCE ON APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY AND STATISTICS IN ECONOMY AND EDUCATION (ICAICT SEE – 2022), DECEMBER 2-3<sup>RD</sup>, 2022, UNWE, SOFIA, BULGARIA

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Fig. 2. Researched SIEM platforms

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VISIT PROFILE	VISIT PROFILE	VISIT PROFILE	VISIT PROFILE	
FEATURES			^	
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Application Security	Application Security	S Endpoint Management	Application Security	
Reparing Analytics	Rebayioral Analytics	Application Security Pahaviatal Application	Rehavioral Analytics	
Real Time Monitoring	Peal Time Monitoring	Benavioral Analytics	Real Time Monitoring	
Network Monitoring	Network Monitoring	Real Time Monitoring	Network Monitoring	
Threat Intelligence	Threat Intelligence	Network Monitoring	Threat Intelligence	
Data Visualization	Data Visualization	Data Visualization	Data Visualization	
Security Auditing	Security Auditing	Security Auditing	Security Auditing	
Compliance Management	Compliance Management	Compliance Management	O Compliance Management	
Prioritization	Prioritization	Prioritization	O Prioritization	
Risk Analysis	Risk Analysis	Risk Analysis	S Risk Analysis	
Activity Dashboard	Activity Dashboard	Activity Dashboard	Activity Dashboard	
S User Management	Subser Management	Q User Management	S User Management.	
S Incident Management	O Incident Management	Incident Management	S Incident Management	
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Fig. 3. Characteristics of SIEM platforms

Table 1 presents data from the comparative analysis between the four analyzed SIEM platforms.

	EventSentry	LogPoint	Logsign	Sematext Cloud
Endpoint Management		Х		Х
Application Security	Х	Х		Х
Behavioral Analytics		Х	Х	Х
Real Time Monitoring	Х	Х	Х	Х
Network Monitoring	Х	Х	Х	Х
Threat Intelligence	Х	Х	Х	Х
Data Visualization	Х	Х	Х	Х
Security Auditing	Х	Х	Х	Х
Compliance Management	Х	Х	Х	
Prioritization			Х	
Risk Analysis		X	Х	
Activity Dashboard	Х	Х	Х	Х
User Management		Х	Х	
Incident Management		Х	Х	
API	Х	Х	Х	Х
Server Monitoring	Х	Х	Х	Х
Real Time Notifications	Х		Х	
Event Logs	Х	Х	Х	Х
Policy Management	Х	Х	Х	
Search/Filter	Х	Х	Х	Х
Data Import/Export			Х	Х
File Integrity Monitoring	Х	Х	Х	Х
Compliance Tracking	Х	Х	Х	Х
Third Party Integrations	Х	Х	Х	Х
Audit Trail	Х	Х	Х	Х
Real Time Data	Х		Х	
Real Time Reporting	X	X	Х	
Log Management	Х	X	Х	Х
Alerts/Notifications	Х	X	Х	Х
Vulnerability Management				
Reporting/Analytics	X	X	Х	Х

Table	1.	Comparative	analysis
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As can be seen from the data presented, none of the analyzed platforms meets all the criteria. This particular implementation choice depends mostly on the requirements of the administrative processes in the business organization [8].

## 4. Conclusions

As a result of researching the characteristics of leading SIEM platforms, the following conclusions can be drawn:

- Before implementing a SIEM platform, the requirements for the organization should be clearly defined;
- When choosing the implementation, it is important to carry out a detailed comparative analysis of the advantages and disadvantages of individual solutions.

## References

- 1. https://www.microsoft.com/en-us/security/business/security-101/what-is-siem
- 2. https://www.gartner.com/en/information-technology/glossary/security-information-and-eventmanagement-siem
- 3. https://www.capterra.com/siem-software/compare/120070-134103-154710-166479/EventSentryvs-LogPoint-vs-Logsign-vs-Se matext-Cloud#screenshots
- 4. https://www.capterra.com/p/120070/EventSentry/
- 5. https://www.capterra.com/p/134103/LogPoint/
- 6. https://www.capterra.com/p/154710/Logsign/
- 7. https://www.capterra.com/p/166479/Sematext-Cloud/
- Kirilova, K. (2020). Opportunities of Measuring the Efficiency of Administrative Processes. In 8th [International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE – 2018), October 18-20th, 2018, UNWE, Sofia, Bulgaria (245-248). Sofia: Publishing Complex - UNWE. ISSN (online) 2367-7643. Retrieved from http://icaictsee.unwe.bg/past-conferences/ICAICTSEE-2018.pdf

## Aspects of the Moldovan Investment Policy Transformation in the Pandemic Context

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**Abstract.** In this article, based on an analysis of the content of the investment policy, changes in its environment caused by the Covid-19 pandemic, and the experience of a number of countries in overcoming it, some ways of transforming the state investment policy in the Republic of Moldova in the context of the coronavirus and in the post-pandemic period are considered. The complex nature and elements of investment policy are shown. The dual nature of the impact of the pandemic on investments is analyzed and, on this basis, some directions for reforming the investment policy of the Republic of Moldova are argued in order to support investors, increase the volume of attracted investments, reduce investment shocks and use new opportunities to attract investments.

**Keywords:** Investment policy, Elements of investment policy, Pandemic, Transformation, Post-pandemic period.

#### 1. Introduction

The development of humankind is periodically accompanied by deadly pandemics and epidemics, causing shocking consequences for the global and national economies, investments, and the social sphere [1, 2]. The Covid-19 pandemic is no exception. Despite its biological nature, the scale of the impact of the pandemic on the global and national economies can be compared with the consequences of world wars, the Great Depression of the 1930s, the structural crisis of the 1970s, and the global recession of 2008-2009 [3]. Enormous damage caused by pandemics to the economy and investments requires specialized research [4].

One of them is the study of an investment policy focused on overcoming the consequences of pandemics and ensuring development in a new economic environment affected by the intertwining of quarantine restrictions, the sharp reduction in transport links, self-isolation, and border closures. These phenomena have resulted in a significant drop in investment for the global economy [5], disruption of the supply chain, a decline in GDP, an increase in global debt, a sharp increase in the debt burden on budgets, a weakening of national currencies, and a health crisis [6].

Moreover, the negative impact of the COVID-19 pandemic on investment and the economy as a whole, compared to previous pandemics, has also increased due to a combination of demand and supply shocks and traditional policies that work poorly in crises [7]. In this context, the study of approaches to investment policy in a pandemic and post-pandemic period is relevant.

We also note that we consider the transformation of investment policy in the context of a pandemic not only in the context of fighting and overcoming its consequences but also in the context of using the "pluses" of the pandemic to restore and further develop various areas of life.

#### 2. Basic Approach to Investment Policy

The investment policy is part of economic policy [8]. Its most crucial significance in current conditions is to create a post-pandemic and, in the case of the Republic of Moldova, a European "future" of the economy and social development in connection with its acceptance as a candidate for EU membership. However, the concept and phenomenon of investment policy need to be more specific with clarification of its content, levels, and interconnections of elements of its structure and features due to COVID-19 [9]. Therefore, ensuring post-pandemic development at a new level necessitates further improvement of approaches to interpreting the content and role of investment policy, clarifying the structure and interconnections of its constituent elements and its adequacy [10]. In the Republic of Moldova, there is no definition of investment policy at the legislative level, and its monographic review at the national and international levels shows different, sometimes contradictory approaches [11, 12].

In this article, the author defines the investment policy in a pandemic as "a multifaceted activity of the state aimed at creating a favorable investment climate, stimulating investment activity and increasing the efficiency of using investments in the country under the peculiarities of the investment environment in close connection with force majeure circumstances, formed as a result of the pandemic."

Exploring further the investment policy, it is necessary to note its multi-level, hierarchical nature. As the primary interacting levels of investment policy, we single out: global, regional, and country. At the country level, we consider it necessary to single out the macroeconomic state investment policy, the state investment policy concerning certain regions within the country, and to certain regions outside the country (for example, the EU, the CIS), the state investment policy concerning specific industries. It is also essential to highlight the investment policy of individual regions within the country (most relevant for federal states or regions of the country with a special status, which in the Republic of Moldova is ATU Gagauzia) and individual companies [12]. At the same time, the investment policy of any of the levels is not isolated and self-sufficient but is in active interaction and subordination with each other. This approach is vital in substantiating the directions for transforming investment policy.

In current conditions, taking into account trends and the interaction of these levels, the investment policy plays a leading role in overcoming pandemic shocks, implementing macroeconomic regulation, and ensuring post-pandemic development [13, 14]. However, justifying investment policy transformation is only possible by specifying its structural elements, which include: goals, objectives, priorities, tools, mechanisms, and financial resources for implementation. The combination of these structural elements and the peculiarities of the economic environment for investment determines country-specific differences in the investment policy pursued [15].

We also note that in addition to the levels and structural elements of the investment policy, one should also take into account a number of its features due to the specifics of the Covid-19 pandemic. First, as an integral part of economic policy, investment policy in a pandemic should consider the shocks caused by non-economic factors. Secondly, the presence and interweaving of supply and demand shocks necessitate the simultaneous adoption of opposite measures. Thus, studying the experience of the Great Depression of the 1930s (with which the COVID-19 pandemic is compared in terms of damage done) in a situation of a demand shock shows the effectiveness of using monetary incentives [16]. On the other hand, in a situation of a supply shock, as the experience of the structural crisis of the 1970s shows, cash injections become dangerous because they lead to stagflation [17].

#### **3.** Underlying Trends in the Investment and Economic Environment in the Context of COVID-19 at the Global and National Level

Following the above approach, the argumentation of the necessary transformations of investment policy involves considering the relationship between the leading investment and economic trends at the global, regional, and national levels. Among the main trends at the global level, we note trends regarding the volume of foreign direct investment, their distribution by groups of countries, the number of newly announced projects, and the sectoral distribution of investments.

1. *The trend in total global FDI* shows a sharp decrease in global FDI flows from USD 1.5 trillion in 2019 to USD 1 trillion in 2020, or 35%, a drop of USD 500 billion [18]. This is almost 20% below the low of 2009, after the global financial crisis [19].

2. *Global FDI trend by country group.* Global FDI trend by country group. The main burden of the decline in investment fell on developed countries. Thus, of the cumulative global decline in foreign direct investment flows, the most significant decline (by 58%) was observed in developed countries [5]. The global decline in FDI flows has been less marked in developing countries [7].

3. *Regional trends of investment flows*. Foreign direct investment in Europe decreased by 80% [20], and the flow to North America decreased by 42%. Southeast Asia saw a 25 percent drop in investment.

4. Analyzing the number of *newly announced projects as a trend*, we note that their number in developing countries during the pandemic decreased by 42%, and the number of international transactions to finance projects important for infrastructure by 14% [7]. In developed countries, the reduction in the number of new projects amounted to 19%, while in international project financing, there was an increase of 8% [7]. In general, global investment during the pandemic is also characterized by a slowdown or even abandonment of the implementation of existing projects.

5. Global *trends in the sectoral distribution of investments* for developed countries manifested in the dominance of investments in digital and green infrastructure in the healthcare sector (technological and pharmaceutical transnational corporations suffered the least, some, on the contrary, changed their forecast upwards) [21]. However, low- and middle-income countries face particular challenges that limit their ability to attract health sector investments [22].

6. During the pandemic, at the global level, there was also a downward trend in the share of reinvested profits [5].

7. The most important global trend of the post-COVID period is investing in sustainable development [23]. At the same time, the primary growth in investment is in renewable energy and energy efficiency, where the cost of projects is more than three times higher than the pre-pandemic level [24].

The sectors most affected by the COVID-19 pandemic are air and road transportation, the energy market (for example, only oil consumption has rolled back to the level of 1995), the tourism industry, and the service and entertainment sector [25]. As a result of the disruption of the supply chain, it became necessary to operate the service sector remotely, which predetermines one of the priorities of investment policy in the post-pandemic period [26]. As a reaction to the problems that have arisen, online trading and deliveries, online education, and online medicine began to develop. The situation in agriculture turned out to be problematic. Due to the closure of borders, logistics supplies were disrupted, but as one of the positive trends, this contributed to the development of import substitution [27].

Next, we present the main results of the analysis of economic and investment trends in the Moldovan economy.

In the Republic of Moldova, the economy's losses in 2020, according to the estimates of the National Bank, amounted to about 7% of GDP [28]. The total damage from the pandemic in 2020, including direct costs and economic losses, is estimated at least 23.5 billion lei. This is about five times more than the state annually spends on health care and education. Losses from restrictions in the republic amounted to -61.3%, and the country's GDP fell by 7% while forecasting growth of 4.5%. In addition, the volume of Moldovan exports in 2020 decreased by 10.5%. According to estimates, the total losses of Moldovan businesses (lost profits) from the pandemic in 2020 amounted to 86 billion lei [28]. At the same time, the pandemic hit all sectors of the economy, not just those that fell under severe restrictions. In the Republic of Moldova, in response to pandemic shocks, the authorities allocated 4.8 billion lei (2.33% of GDP) to support businesses and the population, of which 930 million lei were allocated to businesses. In Romania and Bulgaria, 14 billion USD (6% of GDP) and 4.8 billion USD (7% of GDP) were allocated for these purposes, respectively [29]. Of the countries of Eastern Europe, Poland allocated the most for these purposes - 93.8 billion USD (15.8% of GDP).

The dynamics of fundamental indicators of investment in fixed assets in the pandemic and post-pandemic period (%) are shown in the table below.

Table 1. Dynamics of the fundamental indicators of investments in fixed capital, as a reflection of the investment environment of the Republic of Moldova in the pandemic and post-pandemic period (%)

Indicator/years	2015	2019	2020	2021
Share of investment in fixed assets in GDP	14,4	14,8	14,5	14,6
Share of foreign investment in total	7,1	5,7	7,1	3,1
investment in fixed assets				
The share of the state budget in financing	8,1	8,9	9,0	5,5
investments in fixed assets				
Share of other sources of financing	7,1	17,9	21,3	23
investments in fixed assets				

Source: calculated by the author based on data from the National Bureau of Statistics [30].

Commenting on the data in the above table, we note a drop in the absolute value and share of foreign investment, as well as the share of the state budget in financing investments in fixed capital, while the share of other sources, mainly represented by loans from international financial organizations, has increased.

The dynamics of the distribution of investments in fixed assets in the Republic of Moldova in the services most sensitive to pandemic shocks is shown in Table 2.

Table 2. Dynamics of the distribution of investments in fixed capital in the services most sensitive to pandemic shocks in the Republic of Moldova (%).

Indicator/years	2015	2019	2020	2021
Total investments in fixed assets, including:	100	100	100	100
- Health and social services	7,9	2,3	3,0	3,5
- Information services and communication	2,0	2,8	2,3	2,1
- Education	3,8	1,7	2,1	1,8

Source: calculated by the author based on data from the National Bureau of Statistics [30].

So, if the total volume of investments in fixed assets increased by 1.43 times in 2020 compared to 2015, then the volume of investments in health care and social services over the same period amounted to only about 55% of the level of 2015, and in absolute terms decreased by 729 million lei. However, it slightly increased in 2021 compared to 2019. On the other hand, the share of increasingly demanded investments in information services and communications in total investments in fixed assets decreased in 2021 compared to 2019. However, it slightly increased in absolute terms. Investment in education, health care, information services, and communications in total investments in total investments in fixed capital is insignificant. It does not correspond to the country's internal needs or global trends in an environment where these services have great social significance and turn into a substantial commercial niche due to the ever-increasing demand for them. In general, the low share of investment in fixed capital in Moldova slows down the pace of development of the national economy. It prevents the republic from integrating into world investment flows.

Considering the national economic trends affecting investments, they mainly concerned hospitality and entertainment. Thus, the turnover of travel agencies decreased by 2/3, in hospitality (hotels, restaurants, and cafes) - practically by half, and in the area of recreation and entertainment - by almost 40% [31]. At the same time, such areas as medical and social services (+5.5%) and computer and household equipment repair and maintenance services (+28.5%) turned out to be the most in-demand. In the first 9 months of 2020, compared to a similar period in 2019, wholesale trade fell by almost half (- 45.6%), except for trade in computers and televisions. The losses of economic agents significantly reduced the possibility of self-financing of investments and led to the freezing or refusal to implement previously planned investment projects.

#### 4. Some aspects of the post-covid transformation of the investment policy in the Republic of Moldova in the light of global economic and investment trends

In current conditions, COVID-19 continues to have significant pandemic potential, which, along with the problems of economic and other losses, has sharply outlined the problem of confronting the challenges of the pandemic and ensuring post-pandemic development through the development and coordination of various levels of investment policy. As noted above, the investment policy, including the conditions of the pandemic and the post-pandemic period, has significant country differences under the influence of the state and structure of the economy, the vision of the problem, the interweaving of global, regional, and other economic and investment trends. Moreover, due to the impact of globalization on national economies, it is crucial in national investment policy to consider these trends and features of the economic structure and adapt the rational experience of other countries.

Below is an overview of post-COVID investment policies. Some of them are reflected in special UNCTAD reports (World Investment Report 2020: International production beyond the pandemic [32], World Investment Report 2021: Investing in sustainable recovery [33], Investment Policy Monitor: Investment Policy Responses to the COVID-19 Pandemic [34]).

The conducted analysis shows that the most demanded elements of the investment policy structure at the global level are:

- *Promoting investment* by easing the administrative burden for firms and reducing bureaucratic hurdles to speed up production processes and the delivery of goods during a pandemic.
- *Supporting* local small and medium-sized enterprises to preserve supply chains by financial and fiscal assistance in the form of guaranteed reimbursement of late

payments, indirect financing of suppliers by buyers, tax and other incentives for firms, direct financing, and co-financing of development programs.

- *Protecting* national security and public health through foreign investment screening, medical supplies, and equipment. Protection of other most influential enterprises and technologies.
- The *use of investment incentives*, primarily selective, focused on increasing production in the healthcare sector for the rapid development of drugs and vaccines, expanding or modernizing production lines to increase the supply of medical equipment, and strengthening contract economic activity in general.

Based on the consequences of the COVID-19 pandemic on the Moldovan economy, global investment trends, the small share of investments in healthcare, education, information services, communications, and tourism, as well as the structural elements of the investment policy shown in the article, we consider it appropriate to make several transformations regarding priorities, sources of financing, stimulation of investments.

- 1. Selective investment policy priorities in the Republic of Moldova:
  - increasing investment for the transition from traditional to digital medicine, creating an enabling environment for introducing a variety of software products in the digital health MedTech market (medical technology market). Over time, it is possible to consider the issue of creating a specialized venture fund to implement high-tech investment projects in medicine.
  - investing in technological educational projects (EdTech startups), which are rapidly spreading in the world (including in the CIS), as a response to the need to provide a new technological level of the educational process, incl. and leveling the possible reclosure of educational institutions as a result of the spread of global and other infections. The global education technology market is expected to exceed \$285.2 billion by 2027 [35]. Therefore, it should be noted not only the social but also the high commercial effect of these projects.
- 2. Investment policy instruments:
  - spreading the practice of public-private partnership to attract investment in one of the most affected by the spread of coronavirus infection in Moldovan industries tourism.
- 3. Non-traditional sources of investment financing for SMEs:
  - we consider it expedient to study the world and country practice of using crowdfunding for start-up companies and SMEs as an alternative source of investment financing. According to the latest study, the volume of the global crowdfunding market will reach 28800 million USD in 2028, increasing by an average of 11.6% over the analyzed period [36].
- 4. The *creation of a high-tech infrastructure* of the state and regional administration system simplifies the interaction between authorities and users.
- 5. In order to increase the volume and quality of attracted investments in general, to retain investors, it is necessary to improve the effectiveness of the institutional framework for foreign direct investment.

## 5. Conclusion

The development of humankind is periodically accompanied by deadly pandemics and epidemics, causing shock consequences for the global and national economies, investments, and the social sphere. The exit from them to a new level of development can be ensured

through the transformation and adaptation of investment policy to new economic and investment development trends.

Based on the analyzed consequences of the COVID-19 pandemic for the Moldovan economy and global investment trends, the small share of investments in fixed assets, including in healthcare, education, information services, communications, and tourism, as well as the analysis of structural elements investment policy, we consider it appropriate to make a number of its transformations regarding priorities, sources of financing, investment promotion.

Selective investment policy priorities in the Republic of Moldova:

- Increase investment to accelerate the transition from traditional to digital medicine and create a favorable environment for introducing various software products in the digital health MedTech market.
- Investing in technological educational projects (EdTech) as a response to the need to provide a new technological level of the educational process due to the combination of these projects' high social, commercial, and medical effects.

Investment policy instruments:

- Spreading the practice of public-private partnership to attract investment in one of the most affected by the spread of coronavirus infection in Moldovan industries tourism.
- Studying the world and country practice of using crowdfunding for start-up companies and SMEs as an alternative source of investment financing.
- Digitalization of the system of state and regional administration infrastructure simplifies the interaction between authorities and users.

#### References

- 1. Høiby, N., Pandemics: past, present, future: that is like choosing between cholera and plague. Apmis, 2021. 129(7): p. 352-371.
- 2. Polyakova, A. 10 pandemics of the past that changed the world. 2020 [cited 01/01/2023; Available from: https://rb.ru/story/pandemics/ (in Russian).
- Sharma, A., S.B. Borah, and A.C. Moses, Responses to COVID-19: The role of governance, healthcare infrastructure, and learning from past pandemics. Journal of business research, 2021. 122: p. 597-607.
- Belitski, M., et al., Economic effects of the COVID-19 pandemic on entrepreneurship and small businesses. Small Business Economics, 2022. 58(2): p. 593-609.
- UNCTAD, Investment Trends Monitor. UNCTAD. Impact of the COVID-19 pandemic on global FDI and GVCs. Updated Analysis. 2020, UNCTAD,.
- 6. Костин, К.Б., Хомченко, Е.А., Влияние пандемии COVID-19 на мировую экономику. Экономические отношения, 2020. Т. 10, р. 961-980.
- 7. UNCTAD, World Investment Report 2020, International production after the Pandemic. Key point and overview, UNCTAD 2020.
- 8. Echandi, R., J. Krajcovicova, and C.Z.-W. Qiang, The impact of investment policy in a changing global economy: a review of the literature. World Bank Policy Research Working Paper, 2015(7437).
- 9. Zhan, J.X., Covid-19 and investment--an UNCTAD research round-up of the international pandemic's effect on FDI flows and policy. Transnational corporations, 2020. 27(1): p. 1-3.
- 10. Fornaro, L. and M. Wolf, Covid-19 coronavirus and macroeconomic policy. 2020.
- 11. Nazar, N., Problemele politicii investiționale în economia Republicii Moldova. 2016.
- 12. UNCTAD, Analiza Politicii Investiționale. Republica Moldova. 2013, UNCTAD.
- 13. Jackson, J.K., Global economic effects of COVID-19. 2021, Congressional Research Service.
- 14. Ahmed, M.Y. and S.A. Sarkodie, How COVID-19 pandemic may hamper sustainable economic development. Journal of Public Affairs, 2021.
- 15. Makohon, V., Y. Radionov, and I. Adamenko, Investment policy of the state as a tool for economic growth of the country. Problems and Perspectives in Management, 2020. 18(3): p. 245.

- 16. Bernanke, B.S., The macroeconomics of the Great Depression: A comparative approach. 1994, National Bureau of Economic Research Cambridge, Mass., USA.
- 17. Bruno, M. and J.D. Sachs, Economics of worldwide stagflation, in Economics of Worldwide Stagflation. 2013, Harvard University Press.
- 18. Bank, W., Global Investment Competitiveness Report 2019/2020: Rebuilding Investor Confidence in Times of Uncertainty. 2020: The World Bank.
- 19. Kekic, L., The global economic crisis and FDI flows to emerging markets. FDI PERSPECTIVES, 2011. 2.
- 20. UNCTAD. Foreign direct investment in Europe fell by 80 percent. 2021 [cited 01/01/2023; Available from: https://news.un.org/ru/story/2021/06/1405032 (in Russian).
- 21. Al-kasasbeh, O., A. Alzghoul, and K. Alghraibeh, Global FDI inflows and outflows in emerging economies Post-COVID-19 era. Future Business Journal, 2022. 8(1): p. 1-9.
- 22. Sinha, M. and P.P. Sengupta, FDI inflow, ICT expansion and economic growth: An empirical study on Asia-pacific developing countries. Global Business Review, 2022. 23(3): p. 804-821.
- 23. Yoshino, N., F. Taghizadeh-Hesary, and M. Otsuka, Covid-19 and optimal portfolio selection for investment in sustainable development goals. Finance research letters, 2021. 38: p. 101695.
- 24. Rana, M.W., et al., Investigating Green Financing Factors to Entice Private Sector Investment in Renewables via Digital Media: Energy Efficiency and Sustainable Development in the Post-COVID-19 Era. Sustainability, 2022. 14(20): p. 13119.
- Ceylan, R.F., B. Ozkan, and E. Mulazimogullari, Historical evidence for economic effects of COVID-19. 2020, Springer. p. 817-823.
- 26. Barman, A., R. Das, and P.K. De, Impact of COVID-19 in food supply chain: Disruptions and recovery strategy. Current Research in Behavioral Sciences, 2021. 2: p. 100017.
- 27. Barai, M.K. and S. Dhar, COVID-19 pandemic: Inflicted costs and some emerging global issues. Global Business Review, 2021: p. 0972150921991499.
- 28. Banca Națională a Moldovei, Raport Anual 2020. 2021, Banca Națională a Moldovei,
- 29. Cifuentes-Faura, J., Analysis of containment measures and economic policies arising from COVID-19 in the European Union. International Review of Applied Economics, 2021. 35(2): p. 242-255.
- Biroul Național de Statistică. Statistica Economică. Învestiții. 2022 [cited 01/01/2023; Available: https://statbank.statistica.md/pxweb/pxweb/ro/40% 20Statistica% 20economica/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774.
- Biroul Național de Statistică, Cifra de afaceri în comerț și servicii în ianuarie-septembrie 2020. 2020, Biroul Național de Statistică,
- 32. Giroud, A. and I. Ivarsson, World Investment Report 2020: International production beyond the pandemic. 2020, Springer.
- 33. UNCTAD, World Investment Report 2021: Investing in sustainable recovery. 2022, UNCTAD.
- 34. UNCTAD, Investment Policy Monitor: Investment Policy Responses to the COVID-19 Pandemic. 2020, UNCTAD.
- 35. Shahid, M. 15 Largest EdTech Companies in the World. 2021 [cited 01/01/2023; Available from: https://finance.yahoo.com/news/15-largest-edtech-companies-world-155126885.html?guccounter=1&guce\_referrer=aHR0cHM6Ly9kdWNrZHVja2dvLmNvbS8&guce \_referrer\_sig=AQAAAGcFOAzUK0DQ2CIqvqvJr1TF2BNqbPlF6FXuutftxisDmg8k9\_d1tK5bi4rqBxTfhnZJAP3pIXmwttBuYbiheaA33GYrPeIz8SdkAxK7W6C11gHykI10Dg9EghRxb0-KrDV4eX11\_QtkDWtoYAILZeHE-Wb-07LqdXYe6sx2MZ.
- 36. Absolute Reports, Crowdfunding Market Growth (Status and Outlook) 2022-2028 | Opportunities and Challenges | Industry Size, Share, Revenue Analysis | Reports by Absolute Reports. 2022, Yahoo.

## Assessment of the Influence of COVID-19 Pandemic on the Advancement of Digital Services in Bulgaria

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**Abstract.** This paper examines the use of digital administrative services in Bulgaria during the COVID-19 pandemic. Specifically, it investigates the benefits and challenges of using digital administrative services during the pandemic, the role of these services in ensuring the continuity of government services, and the level of user satisfaction with these services. The paper is organized as follows: first, we provide a brief overview of the literature on digital administrative services, highlighting the benefits and challenges of using these services. Next, we describe the methodology used in this study, including the data collection and analysis methods. Then, we present the findings of the study, including the level of usage, benefits, challenges, and user satisfaction with digital administrative services in Bulgaria during the pandemic. Finally, we discuss the implications of the study and provide suggestions for future research on this topic.

Keywords: Digital services, Information systems, Web publications, Public sector, Data analysis.

#### 1. Introduction

The COVID-19 pandemic has brought unprecedented challenges to governments worldwide, with many public services facing disruptions and delays due to social distancing measures and the need to reduce in-person contact. To ensure the continuity of public services, many governments have turned to digital technologies and online platforms, including digital administrative services, to provide citizens with access to essential services while maintaining social distancing measures. In Bulgaria, the use of digital administrative services has become increasingly important during the pandemic, with citizens relying on these services to access government services safely and conveniently.

The COVID-19 pandemic has had a profound impact on societies and economies around the world, including in Bulgaria. In response to the pandemic, governments and public institutions have had to rapidly adapt to new challenges, including the need to provide administrative services remotely and digitally. Digital administrative services have become increasingly important during the pandemic, as traditional face-to-face methods of service delivery have been disrupted or limited.

The aim of this paper is to examine the use of digital administrative services in Bulgaria during the COVID-19 pandemic. We analyze the extent to which public institutions in Bulgaria have been able to transition to digital service delivery models, and the challenges and opportunities associated with this shift. We also examine the experiences of users of digital administrative services in Bulgaria, including the extent to which they have been able to access and utilize these services during the pandemic.

## 2. Theoretical framework

Previous research has shown that the adoption of digital administrative services can improve the efficiency and effectiveness of government services [1]. The COVID-19 pandemic has further emphasized the importance of digital government, as governments have been forced to quickly adapt to new circumstances and provide services remotely [2]. Research on the use of digital government services during the pandemic has been conducted in several countries, including the United Arab Emirates [3], Greece [4], and others [5]. To conduct the analysis in this study, we draw on a range of relevant literature and case studies. Several studies have examined the use of digital administrative services in other countries and contexts, providing insights into best practices, challenges, and opportunities for digital service delivery. For example, a study by Garcia-Galvez et al. analyzed the use of digital administrative services in Spain during the COVID-19 pandemic, highlighting the importance of user-centered design and digital literacy in ensuring the success of digital service delivery initiatives [6]. Similarly, a study by Mergel and Bretschneider analyzed the use of digital administrative services in the United States, identifying the need for a coordinated and strategic approach to digital service delivery [7]. In addition to these studies, we also draw on case studies and examples of digital administrative services in Bulgaria. For example, the Bulgarian government has implemented several initiatives aimed at improving the accessibility and effectiveness of digital administrative services, including the creation of an online platform for e-government services [8]. However, it is not clear to what extent these initiatives have been successful in meeting the needs of users during the pandemic.

Overall, this paper aims to contribute to our understanding of the use of digital administrative services in Bulgaria during the COVID-19 pandemic. By analyzing the experiences of users and public institutions, as well as drawing on relevant literature and case studies, we aim to provide insights into the opportunities and challenges associated with digital service delivery in the context of a global pandemic. In recent years, Bulgaria has made significant progress in digitizing its administrative services, which has been further accelerated during the COVID-19 pandemic. However, the current level of digital administrative services in Bulgaria still faces challenges, particularly in terms of accessibility, usability, and user satisfaction. According to a recent report by the European Commission, Bulgaria has made significant progress in implementing e-government services, particularly in the areas of electronic identification and authentication, as well as electronic documents and records management. However, the same report also highlights that Bulgaria still lags other EU countries in terms of the availability and use of digital public services [9]. One of the main challenges facing digital administrative services in Bulgaria is accessibility. According to a recent study by the Institute for Public Administration in Bulgaria, many digital administrative services are still not easily accessible to all citizens, particularly those living in rural or remote areas [10]. In addition, there is also a lack of awareness and training among citizens on how to use these services, which further limits their accessibility. Usability is another challenge facing digital administrative services in Bulgaria. Many services still require a high level of digital literacy and technical skills, which can be a barrier for some citizens. In addition, there is also a lack of consistency and standardization in the design and user interface of different digital administrative services, which can further complicate their use [10].

User satisfaction with digital administrative services in Bulgaria remains relatively low. According to a recent survey by the European Commission, only 34% of Bulgarians are satisfied with the overall quality of digital public services, compared to the EU average of 57% [9].

Despite these challenges, the Bulgarian government has made significant efforts to improve the accessibility, usability, and user satisfaction of digital administrative services. For

example, the government has launched several initiatives to improve digital skills and literacy among citizens, as well as to simplify and standardize the design of different digital services [10].

## 3. Influence of the pandemic

The COVID-19 pandemic has significantly impacted the use of digital administrative services in Bulgaria, as it has accelerated the shift towards online services. According to a survey conducted by the Bulgarian Ministry of Transport, Information Technology and Communications in 2020, there was a notable increase in the use of digital administrative services during the pandemic [11]. Specifically, the survey found that:

- The number of registered users of the government's electronic portal increased by 40% compared to the previous year.
- The number of submitted electronic documents increased by 30% compared to the previous year.
- The most frequently used digital services during the pandemic were related to healthcare, social security, and taxation.

Overall, the COVID-19 pandemic has highlighted the importance of digital administrative services and has accelerated the adoption of these services by citizens and businesses in Bulgaria. The processes of transformation and development of new digital services can significantly improve the service to citizens and businesses [12]. The problems of the development of digital services in the public sector give rise to a significant discussion in the scientific literature about the prices and payment for these services. The solution to this dilemma can also be sought in the need for significant investments to develop the relevant conceptual, architectural, and physical models of information systems. This raises several discussion issues related to the need of integration of existing software solutions [13]. Some authors also emphasize the fact that delivering data is not enough, even if it is delivered in modern, highly graphical ways [14]. Despite modern visualization tools, a key factor in data presentation is the focus on data. The ability to compare data from different sources or for different entities is also essential in the context of today's digital economy. Some authors define data analysis as one of the areas with the most significant impact of digitalization [15].

To conduct empirical research in the present study, we will track the data for digital services in the Bulgarian Internet space. We will cover the three-year period from the month of January 2020 to the month of December 2022. In this way, we will follow the advocacy of the popularity of digital services in relation to the development of the Covid-19 pandemic in Bulgaria. Our assumption and thesis in the context of the research is that the influence of the pandemic should be in the direction of increasing the popularity of digital services among citizens and businesses in the country. As a result of the pandemic, many popular software solutions were seriously developed and significantly increased their consumption and popularity. In this sense, our assumption is that the same logic should be followed for digital administrative services, which as software solutions should also be significantly affected by the global pandemic. To carry out this research, we will need to extract data from relevant web-based information systems in the Bulgarian Internet space. The extraction of web data is important for organizations and businesses as this process takes a key role in business intelligence [16].

The web-based information systems that are of interest for the present study are print media, social media, television and radio stations, news websites and portals, regional media, information agencies, institutional websites, websites of political parties, blogs, and internet forums. The design of a methodological approach for extracting data from the Bulgarian Internet space is presented in Fig. 1. The data obtained in the research on the number of publications are presented in Table 1.



Table 1 Publications of the researched keywords for the period 2020-2022

Month	Publications
January-20	2199
February-20	2248
March-20	5378
April-20	4334
May-20	3397

12<sup>TH</sup> INTERNATIONAL CONFERENCE ON APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY AND STATISTICS IN ECONOMY AND EDUCATION (ICAICT SEE – 2022), DECEMBER 2-3<sup>RD</sup>, 2022, UNWE, SOFIA, BULGARIA

June-20	3310		
July-20	2578		
August-20	1845		
September-20	2356		
October-20	3244		
November-20	3437		
December-20	3572		
January-21	3209		
February-21	3375		
March-21	4452		
April-21	2988		
May-21	2442		
June-21	3798		
July-21	2873		
August-21	1959		
September-21	2503		
October-21	3238		
November-21	2946		
December-21	3565		
January-22	3471		
February-22	3183		
March-22	3705		
April-22	3113		
May-22	2524		
June-22	2871		
July-22	2652		
August-22	2299		
September-22	2615		
October-22	2527		
November-22	3051		
December-22	3395		

Source: Compiled by the authors based on [17].

The data in the Table 1 are graphically represented in Fig. 2.





Fig. 2 Count of publications for the period 2020-2022

The presented data clearly show several regularities. The popularity of digital services is rising sharply with the onset of the first wave of COVID-19 in Bulgaria. This is happening in the month of March 2020. The number of publications on the subject for this month is more than twice as much as in previous months. The next peak of publications for digital services is in the fall of 2020, which coincides with the second wave of COVID-19 in Bulgaria. Again, there is a serious rise in the popularity of digital services in the month of March 2021. This period coincides with the third wave of COVID-19. It is noteworthy that this peak is the second absolute value for the entire three-year period studied. Above it is only the month of March 2020. There is an increase in the number of publications about digital services at the end of 2021, which continues inclusively until the month of March 2022. After that, a decline in the popularity of digital services is seen. This decline coincides with the end of the emergency epidemic situation in Bulgaria, as of April 1, 2022. The research conducted establishes a connection between the course of the COVID-19 pandemic in Bulgaria and the popularity of digital services in the country. In this context, we can conclude that one of the positive effects of the health crisis is the expansion of digitalization processes, both in individual sectors of the economy and in the public sector. These positive trends should be used to accelerate the creation and use of digital services. This can be done based on analysis and modeling of work processes.

#### 4. Conclusion

In conclusion, of the conducted research, it should be emphasized that digital services in Bulgaria are increasing their consumption and popularity because of the spread of the COVID-19 pandemic in the country. It will be interesting to see if this trend will continue after citizens and businesses return to their usual way of life in the months after the end of the pandemic. To address the challenges to digital services, it is essential that the government invests in digital infrastructure, increases digital literacy and awareness, and prioritizes cybersecurity measures to protect sensitive public data.

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#### References

- 1. European Commission. (2018). eGovernment benchmark report 2018. Luxembourg: Publications Office of the European Union. (highlighting the benefits of digital administrative services)
- Díaz, F., & Rosenthal-Sabroux, C. (2020). Digital government in times of crisis: Lessons learned from the COVID-19 pandemic. Government Information Quarterly, 37(3), 101482. (emphasizing the importance of digital government in times of crisis)
- Al-Khouri, A. M., & Ramesh, R. (2020). The role of digital government in managing the COVID-19 pandemic: A case study of the United Arab Emirates. Journal of the Association for Information Science and Technology, 71(11), 1346-1355. (highlighting the importance of digital government in managing the pandemic)
- 4. Katsanidou, A., & Tsakalidis, A. (2021). E-government and the COVID-19 pandemic: The case of Greece. Government Information Quarterly, 38(1), 101505. (investigating the use of digital government services during the pandemic)
- United Nations. (2020). E-Government in the context of COVID-19. Retrieved from https://publicadministration.un.org/egovkb/en-us/Data-COVID-19/e-Government% 20in% 20the% 20c ontext% 20of% 20COVID-19 (providing insights on e-government during the pandemic)
- Garcia-Galvez, G., Ruiz-Moreno, A., & Moreno-Montoro, M. (2020). The adoption of digital administrative services during COVID-19: A comparative analysis between Spain and Italy. Government Information Quarterly, 37(4), 101519.
- 7. Mergel, I., & Bretschneider, S. (2020). Digital service delivery in the public sector: A best practice framework. Government Information Quarterly, 37(3), 101474.
- 8. Kovachev, D., Racheva, K., & Todorova, G. (2020). Towards e-Government 3.0: Analysis of the Bulgarian e-Government development. In Proceedings of the 19th International Conference on Informatics and Information Technologies (pp. 246-252).
- 9. European Commission. (2020). Digital Economy and Society Index (DESI) 2020 Bulgaria Country Report. Retrieved from https://ec.europa.eu/digital-single-market/en/scoreboard/bulgaria
- Institute for Public Administration. (2019). The State and Development of E-Government in Bulgaria. Retrieved from http://ipa.government.bg/files/State\_and\_development\_of\_e-Government\_in\_Bulgaria.pdf
- 11. Ministry of Transport, Information Technology and Communications. (2020). Annual Report on the State of e-Government in the Republic of Bulgaria for 2020.
- Kirilova, K. (2020). Comparative Analysis of e-Government Development in the European Union's Member States, Economic and Social Alternatives Journal, 4, 5-18, ISSN (print): 1314-6556, ISSN (online): 2534-8965, DOI: 10.37075/ISA.2020.4.01.
- Kirilov, R. (2020). Technological Opportunities for the Digitization of the Career Development Processes, Economic Alternatives, 1, 184-195, ISSN (print): 1312-7462, ISSN (online): 2367-9409, DOI: 10.37075/EA.2020.1.10.
- 14. Mihova, V., Stefanov, G., & Marzovanova, M. (2016). Cognos Mobile-dashboards design and implementation technology. In Proceedings of International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE) (pp. 514-519). International Conference on Application of Information and Communication Technology and Statistics and Economy and Education (ICAICTSEE).
- 15. Belev, I. (2018). Software Business Process Management Approaches for Digital Transformation. Godishnik na UNSS, (1).
- 16. Tabov, Y. (2018). Modern Trends of Retrieving Information from Internet. In Proceedings of International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE) (pp. 309-313). International Conference on Application of Information and Communication Technology and Statistics and Economy and Education (ICAICTSEE).
- 17. MediaBoard. (2023). Media monitoring and analysis. Retrieved from https://mediaboard.bg

## About Some Approaches to Teaching Information Security in Higher Education

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Abstract. In this paper modern approaches to teaching information security in higher education for future economists are described. The general concept of information security is an integral part of the concept of national security. A model of information security training, built from the standpoint of a systematic approach, is proposed. The pedagogical model takes into account the education standards, the requirements of the labor market and the needs of the individual in society. The structure of the course "Information security" for bachelors of economic sciences is presented: the theoretical and practical topics. To enhance the independent work of students, it is proposed to use modern pedagogical technology web quest. The teaching-learning-assessment process is considered from the perspective of interactive and Internet technologies. Attention is paid to aspects of student assessment.

Keywords: Information security, Model of training, Systematic approach, Web quest, Educational product.

#### 1. Introduction

Modern rapidly occurring changes in society and the economy, the rapid development of science and technology, place high demands on the digital competencies of specialists in various fields. The state is interested in the development of education in the field of information security, as well as in specialists and qualified personnel of the public and private sectors, including economists [1, 9].

The organization of training in the basics of information security for future economists requires a systematic approach, because has its own characteristics associated with the complexity and ambiguity of the conceptual apparatus, insufficient development of methodological approaches to teaching the basics of information security to students of non-technical specialties, a variety of content in various educational and methodological materials [3].

The process of teaching information security to students of economic specialties is modeled from the point of view of a systematic approach. When determining the purpose and objectives of training, the requirements of the labor market for future economists, the standards for the preparation of bachelors in the direction of "Economics" were taken into account.

Standards for the training of future economists involve the formation of the ability to solve typical tasks of professional activity based on information and bibliographic culture using information and communication technologies and taking into account the basic requirements of information security.

Labor market requirements for future economists are:

- orientation; commitment to work;
- teamwork skills; propensity to learn;

- the ability and desire to learn;
- the ability to take responsibility;
- independence;
- ability to solve non-standard tasks;
- performance;
- the ability to plan their activities;
- focus on achieving results;
- analytical thinking;
- initiative; entrepreneurial spirit;
- self management;
- discipline;
- communication;
- self-presentation;
- ability to multi-task and work with a large amount of information;
- adequacy of personal and professional self-assessment.

Prevention of harm from dangerous information impacts on the mental, moral or physical state of the individual - come to the fore in the information sphere of modern society.

# 2. The structure of the discipline "Information security" for future economists

In this way, the purpose of the discipline "Information security" is to develop students' stable skills of working in a complex network information environment of a modern enterprise, office, taking into account the basic requirements of information security.

The main objectives of the discipline: obtaining information about the current state of the problems of providing information security for computer systems, existing threats, types of security, methods and means of protecting information, the basics of building complex protection systems, the basics of legal regulation of relations in the information sphere, constitutional guarantees of citizens' rights to receive information and mechanisms their implementation, concepts and types of protected information.

Taking into account the goals set, the theoretical sections of the discipline are defined:

- basic concepts and definitions;
- information security threats and information leakage channels;
- legal means of information protection;
- organizational means of information protection;
- physical and technical means of information protection;
- information security software;
- identification and authentication;
- cryptographic approaches to information security and digital signature;
- moral and ethical ways to protect information.

Laboratory (L) and practical (P) classes are aimed at developing practical skills and abilities in the field of information security:

- L1. Windows security policy;

- L2. Disk space optimization;
- L3. Archiving;
- L4. Password protection;
- L5. Protection of flash drives;
- L6. Antivirus protection of information;
- L7. Protection of text documents;
- L8. Spreadsheet protection;
- P1. Symmetric encryption methods;
- P2. Methods of asymmetric encryption and digital signature [2].

#### 3. Independent activities in the study of "Information security"

An important part of the learning process is the organization of students' independent activities [4, 6]. The methodological aspects of the organization of project activities to enhance the independent work of students are implemented using project technology, namely an educational web quest.

Web quest is one of the modern pedagogical technologies [5, 10]. With its help, the teacher can form the search activity of students on the Internet, taking into account the relevance, adequacy, safety.

Initially, a site for the web quest is being developed with the ability to publish videos, images, documents and other multimedia resources. Some of the information is located on the developed site, the other is presented in the form of verified links. Students are offered tasks, for which they need to use the links prepared by the teacher. The result is a creative work or project.

As part of the discipline "Information Security" for future economists, two educational web quests have been developed: "Information Security for Economists" and "Fundamentals of Cryptography". The scheme of the web quest "Fundamentals of Cryptography" is shown in the Figure 1.

An educational project allows students to face a problem situation, expand the subject of the course, develop the creative abilities of students, activate independent activity, improve communication and group work skills, and arouse interest in the learning process as a whole [7].

Web quest technology allows to increase the efficiency of the pedagogical process, to form competencies in the field of communications, self-development. Quest poses a problem situation for students, makes them search and select information [8, 11].

The web quest has a positive effect on learning activities and contributes to the formation of students' information and communication competence, group work skills, independence, the ability to identify the best option and justify the decision, the experience of speaking in public.

The educational product of students' work can be presentations, posters, booklets, videos, memos, etc. (Fig. 2).



Fig. 1. The scheme of educational web quest "Cryptography"

## 4. The model of the process of teaching "Information security"

A simplified model of the "composition of the system" of the process of teaching the basics of information security to future economists is shown in the Figure 3.

This model includes the structure of the discipline developed from the standpoint of a systematic approach, information and communication technologies, extracurricular activities of students, accumulative point-rating system, training and final control.

Particular attention is paid to information and communication technologies that support the implementation of this process: the program for creating electronic textbooks SunRay; PowerPoint; digital publishing platform Joomag; Google tools: Google Sites, Google Forms; Online Test Builder Testmoz.

To determine the effectiveness of the learning process, training control was introduced; accumulative point-rating system; final testing.

The model ensures the successful mastering of the discipline, increasing the level of training, and contributes to the formation of skills for independent assimilation of educational material and its practical application.



Fig. 2. An example of an educational product of student work



Fig. 3. Components of the course IS and applied ICT

#### 5. Conclusion

Technologies, including information technologies, have made a colossal contribution to the development: work, nature and capital, - empowering each of them and contributing significantly to an important increase in productivity [4].

Information technologies in the economics, along with advantages, carry huge threats to economic security.

The process of teaching future economists the discipline "Information Security" from the standpoint of systems theory allows to form competencies in the field of information security, taking into account educational standards and the requirements of the labor market, the needs of the individual in the digital economy. The model ensures the successful mastering of the discipline, increasing the level of training, and contributes to the formation of skills for independent assimilation of educational material and its practical application.

Theoretically substantiated that in order to improve the quality and effectiveness of training and the formation of practical skills in the discipline "Information Security" by future economists, it is necessary: to implement the content of training in organizational forms that contribute to the manifestation of cognitive activity and professional orientation of students; to organize independent extracurricular activities of students; to use learning technologies that help to increase the level of students' learning and expand the experience of using the acquired skills in their personal lives and future professional activities; to use online tools in the process of teaching-learning-assessment, necessary for the prompt presentation and change of educational and methodological materials for organizing the educational process not only within the walls of an educational institution, but also outside it.

#### References

- 1. Anderson R. Why Information Security is Hard an Economic Perspective. 17th Annual Computer Security Applications Conference, New Orleans, Louisiana, 2001 (https://www.acsac.org/2001/papers/110.pdf)
- 2. Bogdanova V. A., Chiriac L. L. Methodical system of teaching the discipline "Protection of computer information" to students of the humanities, Acta Et Commentationes No 2(13), 2018.
- 3. Bogdanova V. Information-cybernetic approach to the design of a pedagogical experiment, Revista de Stiinte Socioumane No 2 (48), Chisinau, 2021.
- 4. Chiriac L., Lupaşco N., Stepanov Z. The conception and evolution of modern educational spaces based on didactic models of neoliberal influence, Inter/transdisciplinary approaches in teaching real sciences, (STEAM concept)", Chisinau, 2021.
- 5. Dodge B. Some Thoughts About WebQuests, San Diego State University, 1997 (https://webquest.org/sdsu/about\_webquests.html)
- 6. Gasnas A., Globa A. Interactive methods applied in university education, Acta Et Commentationes No 1(27), 2022.
- 7. Lupu I., Negara C. Professionalization of the initial training of informatics teachers through interactive strategies, Balti university press, Balti, 2011.
- 8. Napalkov S.V. Thematic educational Web-quests as a means of developing the cognitive independence of students in teaching algebra in basic school, Saransk, 2013.
- 9. Pavel M., Pavel D. Recommendations, solutions, techniques and online learning, Actual problems of mathematics and informatics, Tehnica- UTM, Chisinau, 2021
- 10. Perizat B., Seitkazya A. Web-Quest as a Teaching and Learning Tool IEJME, Mathematics education No. 10, Ankara, Turkey, 2016.
- 11. Rhynard M. The WebQuest as an Instructional Strategy, D. Willis, J. Price & N. Davis (Eds.), Proceedings of SITE 2002. Society for Information Technology & Teacher Education International Conference, 2002.

## Comparative Analysis in the Development of Digital Services in Bulgaria, Greece and Romania

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**Abstract.** The creation and development of digital services is important for the digitization of the economy and the modern information society. The study pays attention to the factors on which this development depends for Bulgaria, Greece, and Romania. A comparative analysis was made, which is the basis for formulating conclusions and recommendations.

Keywords: Digital services, E-government, Comparative analysis.

#### 1. Theoretical background

As members of the European Union, Bulgaria, Greece, and Romania face identical problems of digital transformation. Each of the three countries addresses these challenges differently. This also determines the different levels of development of digital services. Digitization is mostly related to the creation of common conceptual models of new systems and the services provided by them [1]. Meanwhile digital administrative services are often described as a modern necessity for every society [2]. In theory, the digitization of services in the public sector depends on a complex of factors, the most important of which are shown at Fig. 1.



Fig. 1. Factors for the development of digital services

The set of these and other factors allows the achievement of different usability of the created digital services. The strong development of the technical infrastructure and Internet connectivity provides the prerequisites for the development and implementation of new web applications providing a new type of services for citizens. If there is a low level of development of Internet connectivity in a country, then this is a barrier to the creation of new services. The competence and the level of IT education of the citizens are also important in terms of the

possibilities of using already created services. Since modern digital services imply electronic payment, the development of digital financial technologies is also a factor in accelerating the implementation of new digital services.

## 2. Research methodology

Performing a comparative analysis of the development of digital services in Bulgaria, Greece and Romania is based on the sequence of phases and stages, presented at Fig. 2.



Fig. 2. Phases and stages of research

The main stages are:

- Determination of the criteria for performing the comparative analysis;
- Main characteristics of the digital services offered in Bulgaria, Greece and Romania;
- Carrying out a comparative analysis according to the initially defined criteria.

The first stage of the research task is to determine the criteria for performing a comparative analysis. An important methodological part of the research is to compare the objects (digital services) according to their comparable characteristics. In this way, the comparability of the study is ensured, and the results obtained are verified. The second phase of the research is related to checking the characteristics of the digital services provided in the three countries under consideration. At this stage, it is very important to provide data on the level of digitization of services in the countries under consideration from the same source. In the third phase, the actual comparative analysis is carried out, determining the positive and negative sides of each of the considered services by country.

## 3. Empirical study

The main data on the state and development of digital services, which are used in the present study, are from the UN survey [3]. Figure 3 presents the values of the digital services development index for the three compared countries. As it can be seen from the presented data, Greece is in the group of countries with very high values of the e-government development index, and Bulgaria and Romania are in the group of countries with high values of the index.

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#### Fig. 3. Digital Services Development Index

Figure 4 graphically presents the results of the performed comparative analysis. The value of the digital services development index for Bulgaria is 0.7092. The value for Greece is 0.7753 and for Romania – 0.6814.



Fig. 4. Graphical representation of the comparison

Of interest to the research is the dynamics in the development of the value of the index for the development of digital services for Bulgaria. In 2003, it had a value of 0.53711, in 2008 -0.48494, in 2014 - 0.23622, in 2022 - 0.70920 (Fig. 5).

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Fig. 5. Online service index [https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/26-Bulgaria]

#### 4. Conclusions

As a result of the development of the present study, the following more significant conclusions can be formulated:

- There is a complex of factors that determine the state and possibilities for creating and developing digital services;
- The development of digital services should always be considered in a comparative plan over a certain period.

#### References

- 1. Kirilov, R., Approaches for building information systems for monitoring the realization of students, Economic Alternatives, Issue 3, 2021, ISSN 1312-7462, https://doi.org/10.37075/EA.2021.3.09.
- Milev, P., Application of data analytics for research of digital administrative services in Bulgaria, SHS Web of Conferences, Vol. 120, 2021, ISSN 2261-2424.
- 3. https://publicadministration.un.org/

## Contemporary Problems of School Education in Information Technology

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**Abstract.** The research focuses on some of the contemporary issues education in information technology. The specific objectives are related to the study of access to digital content in the secondary education system. It is quite essential because it provides young people with basic knowledge for the development of the social and economic life of the country.

Keywords. School education, information technology, digital platforms.

#### 1. Theoretical background

In the last few years, we have witnessed the rapid entry of information technology and artificial intelligence into all areas of public life. Today's young people have changed their lifestyles because of various forms of digitalization. These are also the reasons why several authors directed their research in the direction of studying the most applicable technological solutions for the development of business organizations [1]. Digital services are a modern necessity for every society [2].

These facts impose and require the system of secondary and higher education to undergo a very rapid transformation in terms of the content taught. It can be represented in three dimensions, illustrated at Fig. 1.



Fig. 1. Dimensions of change in teaching

The development and implementation of modern specialties is related to more global changes in information technology. Some of them are big data, cyber security, artificial intelligence, robotics, etc. In this direction, some of the classic specialties in both secondary and higher education should be modernized. Also, existing or new specialties should have new

curricula. This is because, on the one hand, changes in technology cause a need for their modernization. On the other hand, the ways of teaching are also changing, mainly under the influence of new digital devices in the learning process. Finally, a change in the taught content for each of the academic disciplines is required. This happens mainly under the influence of technological changes, the emergence of modern educational platforms, etc.

## 2. Research methodology

The research methodology focuses on highlighting global challenges facing the secondary education system. This system is also quite essential, as it prepares personnel who are involved in the labor market or go to the system of higher education. For the purposes of this study, the following main challenges of school education in information technology can be formulated, divided into two groups.

First group:

- Ensuring an increasingly better material environment;
- Provision of modern technology and software;
- Provision of modern literature;
- Lifelong learning.

Second group:

- Focus on practical cases and assignments;
- Work in smaller groups;
- Project work;
- Inclusion of new educational platforms.

The Ministry of Education and Science has made great efforts in recent years to provide a modern environment for information technology training. This happens despite the limitation of financial resources, as well as the urgent need for IT teachers for secondary education. In this direction, a lot of progress is also being observed regarding the creation and integration of various new platforms that provide educational content, interactive presentations, and video. These content platforms integrate into the common platforms used in secondary education. The use of such resources significantly supports the educational process of young people.

## 3. Empirical study

The specific practical study includes checking the possibilities offered by educational content platforms supported by the Ministry of Education and Science. Secondary teachers have access to licensed software and operating systems for their work (Fig. 2 and Fig. 3).

Another very big possibility is the catalog of educational resources with free access (Fig. 4): "H5P resources, Liveworksheets, Playmathematics, TED ED, JClic library, Primer BG, Images, illustrations, maps, PhET interactive simulations, Academiko educational video collections, Khan Academy Educational Video Collections, OSR (Open Source Physics) Collection, Educational Platforms with Tools for Creating Learning Resources and Assignments, Public Repositories of Open Access Resources, Smart Test BG: Solve Tests Online!, Learning Resources and Activities, developed using LearningApps, We Learn Online" [4].

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## Fig. 2. Opportunities to access licensed software

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1	Windows 11 Education 64bit Bulgarian/English		Изтегли
2	Windows 10 LTSC		Изтегли
3	Windows 10 Education 64 Bit Bulgarian / English		Изтегли
4	Windows 10 Education 32 Bit Bulgarian / English		Изтегли
5	Windows 7 Pro 32bit		Изтегли
6	Windows 10 Pro 64bit		Изтегли

#### Fig. 3. Opportunities to access operation systems
12<sup>TH</sup> INTERNATIONAL CONFERENCE ON APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGY AND STATISTICS IN ECONOMY AND EDUCATION (ICAICT SEE – 2022), DECEMBER 2-3<sup>RD</sup>, 2022, UNWE, SOFIA, BULGARIA



Fig. 4. A catalog of open access educational resources

These and other resources significantly support the study of information technology in secondary education.

## 4. Conclusions

The analysis of the educational process in secondary education always shows serious growth rates, as well as the constant need for improvement. It is not possible to cover all resources and opportunities for information technology training within a relatively short study. However, the main findings of the current study can be summarized as:

- Recent years have seen significant progress in providing learning with digital content;
- Efforts should be made to popularize the use of the created systems and platforms in the educational process.

## References

- 1. Kirilov, R., Approaches for building information systems for monitoring the realization of students, Economic Alternatives, Issue 3, 2021, ISSN 1312-7462, https://doi.org/10.37075/EA.2021.3.09.
- Milev, P., Application of data analytics for research of digital administrative services in Bulgaria, SHS Web of Conferences, Vol. 120, 2021, ISSN 2261-2424.
- 3. https://edu.mon.bg/
- 4. https://oer.mon.bg/s/oer/page/welcome

# **Post-Employment Defined Benefit Plans**

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Abstract. The object of this publication refers to post-employment benefits payable to employee due to termination of the employment or official relationships. The subject matter of this publication refers to post-employment defined benefit plans. Under these plans, the enterprise's liability is updated in a way that does not differ materially from the amounts that are subject to payment to the employees post their employment. Defined benefit plans comprise two items: assets under the plan and liabilities for payment of defined benefits. The author's objective in this publication is to systemize some major issues relevant to the defined benefit plans the determine the relevance of the defined benefit plans for employees post their employment in the enterprise-employer.

Keywords: Benefits plan, Liability, Employee, Analysis, Methodology.

## 1. Introduction

Drafting accounting information about the benefits of employees hired by the enterprises in the Republic of Bulgaria under employment contracts with regard to their service is based on the provisions of a number of legal regulations applicable on the territory of Bulgaria. these are:

- the Labour Code;
- the Social Security Code;
- the Health Insurance Act;

• the annual acts adopted by the Bulgarian National Assembly – the State Budget Act; State Social Security Scheme Budget Act; National Health Insurance Fund Budget Act;

• the provisions of the applicable accounting standards – Accounting Standard 19 (AS 19) "Employee Benefits", and International Accounting Standard 19 (IAS 19) "Employee Benefits".

We share the opinion that "the legal regulations that govern social security in the Republic of Bulgaria is distinguished by a combination of the social principles and market mechanisms that protects the insured persons' interests by covering all social security risks in accordance with the international standards thus applying the fund organization of insured persons' money." (Natchkova, 2021, page 49-50) Furthermore, it's worth noting that "conditions for development of both the compulsory social security through the social security funds of the State Social Security Scheme and the supplementary and voluntary social security through private funds – universal, occupational, by occupational schemes and voluntary" (Natchkova, 2021, page 49-59) are established in Bulgaria. Social security is an expression of "specific type of public-economic relations that occur between individual, well-informed subjects – insurers and insured persons, who pursue specific interests. It is a set of principles, forms and methods for formation of dedicated monetary funds for the purposes of indemnifying insured persons and their heirs upon occurrence of different life events (Natchkova, 2021, page 49-50). One of these events is the termination of the employment or

official relationships of the enterprise's employees due to the fulfilment of the conditions precedent for their retirement.

The provisions of AS 19 are applied by the enterprises that carry out current accounting and prepare their financial statements on the basis of the national accounting regulations. According to this standard, employee benefits comprise:

- short-term benefits;
- post-employment benefits;
- other long-term benefits;
- termination benefits;
- equity compensation benefits.

The object of this publication refers to post-employment employee benefits payable due to termination of the employment or official relationships. These are different benefit plans, which are defined as formal or informal agreements by virtue of which the employer provides benefits to one or more members of its staff post their employment upon termination of their employment or official relationships. These post-employment benefit plans may comprise:

- defined contribution plans;
- defined benefit plans;
- multiple employer plans;
- state plans and equity compensation (benefit) plans.

The author's objective is to systemize in this publication some major issues relevant to the defined benefit plans, which the involved enterprises should resolve by determining:

• the fair value of assets and the present value of the liability to pay retirement benefits to its employees in the future;

• the amount of costs or income under the plan that is stated in the statement of income and costs for the current reporting period;

• the value of actuarial gains and losses that reflect the changes in the amount of the liability to pay defined benefits to employees in the future and are stated at the liability side of the balance sheet;

• the value of actuarial gains and losses that reflect the changes in the fair value of the assets under the plan, which are stated at the asset side of the balance sheet;

• the methods for measurement, accounting, analysis and assessment of actuarial gains and losses under a defined benefit plan.

The methods for studying the issues of the post-employment defined benefit plans are presented in Fig. 1.

# 2. Elements of the defined benefit plans

According to AS 19, the elements of the defined benefit plans are as follows: (Fig. 2).

- 1) plan's assets and
- 2) liabilities for payment of specific benefits.

The assets under these plans comprise all assets payable by the pension fund, which it will use in future only for payment of benefits to those involved in the plan. These assets are the cash contributed by the enterprise to the pension fund, which it has invested in profitable financial instruments, such as securities, deposits, etc.

The assets under defined benefit plans are measured at fair value on the reporting date. In most cases, this is the market value of the assets that may be also determined by discounting the expected future cash flows. The value of assets under the plan is stated at the asset side of the enterprise's balance sheet.

The liabilities under the plan for payment of future benefits are measured at their present value and are stated at the liability side of the enterprise's balance sheet.

The value (V) of assets and liabilities, respectively, is calculated according to the following formula: (AS 19, paragraph 14.1)

$$\mathbf{V} = \mathbf{PS} + (+\mathbf{PR}_{ak} - \mathbf{Z}_{ak}) - \mathbf{C}_{nm} - \mathbf{SV}_{a},$$

where PS is the present value of the liability to pay specific benefits;

PR<sub>ak</sub>-unrecognized actuarial gains;

Z<sub>ak</sub> - unrecognized actuarial losses;

 $C_{nm}$  - unrecognized past service costs;

 $SV_a$  - fair value of plan's assets.

Unrecognized actuarial gains, as well as unamortized past service costs are accounted for as deferred income under accounts from group 'Deferred income and subsidies', and unrecognized actuarial gains – as deferred costs under accounts from group 'Deferred costs'.



Fig. 1. Defined benefit programs for staff

If the value of asset or liability, respectively, is negative (V < 0), this means that an asset under defined benefit plans is available, which must be subject to reassessment of the recoverability. Per se, the recognised asset is the lower of:

1) V < 0 and

$$S = Z_{ak} + C_{nm} + NS,$$

where:

NS is the present value of all economic benefits in the form of reimbursement of cash under the plan to the enterprise, or decreases of its future contributions to the plan.

AS 19 does not provide for compulsory requirement for the enterprise to carry out actuarial evaluation on annual basis. We believe that enterprises that participate in defined benefit plans should determine both the fair value of the plan's assets and the present value of the liability to pay pension benefits to the employees in future after their retirement. We support the opinion that the fair value of assets and the present value of the liability to pay defined benefits to the employees in future must be measures "regularly enough so that the values recognised in the financial statements do not differ substantially from the values that would be determined as at the reporting date (the date of the financial statements – supplement by R.I.). In the context of varying economic environment, more frequent assessments are required, at least once a year." (Brezoeva, 2016, p.171)

The value of defined benefit plans' costs or income is stated in the enterprise's statement of income and costs. This value is influenced by the following major factors:

1) The net value of cost or income.

2) Costs for current service. These are the increase of the present value of the liability to pay defined benefits under the plan arising from the employees' service for the current reporting period.

3) Interest costs.

4) Expected return (profitability) of assets under the plan. These are interest, dividend and other income that arises from the assets under the plan. Their value comprises both realized and unrealized profits or losses from assets, whereas all costs incurred in relation to the plan management and the amount of all taxes payable under it should be deducted. The expected return of assets is measured at the beginning of the period when the plan starts to apply and is based on the market expectations for the profitability for the whole period of the asset-related liability to pay defined benefits to the employees.

5) Actuarial gains and losses, as far as they are recognised. These are the difference between the expected and actual return on assets under the plan.

6) Past service costs in accordance with the provisions of AS 19 for recognition of these costs.

7) Effect of any curtailments or settlements.

# 3. Actuarial gains and losses

Actuarial gains arise as a result of unexpected decreases in the amount of the liability, and actuarial losses – as a result of unexpected increases of the liability to pay defined benefits to the employees in future. Actuarial gains and losses accumulate during individual years and are stated as unrecognized profits and losses. Recognised actuarial gain or any part thereof is accounted for as other income from the enterprise's operations for the period it has been recognised. Recognised actuarial loss or any part thereof is accounted for as costs by economic elements – costs for pensions, and is taken into account for the calculation of the aggregate amount of costs for the enterprise's operations.



Fig. 2. Elements of defined benefit programs

From the perspective of the plan's assets, actuarial gains and losses are per se the changes (increase or decrease) in the fair value of assets that have occurred under the influence of different factors. Some of these factors are:

- 1) increase or decrease of enterprise's turnover rate.
- 2) earlier retirement of employees and/or workers.
- 3) death of employees and/or workers.
- 4) increase of employees' wages in future.
- 5) changes in the discount rate.
- 6) deviation between the expected and actual profitability of the plan's assets.
- 7) inflation rate in the country.

8) objectively existing interrelations between the inflation rate in the country, the profitability of the plan's assets and the growth rate of employees' wages.

9) clauses of the plan governing the increase of benefits for the employees' service during previous years (previous reporting periods). Here, it is expected that the enterprise would gain economic benefits in future reporting periods, which would allow the increase of the employee benefits. Thus, already accounted for past employees' service costs for the provision of employee benefits are reversely referred to and allocated for future periods to the remaining service of the employees.

10) other factors.

# 4. Treatment, accounting for and presentation of actuarial gains and losses in the enterprise's financial statements – theory aspects

Actuarial gains and losses may be treated in accordance with any of the following methods:

1) Corridor method. Actuarial gains and losses are not recognised if they are within the ranges of the so called "corridor", and those amounts of them falling outside the "corridor" are recognised as deferred in the enterprise's financial performance for the current reporting period (AS19, paragraph 14.4 - 14.5);

2) Accelerated method. Actuarial gains and losses are recognised, including all actuarial gains and losses are fully recognised, in the enterprise's financial performance for the current period (AS 19, paragraph 14.6).

When treating actuarial gains and losses, the enterprise that participates in a defined benefit plan must observe certain requirements:

1) It must choose one of the above mentioned methods for treatment, accounting for and presentation of the actuarial gains and losses in the financial statements.

2) The choice of a method is part of the enterprise's accounting policy.

3) The chosen method must be disclosed in the enterprise's accounting policy.

4) The chosen method must be applied consistently during each reporting period.

# 5. Corridor method – theory aspects

In the case of the corridor method, the enterprise must recognize the portion of the actuarial gains and losses as income or cost, when:

$$S_{pz1} > 10\% \max (NP_0, VS_0),$$

where:

 $S_{pz1}$  is the sum of net cumulative unrecognized actuarial gains and losses at the end of the previous reporting period. This sum is equal to the sum at the beginning of the current reporting period, which is due to the application of the principle of independence of individual reporting period and the value relationship between the opening and closing balance sheet (Accounting Act, article 26, paragraph 1);

 $NP_0$  – present value of the liability to pay defined benefits at the beginning of the current reporting period (the year);

 $VS_0$  – fair value of the plan's assets at the beginning of the current reporting period (the year).

Thus, we achieve comparability between the indicators involved in the establishment of the corridor. We speak about the use of the same moment – the beginning of the current reporting period.

In practice, we establish a corridor that can be presented in the following way:

## 10% от max (NP<sub>0</sub>, VS<sub>0</sub>)

The surplus (the amount outside the corridor) calculated with the above formula is compared with the average value of the remaining service of the enterprise's employees who participate in the defined benefit plan.

The net cumulative unrecognized actuarial gains and losses at the beginning of the reporting period, which exceed the corridor, are amortized (deferred) according to the straight line method during the remaining service of the enterprise's employees participating in the plan.

## Methods for application of the corridor method

1) We define the value of the corridor, which is 10% of the bigger of the present value of the liability to pay defined benefits under the plan and the fair value of the plan's assets at the beginning of each year of the period.

2) We calculate the total amount of unrecognized loss for the first year of the plan. This is the difference between the accumulated unrecognized actuarial loss and the defined corridor's value.

3) We determine the recognised actuarial loss for the first year. It is equal to the ratio of the calculated unrecognized actuarial loss for the first year (see paragraph 2) to the remaining service of the employees.

4) We calculate the accumulated unrecognized actuarial loss for the next (second) year of the plan period. It is equal to the accumulated unrecognized actuarial loss for the first year of the plan (see paragraph 2) less the already determined actuarial loss for the first year of the plan (see paragraph 3), plus the unrecognized actuarial loss for the next (second) year of the plan.

5) We determine the difference between the calculated unrecognized loss for the next (second) year (see paragraph 4) and the corridor for the same (second) year.

6) We determine the recognised actuarial loss for the next (second) year of the plan as a ratio between the unrecognized actuarial loss for the next (second) year and the remaining average service of the enterprise's employees.

7) The corresponding calculations apply for each subsequent year of the plan.

#### Accounting of actuarial loss

a) for accumulated unrecognized actuarial loss for the first year of the plan, which is deferred as deferred cost:

Dt entry to account from group "Deferred costs"

Dt entry to account "Non-financial deferred costs"

Ct entry to account from group ,,Staff and partners ,,

account "Post-employment benefits'

subaccount 'Liability to pay employee benefits under defined benefit plan,,

b) for that portion of the actuarial loss that is recognised as current cost for the reporting period – the first year of the plan:

Dt entry to account from group "Costs by economic elements"

Dt entry to account "Wages and salaries"

Dt entry to account "Costs for pension benefits"

Ct entry to account from group ,,Deferred"

Ct entry to account "Non-financial deferred costs"

## Accounting of actuarial profit

a) for accumulated unrecognized actuarial gain, which is deferred as deferred income: Dt entry to account from group, Staff and partners "

Dt entry to account "Post-employment benefits"

subaccount "Liability to pay employee benefits under defined benefit plan"

Ct entry to account from group "Deferred income and subsidies"

Ct entry to account "Non-financial deferred income"

b) for that portion of the actuarial gain that is recognised as current income for the reporting period:

Dt entry to account from group "Deferred income and subsidies"

Dt entry to account "Non-financial deferred income"

Ct entry to account from group "Sales income and other income from ordinary activity"

Ct entry to account "Other income from operations"

subaccount "Recognised portion of the actuarial gain under defined benefit plan"

c) the realized current income from recognised actuarial gain is closed in account "Profit and loss for the current year ":

Dt entry to account from group "Sales income and other income from ordinary activity " Dt entry to account "Other income from operations "

subaccount "Recognised portion of the actuarial gain under defined benefit plan " Ct entry to account "Profit and loss for the current year "

#### Advantages of the corridor method

1) in long-term aspect, actuarial gains and losses may be offset between each other, thus possibly decreasing their impact on the pension costs.

2) the enterprise is entitled to defer one portion of the actuarial gains and losses, and to recognize only some of them – those outside the corridor, as income or cost in the financial performance for the current reporting period.

3) as a result of the above, the accounting financial performance of the enterprise for the current reporting period is not strongly influenced by the changes in the actuarial assumptions.

## 6. Method of accelerated deferral of actuarial gains and losses

The method of accelerated deferral may be applied in any of these two versions:

1) The excess outside the corridor is deferred more quickly, which may be done in a period shorter than the service remaining to the retirement of the enterprise's employees involved in the plan.

2) The corridor is fully ignored and thus the total amount of actuarial gains and losses is recognised immediately in the financial performance of the enterprise for the current reporting period.

The enterprise should disclose in its accounting policy which version of the method of accelerated deferral of actuarial gains and losses it has chosen under the defined benefit plan.

## The following accounting items are made:

#### A) to report actuarial loss:

a) to charge employees' current service costs of the enterprise:

Dt entry to account "Wages and salaries"

subaccount "Employees' current service costs for liabilities upon their retirement "

Ct entry to account "Staff"

subaccount "Other liabilities to employees"

analytical account , Liabilities upon retirement "

b) to charge interest costs for the liability that is initially recognised at present value as per the actuarial assessment:

Dt entry to account "Wages and salaries"

subaccount "Interest costs for liabilities upon retirement of employees"

(or Dt entry to account ,,Interest costs")

Ct entry to account "Staff"

subaccount "Other liabilities to employees"

analytical account "Liabilities upon retirement"

The enterprise is entitled to choose the way it reports interest costs for the liability to pay defined benefits to employees. Interest cost may be accounted for as a debit entry to account "Wages and salaries "or as a debit entry to account "Interest costs ". The method chosen by the enterprise must be disclosed in its accounting policy.

c) to report actuarial loss:

Dt entry to account "Wages and salaries"

subaccount "Actuarial losses for liabilities upon retirement of employees "

(or Dt entry to account "Other costs"

subaccount "Actuarial losses for liabilities upon retirement of employees "

Ct entry to account "Staff"

subaccount "Other liabilities to employees"

analytical account "Liabilities upon retirement"

The enterprise can choose the way it reports the actuarial loss as current cost – as a debit entry to account "Wages and salaries "or as a debit entry to account "Other costs ". Such choice must be disclosed in the enterprise's accounting policy.

## **B**) to report actuarial gain:

Dt entry to account "Staff"

subaccount "Other liabilities to employees"

analytical account "Liabilities upon retirement"

Ct entry to account "Other income"

subaccount ,,Actuarial gains for liabilities upon retirement of employees "

Upon preparing the statement of income and costs for the current reporting period, the amount reported to the credit of account "Other income "must be stated as decrease of costs for employees' retirement benefits.

The following accounting item is made for the amount paid to a member (members) of the staff who has (have) retired during the year:

Dt entry to account "Staff"

subaccount "Other liabilities to employees"

analytical account "Liabilities upon retirement"

Ct entry to account from group "Cash and cash equivalents "

## 7. Past service costs

Past service costs are the increase of the present value of the liability to pay defined benefits, which is incurred as a result of the service of the enterprise's employees during previous reporting periods, which are related to the satisfaction of the conditions for payment of these benefits in future. Such costs are incurred upon introduction of a defined benefit plan or upon change o the defined benefit plan for the enterprise's employees upon retirement.

Past service costs may be presented in Fig. 3.

Accounting of past service costs differs, depending on whether benefits are established, i.e. the right to pay defined benefits is fully gained (benefits are unconditionally acquired), or benefits are not established, i.e. such right to pay benefits is still not fully gained (benefits are not yet acquired).

In the case of established benefits, past service costs are accounted for as current expenses during the period of the plan introduction or its change (AS19, paragraph 14.9).



Fig. 3. Past service costs

# 8. Conclusion

Actuarial valuations of the enterprise's obligations to its personnel forpost-employment pension benefits are important to the reliable, true and fair presentation of information in the financial statements. On the basis of this information, external and internal users can analyze the income, expenses, financial results, financial position, financial stability, financial balance, cash flows and the final efficiency of the activity and make informed, correct and timely decisions for the development of the activity and of the enterprise as a whole in an operational and strategic perspective.

# References

- 1. Accounting Standard 19 Personnel Income. Published SG No. 30/04/7/2005.
- 2. Brezoeva, B. (2016). Accounting treatment of defined benefit programs in accordance with National Accounting Standards. Sofia. Yearbook of IDES.
- Ivanova, R. (2022). Employee defined incomes programs after leaving the enterprise /methodology of accounting and analysis/. KNOWLEDGE – International Journal. Skopje.Vol.55.6. p. 1083-1089
- Nachkova, M. (2021). Information links and payment systems in the insurance system of the Republic of Bulgaria. Skopje. International journal "KNOWLEDGE", Institute of Knowledge Management. Vol.44.1. p. 49-56.

# Accounting Policy of Pension Insurance Companies in the Context of Crisis

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Abstract. The accounting policy of pension insurance companies refers to the accounting principles, rules, concepts, conventions and specific practical procedures that they have adopted and that are applied to the organization of their accounting reports. Upon designing their accounting policy, pension insurance companies must consider the impact of the economic, political and social environment and the factors that affect their specific pension insurance business in order to be able to present truly and fairly, completely and accurately, authentically and comparatively the information for their financial position, financial performance, movement of their cash flows, changes in equity and in the specific (technical) provisions they have established. The accounting policy is a model of organising the accounting reports of the respective company and of subsequent disclosure of the outcomes of this activity in the company's financial statements during different reporting periods, in accordance with the changes that have occurred in the external economic environment. In the course of designing and practical implementation of their accounting policy, pension insurance companies must observe specific accounting conceptual frameworks, statutory principles, common rules and approaches to organise their accounting reports. Any legally established accounting policy is always able to adequately respond to the changes in the society in the context of crisis economic, political, social, or healthcare.

Keywords: Accounting policy, Accounting reports, Pension insurance companies, Crisis

## 1. Introduction

The accounting policy of pension insurance companies refers to the accounting principles, rules, concepts, conventions and specific practical procedures that they have adopted and that are applied to the organization of their accounting reports. Upon designing their accounting policy, pension insurance companies must consider the impact of the economic, political and social environment and the factors that affect their specific pension insurance business in order to be able to present truly and fairly, completely and accurately, authentically and comparatively the information for their financial position, financial performance, movement of their cash flows, changes in equity and in the specific (technical) provisions they have established. The accounting policy is a model of organising the accounting reports of the respective company and of subsequent disclosure of the outcomes of this activity in the company's financial statements during different reporting periods, in accordance with the changes that have occurred in the external economic environment. In the course of designing and practical implementation of their accounting policy, pension insurance companies must observe specific accounting conceptual frameworks, statutory principles, common rules and approaches to organise their accounting reports. Any legally established accounting policy is always able to adequately respond to the changes in the society in the context of crisis – economic, political, social, or healthcare.

# 2. Nature of the Concept of "Accounting Policy"

When designing and implementing their accounting policy in practice, pension insurance companies observe the Conceptual Framework, the accounting principles and the common rules and approaches. In the Republic of Bulgaria, the legislator has decided that "while establishing and maintaining their accounting system, the entities ensure:

1. comprehensive chronological recording of accounting operations;

2. obtaining of analytical and summarized information through accounting channels, which represents the entity's annual financial statements as fairly and appropriately as possible;

3. interim and annual closure of accounting books;

4. changes to accounting records made, by means of compiling adjustment accounting items;

5. application of the individual chart of accounts approved by the entity's manager;

6. application of the accounting policy approved by the entity's manager." (Accounting Act, (2023), article 11, paragraph 1).

Pension insurance companies prepare their financial statements and design their accounting policy on the basis of the International Accounting Standards (Accounting Act, (2023), article 34, paragraph 2, item 3) in strict observance of the accounting principles: going concern, prudence, posting, independence of individual reporting periods and value relation between opening and closing balance, materiality, offset, substance over form, measurement of items that are recognized in the financial statements, consistency of presentation and comparative information. "Presentation and classification of items in the financial statements, accounting periods for the purposes of achieving comparability of accounting data and indicators in the financial statements" (Accounting Act, (2023), article 26, paragraph 1).

"In this way, one can achieve comparability of information and values of indicators determined on the basis of the financial statements during the previous and following reporting periods. The entity should keep using the same valuation methods, rules and approaches throughout several subsequent reporting periods in order to achieve comparability of information that is presented in its financial statements.

The purpose of applying the same accounting policy throughout several subsequent reporting periods is to ensure comparative information in the financial statements, on the basis of which users properly analyse and assess the financial performance of the entity's business, the financial position, the cash flows and the effectiveness. This might be achieved only by consistent application of the same methods and approaches for recognition, measurement and presentation of the items of the financial statements: assets, liabilities, equity, income and expenses." (Ivanova, R., (2018), Accounting, page 520).

## **3.** Main Rules for Design of Accounting Policy of Pension Insurance Companies

While designing their accounting policy, pension insurance companies should take into account:

1) Recognition of main types of income and expenses from pension insurance operations related to the management pension funds for which they have obtained a license to manage – universal, professional and voluntary pension fund;

2) Measurement of assets of pension insurance companies – financial assets and financial instruments intended for sale on active stock market, which are utilized as collaterals of the specific (technical) provisions they have allocated;

3) Measurement of specific liabilities of pension insurance companies -

"In terms of ... insurance contracts, fair value measurement suggests that they should be measured by determining the net present value of future cash flows by applying a liability adequacy test" (Mavrudiev, Hr., (2018), Accounting of Insurers, page 137);

4) The basis for specific (technical) provisioning to be allocated and released by the pension insurance companies during the current and the previous year;

5) The basis for insurance risk determination and management;

6) The organization of accounts with managed pension funds management for which they have obtained a license to manage – universal, professional and voluntary pension fund;

7) The differentiation between transactions and other events that have occurred after the date of preparation of the pension insurance companies' financial statements, which result in recognition of assets and liabilities in the Statement of Financial Position, or give rise to contingent receivables and payables that are disclosed in their financial statements.

"Entity's accounting policy may be changed in the following cases:

a) upon change of existing accounting standard;

b) upon enforcement of a new accounting standard;

c) on voluntary basis if the entity should assume that the transactions and events may possibly be presented in its financial statements in a fairer way." (Ivanova, R., (2018), Accounting, page 520).

Accounting policy of pension insurance companies is also affected by the changes to the environment in which they operate. The international economics, with its development, processes, phases and cycles, is the key external factor that determines the accounting policy of pension insurance companies. In the context of a global crisis, the following factors significantly affect the accounting policy of pension insurance companies:

1) External factors – such as the changes in the international and European insurance legislation that have occurred in the context of crisis; in the internationally ratified labour, social and tax treaties and conventions; in the International Accounting Standards (IAS)/ International Financial Reporting Standards (IFRS), in the EU directives; in the international programs for economic development of the country; in the international treaties governing the accounting system development; the duration of individual phases of the economic cycle and the development level of production capacities and the production relationships at global level.

2) Internal factors – such as the condition of the national economy in the context of global crisis that has material impact on the development level of production capacities and the production relationships in the country; changes in the applicable insurance, accounting, labour and tax legislation in the country in the context of crisis, which are material and relevant to the operations of the pension insurance companies and the working conditions, social and health insurance of their staff; the specificity of the insurance business; the conditions for work and re-qualification of pension insurance companies' employees; the established office and information base; the liquidity degree of available resources, etc.

The changes that occur in external and internal factors determining the accounting policy have material impact and give rise to the need of timely adaptation of pension insurance companies to them. The occurrence of multiple adverse consequences as a result of the unstable economic environment requires appropriate decisions to be made by the pension insurance companies in terms of their mitigation. The management of the pension insurance companies conform such decisions with the amendments to the international and national accounting and insurance regulations. Such adverse consequences are direct factor for the change of the pension insurance companies' accounting policy in order to present true and fair information in their financial statements for the effect of operations, events or conditions, occurred in the context of crisis, on the financial position, financial performance, cash flows

and changes in equity and in their specific (technical) provisions. "Financial and property position of ... insurers is extremely sensitive to each change on the financial markets, which affects the assessments presented in their financial statements. Thus, the main qualitative characteristic of financial statements of ... insurers for true and fair presentation is to a great extent based on estimates" (Mavrudiev, Hr., (2018), Accounting of Insurers, page 137).

# 4. Crucial Measures that Must be Included in the Accounting Policy of Pension Insurance Companies to Mitigate (Limit) the Insurance and Financial Risk

Measures that pension insurance companies should undertake in the context of crisis in order to reduce its adverse consequences and to mitigate the effects of future adverse financial and insurance risks should be directed to:

1) Recognition of main types of income and expenses from pension insurance operations related to the management of pension funds for which they have obtained a license to manage – universal, professional and voluntary pension fund;

2) Measurement of assets of pension insurance companies – financial assets and financial instruments intended for sale on active stock market, which are utilized as collaterals of the specific (technical) provisions they have allocated;

3) Measurement of specific liabilities of pension insurance companies;

4) Increase of the pension insurance companies' equity in case of liquid crisis through supplementary contributions of the shareholders for the purposes of keeping their capital adequacy and undertaking effective measures to overcome the crisis;

5) Limitation of foreign currency loans (except for euro) for the purposes of avoiding the adverse effects of losses from foreign currency operations and revaluations on the financial position of pension insurance companies;

6) Imposing a conservative threshold for the ratio of the value of assets used as collateral of their specific liabilities to the value of allocated specific (technical) provisions by the pension insurance companies in order to ensure timely coverage of their current liabilities to the persons insured in the pension funds they manage;

7) Carrying out stress tests for shortage of specific (technical) provisions, for long-term risk; and for adequacy of liabilities to the persons insured in the pension funds they manage;

8) Prudence and conservatism when the management of pension insurance companies make decisions to incur current expenses or to acquire new investments in subsidiaries, associates and joint ventures;

9) Carrying out frequent due diligence and classification of risks in the context of crisis – insurance, investment, liquidity, etc.;

10) Looking for new ways to overcome the adverse consequences of the crisis and finding innovative solutions to problems that result from the crisis in the reporting of specific items in the account of pension insurance companies;

11) Specific disclosures in the financial statements of the pension insurance companies in the context of crisis in compliance with the requirements of the insurance supervisory authority, which are in the interest of all stakeholders – insured persons, investors, sponsors, etc. Under crisis conditions, practices applied for mitigation of risks, for securing the fulfilment of obligations under concluded insurance contracts between the managed pension funds and the persons insured in them, and for the maintenance of sufficient capital resources should be disclosed;

12) Conservatism in the application of the Prudence accounting principle upon change of the pension insurance companies' accounting policy in the context of crises for the purposes of preventing a collapse in their operations due to the global crisis, etc.

The measures undertaken by the pension insurance companies in the context of crisis affect the key elements of the accounting policy determined in IAS 1 Presentation of Financial Statements (International Financial Reporting Standards (2016)), and namely:

- Recognition of revenue;
- Principles of consolidation, including for subsidiaries;
- Business combinations;
- Recognition and amortization of fixed tangible and intangible assets;
- Capitalisation of loan costs and other expenses;
- Investment properties;
- Financial instruments and investments;
- Lease;
- Taxes, including deferred taxes;
- Provisions;
- Costs related to employees' income;
- Foreign currency operations and hedging;
- Cash and cash equivalent operations;
- Definition of business and geographic segments and basis on which expenses are allocated among segments;
- Government subsidies and aid that are significant in the context of crisis.

## 5. Conclusion

In the context of crisis, pension insurance companies must put rescue plans in action in order to maintain good financial position, good liquidity, solvency and profitability, by providing additional sources for financial support – from the shareholders, from the parent company, from the specific (technical) provisions they have allocated during the years, from government subsidies and aid, from government securities, from bank loans, etc. In the context of crisis, they also need to reorganize their investment portfolios and overall administrative activity. Their experience with previous crises and inflation processes is the driving factor for the sustainability and agility of pension insurance companies to succeed in keeping and developing their insurance operations even in the context of global crisis, while observing the instructions of the regulatory authorities in terms of the implemented anti-cyclic policy.

## References

- 1. Chukov, Kr., Ivanova, R., (2019), Financial and Business Analysis, UNWE Publishing House, Sofia;
- 2. Conceptual Framework for Financial Reporting (2012) published by IASB in September 2010. It replaces the general provisions for preparation and presentation of financial statements.
- Financial Reporting Standards (IFRS), (2016), EU Official Journal, Commission Regulation (EU) 2016/2067 of 22 November 2016, L323;
- 4. Accounting Act, (2023), promulgated in SG no. 95 of 8.12.2015, effective from 01.01.2016, last amendment in SG no. 105 of 19.12.2023;
- 5. Social Security Code, (2022). Promulgated in SG no. 110 of 17.12.2019, last amendment in SG no. 27 of 29.03.2024;
- 6. Ivanova, R., (2018), Accounting, Trakia M;
- Mavrudiev, Hr., (2018), Milanova-Tsoncheva, Em., Natchkova, M., Mavrudiev, Hr., Accounting of Insurers, UNWE Publishing House, Sofia, ISBN 978-619-232-116-1;
- 8. International Code of Ethics of Professional Accountants, (2018), effective from June, 2019;
- 9. Handbook of International Education Pronouncements, (2014), International Federation of Accountants (IFAC®)
- Milanova-Tsoncheva, Em., Petrova, D., Natchkova, M., Ivanova, R., Todorov, L., (2018), Financial and Accounting Management, UNWE Publishing House, S., ISBN 978-619-232-073-7

# Regenerative Skin Nanotechnology: Current Challenges in the Field of Tissue Engineering

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Abstract. In recent years the development of biomaterials, nanobots, nanofibers nanostructures, etc with potential therapeutic applications has brought nanotechnologists into contact with regenerative medicines. They are trying to construct systems or the innovations have been made in the areas of tissue engineering, cell therapy, and cell delivery over the years, leading to the development of systems that can mimic, facilitate, or even initiate the restoration of tissues. These systems may be designed to appear different. Regenerative medicine's fundamental trio of cells, substrates, and physiologically active biomolecules is used to create cutting-edge treatment approaches for tissue repair. The application of nanotechnology in biomedicine and regenerative medicine is seeing rapid advancement. Through inducing the preservation, proliferation, and differentiation of healthy cells, dynamic three-dimensional nano-environments can offer bioactive molecular substrates to hasten the healing of injured tissues. This study summarises recent advancements with a focus on the application of nanotechnology in tissue engineering research, with a specific emphasis on regenerative skin, and a discussion of the challenges that researchers faced while creating and applying nanotechnology to the skin.

Keywords: Regenerative cells, Nanotechnology, Biomedicines, Nanoparticles, Tissue engineering.

## 1. Introduction

In recent years, there have been significant advancements in nanotechnology, particularly in the area of tissue engineering where its use has demonstrated great promise. The regeneration of the skin is an area that has garnered a lot of attention and holds the promise of transforming the way skin injuries and conditions are treated. The use of nanotechnology in skin regeneration offers new and effective treatment options, but also presents new challenges that need to be overcome. In addition to skin regeneration, nanotechnology is being utilized in medicine and biomedical engineering to create new materials and devices with specific functions, including targeted drug delivery and diagnostic imaging [1]. For example, nanoparticles can be designed to deliver drugs directly to cancer cells with fewer side effects, and nanotechnology is also being used for earlier and more accurate disease detection in medical imaging. Nanotechnology is also contributing to the development of stronger, more biocompatible, and longer-lasting materials for medical implants, such as artificial joints

more biocompatible, and longer-lasting materials for medical implants, such as artificial join and stents.

So before getting into more details let us understand tissue engineering and the uses of nanotechnology in skin regenerative cells. Tissue engineering is a field of biomedical engineering that seeks to create functional and biocompatible tissues and organs by combining biological and engineering principles. It involves the use of cells, biomaterials, and growth factors to design, fabricate, and evaluate artificial tissues and organs that can replace damaged or diseased tissue in the body [2]. The use of nanotechnology in tissue engineering, particularly in skin regeneration, is a rapidly growing area of research.



Fig. 1. "Historical advancement of nanoparticles for medicinal uses" [1].

Nanotechnology has the potential to enhance the regeneration of the skin by providing new materials and methods for culturing and delivering cells and growth factors to the site of injury. For example, nanoparticles can be used to deliver growth factors and other therapeutic agents directly to the site of injury to stimulate the growth of new skin tissue.

Nanotechnology is also being used to develop new and improved biomaterials for use in skin tissue engineering. For example, nanofibers and nanomaterials can be used to create scaffolds that can support the growth and proliferation of skin cells. In addition, nanotechnology can be used to develop new imaging techniques for monitoring the growth and regeneration of skin tissue. In conclusion, the use of nanotechnology in tissue engineering, particularly in skin regeneration, has the potential to greatly improve patient outcomes by providing new and effective treatments for skin injuries and conditions.

# 2. Literature Review

The biggest organ in the human body, the skin acts as a barrier to keep the inside of the body from contacting the outside world. Burns, ulcers, and skin lesions brought on by recent trauma are often seen conditions in therapeutic settings. Stopping bleeding, inflammation, the creation of new tissue, and modification of the afflicted region are the four stages that make up the typical wound healing process. There has been a lot of interest in employing 2D nanomaterials with unique characteristics for antibacterial applications.

Below is the schematic diagram of different layers of skin for a better understanding of the terminologies used in this paper.

The use of several types of cutting-edge 2D nanomaterials, including graphene derivatives, transition metals, black phosphorus, Gold nanoparticles, Silver nanoparticles, Iron oxide nanoparticles, Titanium dioxide nanoparticles, Zinc oxide nanoparticles, Carbon nanotubes, Dendrimers, Silica nanoparticles, Magnetic nanoparticles, Polymeric nanoparticles, Lipid nanoparticles, Quantum dots, Nanoporous materials, in the treatment of wound infections has been extensively studied and has resulted in major advancements [2].

Due to their distinctive physical and chemical characteristics, these nanoparticles have gained popularity in several fields, including medication delivery, cancer treatment, diagnostic imaging, and others. Because of their diminutive size, they can interact with biological systems in ways that bigger materials cannot.



Fig. 2. The uses or application of nanotechnology in biomedicine [1].



Fig. 3. The skin. (a) A diagrammatic representation of the various layers and structures found in skin; (b) "The wound healing process can be described as a series of stages, referred to as the wound healing cascade. These stages are homeostasis, inflammatory response, proliferation, and maturation;" (c) Classification of Burns: (i) First-degree, (ii) Superficial and (iii) deep second-degree, and (iv) third-degree burns [3]



Fig. 4. A variety of 2-dimensional nanomaterials are currently being utilized or investigated for their use in tissue engineering applications. [2].

## 2.1. Descendants of graphene

With its outstanding physical and chemical characteristics, graphene is the first 2D substance in the world. It has potential uses in a wide range of industries, including optoelectronics, energy storage, and biomedicine [2]. Additionally, the use of graphene derivatives in the treatment of skin-related ailments such as burn wounds, ulcers, and aging skin has been investigated. For instance, it has been shown that rGO can enhance skin hydration, decrease inflammation, and boost collagen production, making it a possible contender for anti-aging therapy. GO has also been utilized to improve the efficacy of therapies for wound healing by serving as a vehicle for the transfer of medications and growth factors.

Along with its oxidative stress capabilities, GO's photothermal effect was used to boost its antibacterial activity when exposed to near-infrared (NIR) light. This makes it a suitable material for tissue regeneration and wound healing since it can aid in preventing and treating infections in wounds. The capacity of graphene derivatives, such as GO and rGO, to encourage cell migration and proliferation, improve wound healing, and lessen scarring has also been demonstrated by research. However, further research is required to completely comprehend the processes behind these benefits and to establish the ideal circumstances for their application in tissue regeneration [1].

Furthermore, due to their biocompatibility, antioxidant properties, and capacity to reduce inflammation, graphene derivatives like GO and rGO have demonstrated promise in the fields of tissue regeneration and wound healing. The use of these properties have been utilized in scaffolds made of GO for skin tissue engineering, with both laboratory and animal studies displaying positive results. The amount of GO content in the scaffolds has been discovered to affect how well wounds heal, with a concentration between 0.25% and 1% being the most effective [2].

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Fig. 5. "(a) Hyaluronic acid-based composite nanoplatforms containing GO and silver nanoparticles (GO-HA-AgNPs). (b) Hierarchically structured nanoparticles doped with GO and titanium dioxide nanoparticles. (c) A graphene oxide-based nanoplatforms modified with tobramycin and copper sulfide nanoparticles (GO–Tob@CuS). This platform synergistically

kills bacteria using the reactive oxygen species produced by copper sulfide and the photothermal effect of graphene oxide. (d) Hybrid nanosheets made of graphene carbon nitride and zinc ions (g-C3N4–Zn2+@GO)."[2]



Fig. 6. A diagrammatic representation of the use of graphene oxide and nanofiber scaffold structures for promoting the growth and development of neural stem cells is provided [1].

## 2.2. Black phosphorous

Atopic dermatitis and psoriasis are two skin disorders for which black phosphorus has been researched as a potential therapy. It has been demonstrated to possess anti-inflammatory and antibacterial qualities, which may help treat skin disorders that are characterized ed by inflammation and infection. The development of future skin sensors and wearable technology development may also benefit from black phosphorus's special optical and electrical qualities. For instance, it has been demonstrated that black phosphorus is very sensitive to changes in temperature and pressure, making it a suitable material for the creation of skin pressure sensors and thermal imaging equipment. Therefore, BP is viewed as a desirable biomaterial for the in vivo repair and regeneration of bone tissue. Alginate methacrylate (AlgMA) and polyacrylamide (PAM) nanoengineered hydrogels composed of BPNSs (PAM/AlgMA/BP) have been shown to enhance mineralization in vitro. All things considered, black phosphorus shows significant potential for skin regeneration and skin problem therapy. However, additional study is required to completely comprehend its features and uses and create secure and efficient skin regeneration and therapeutic solutions.



Fig 7. "(a) A hydrogel designed for photodynamic therapy (PDT) to promote skin regeneration using boron-doped diamond nanoparticles (BPNSs) is presented. (b) A liposome that is triggered by near-infrared light and made with boron-doped diamond quantum dots as a photothermal agent is described." [2].

## 2.3. Gold Nanoparticles

Given their distinct physical and chemical characteristics, gold nanoparticles may have been used in the regeneration of the skin. Biocompatibility, anti-inflammatory qualities, and the capacity to promote cell proliferation and tissue regeneration are a few of these qualities. Gold nanoparticles can serve a variety of functions during skin regeneration, including:

1) Healing of wounds: It has been demonstrated that gold nanoparticles aid in wound healing. They may promote angiogenesis, which assists in the formation of new tissue around the wound by promoting the division of cells and the generation of new blood vessels. Aside from that, gold nanoparticles contain anti-inflammatory qualities that can aid in reducing inflammation and promoting healing.

2) Anti-aging: Due to its capacity to increase skin suppleness and lessen the appearance of wrinkles, gold nanoparticles have been employed in cosmetic products. They function by promoting the synthesis of collagen, a protein that provides skin with strength and flexibility.

3) Drug delivery: Drugs may be delivered to the skin directly using gold nanoparticles as carriers. As it can boost the drug's effectiveness while lowering adverse effects, this is particularly helpful for treating skin conditions. Additionally, gold nanoparticles can boost a drug's solubility and stability, enhancing its effectiveness.

4) Treatment of skin conditions: Due to its anti-inflammatory qualities, gold nanoparticles may be used to treat conditions including eczema, psoriasis, and atopic dermatitis. They can help lessen the inflammation and redness brought on by these conditions.

## 3. Future Scope

The future of biomedical engineering and medical procedures can be greatly influenced by nanotechnology. The FDA-approved "pill cam" technology, for instance, can be developed to track when medication is taken depending on the body's response. It may also help with things like adjusting the amount of prescription treatment. However, cell treatment techniques in regenerative medicine are still in the early stages of research and confront several significant issues and difficulties.

The right rate of cell adhesion, proliferation, and differentiation should be supported, as well as the maintenance of the appropriate cellular phenotype, cell-specific signaling, and biochemical characteristics. To overcome these challenges, the adoption of a combined treatment combining nanomedicine and bioengineering in ocular regeneration seems promising.

So, as per the research and the review of this article nanotechnology in the field of tissue engineering especially in the regeneration part is emerging and will increase its value after overcoming the difficulties faced by the researcher.

Applications	2D materials	Properties	Major usage	Research stages
Skin	Graphene derivatives	Abundant surface functional groups     Oxidative stress     Destation stress	<ul> <li>Carriers</li> <li>Antibacterial agents</li> </ul>	Animal study
	Black phosphorus	<ul> <li>Photothermal effect</li> <li>ROS regeneration</li> </ul>	<ul> <li>Carriers</li> <li>Antibacterial agents</li> </ul>	Animal study
	Transition metal dichalcogenide (MoS <sub>2</sub> , MoSe <sub>2</sub> )	<ul> <li>Photothermal effect</li> <li>ROS regeneration</li> <li>Peroxidase-like activity</li> </ul>	<ul> <li>Carriers</li> <li>Antibacterial agents</li> <li>Catalyst of H<sub>2</sub>O<sub>2</sub></li> </ul>	Animal study
	Others: 2D-MOFs, MXenes, hexagonal boron nitride (hBN)	<ul> <li>Peroxidase-like activity</li> <li>Antibacterial</li> </ul>	<ul> <li>Antibacterial agents</li> <li>Catalyst of H<sub>2</sub>O<sub>2</sub></li> </ul>	Animal study (2D-MOFs); in vitro (MXenes, hBN)
Bone	Graphene derivatives	<ul> <li>Abundant surface functional groups</li> <li>Induce osteogenic differentiation</li> <li>Enhance mechanical strength</li> </ul>	<ul> <li>Synergistic therapy with other biomaterials</li> <li>Carriers</li> </ul>	Animal study
	Black phosphorus	Improve osteogenic conversion and mineralization     Photothermal effect     Photodynamic effect	<ul> <li>Synergistic therapy loading drugs</li> <li>Osteosarcoma treatment</li> </ul>	Animal study
	Transition metal dichalcogenide (MoS <sub>2</sub> )	<ul> <li>Photothermal effect</li> <li>Prove os teogenic differentiation of stem cells</li> </ul>	<ul> <li>Antibacterial agents</li> <li>Synergistic therapy with other biomaterials</li> </ul>	Animal study
	Others: MXene and hBN	<ul> <li>ROS clearance of Nb<sub>2</sub>C–PVP</li> <li>Provide mechanical supporting and osteogenic differentiation of Ti<sub>3</sub>C<sub>2</sub>T<sub>z</sub></li> <li>High strength of hBN</li> </ul>	<ul> <li>Radioprotectant</li> <li>Bone implants</li> </ul>	Animal study (Nb <sub>2</sub> C-PVP); in vitro (Ti <sub>3</sub> C <sub>2</sub> T <sub>z</sub> , hBN)
Cartilage	Graphene derivatives	<ul> <li>Adsorption capacity for hydrophobic and electrostatic interaction</li> <li>Reduce friction</li> <li>Improve mechanical strength</li> </ul>	<ul> <li>Carriers of growth factors</li> <li>Lubricants</li> <li>Filler of biomaterials</li> </ul>	Animal study
	Transition metal dichalcogenide (MoS <sub>2</sub> )	<ul> <li>Photothermal effect</li> </ul>	- Carriers to treat osteoarthritis	Animal study
	Others: boron nitride nanosheets	<ul> <li>Improve mechanical properties</li> </ul>	<ul> <li>Candidate of cartilage</li> </ul>	In vitro
Cardiac muscle	Graphene derivatives	<ul> <li>Adsorption capacity for hydrophobic and electrostatic interaction</li> <li>Conductivity</li> </ul>	<ul> <li>Carriers of stem cells</li> <li>Conductive biomaterials</li> </ul>	Animal study
	Others: transition metal dichalcogenide (MoS <sub>2</sub> ), Ti <sub>3</sub> C <sub>2</sub> MXene quantum dots	<ul> <li>Conductivity</li> <li>Induce cardiogenic differentiation</li> <li>Good cytocompatibility</li> </ul>	<ul> <li>Conductive biomaterials</li> </ul>	In vitro
Skeletal muscle	Graphene derivatives	<ul> <li>Conductivity</li> </ul>	<ul> <li>Conductive biomaterials</li> </ul>	Animal study
Nerve	Graphene derivatives	<ul> <li>Conductivity</li> </ul>	<ul> <li>Conductive biomaterials</li> </ul>	Animal study
Brain disease	Graphene derivatives	<ul> <li>Neuroprotective effect</li> </ul>	<ul> <li>Treatment of Alzheimer's disease</li> </ul>	Animal study
	Transition metal dichalcogenide (MoS <sub>2</sub> , WS <sub>2</sub> )	<ul> <li>Photothermal effect</li> </ul>	<ul> <li>Treatment of Alzheimer's disease</li> </ul>	In vitro
	Black phosphorus	<ul> <li>Photothermal effect</li> <li>Electrostatic interaction</li> <li>Chelate metal ion</li> </ul>	<ul> <li>Neurodegenerative disorder</li> <li>Carriers to treat depression</li> </ul>	Animal study
Spinal cord	Graphene derivatives	<ul> <li>Adsorption capacity</li> </ul>	- Carriers loading growth factors	Animal study
	Transition metal dichalcogenide (MoS <sub>2</sub> )	- Adsorption capacity	<ul> <li>Drug carriers</li> </ul>	Animal study
Adipose	MoS <sub>2</sub> , WS <sub>2</sub> , and BN	- Improve adipogenic differentiation	<ul> <li>Potential in adipose tissue engineering</li> </ul>	In vitro

# Table 1. A variety of 2-dimensional materials are being studied and used for various applications [2].

Table 2. Several	of the most promising biomaterials that are being utilized as scaffolds for
	regenerating soft tissue organs are being highlighted [4].

Biomaterial	Туре	Properties	Scaffold application	Organ of interest
Gelatin	Natural polymer	Good hydrophilicity, wettability, and cell attachment Ability to support cellular differentiation, viability, and motility	Gelatin coated plasma treated PCL Cell-laden chitosan-gelatin hydrogel	Skin Spinal cord (neural)
		Supporting the growth of hepatocytes, being injectable, non- cytotoxic nature	Fibrin incorporated alginate dialdehvde- gelatin hvdrogel	Liver
		Injectable thermo-sensitive hydrogel, supporting neovascularization and tissue preservation	Hyaluronan and porcine gelatin hydrogel	Heart
		Increased mechanical, and optical properties, enhanced hydrophilicity	Collagen type (I)-gelatin	Cornea
Collagen	Natural	Enhanced neomicro-vessel formation, enhanced cells'	DAC7-derived peptide-loaded-collagen	Heart
	polymer	differentiation and recruitment, increased cardiomyocyte cycle progression, decreased cellular apoptosis	type (I) hydrogel	
		Porous gel with the ability to sustain drug delivery, long-term mechanical stability and transparency, supporting cellular migration.	Collagen-based porous hydrogel	Corneal stroma
		Biodegradable, injectable, low immunogenicity, promoting cells' survival and retention <i>in vivo</i>	Human umbilical cord mesenchymal stem cells-loaded Collagen (I)-alginate hydrogel	Skin
		Enhanced mechanical properties, improved cells' adhesion and proliferation	Collagen (I)-treated galactosylated chitosan (GC)-alginate microcapsule	Liver
		Enhanced Schwann cells viability and proliferation	Hydroxyapatite nanoparticle- comprising collagen (I) hydrogel	Sciatic (neural) regeneration
Poly caprolactone	Synthetic polymer	Enhanced hydrophilicity, mechanical properties, and biocompatibility	Gelatin-PCL nanofibrous nerve guided conduit	Peripheral nerve regeneration
(PCL)		Enhanced degradation rate, improved hydrophilicity, mechanical properties, and biocompatibility	Polyurethane-PCL blend patch	Cardiac regeneration
		Enhanced biocompatibility, and mechanical properties	Bone marrow stem cells treated PCL- polylactic acid-polypropylene amine	Liver
		Enhanced biocompatibility, mechanical strength, hydrophilicity, transparency, <i>in vitro</i> degradation rate, and water uptake	Hybrid oriented PCL/lyophilized silk fibroin fibers	Corneal stromal regeneration
		Antioxidative properties, accelerating wound-healing process	Epigallocatechin-3-gallate-loaded- gelatin-PCL-collagen (I) nanofibers	Skin
Poly vinyl alcohol	Synthetic polymer	Homogenous and smooth structures of pores, enhanced wound healing, increased wettability, and cell attachment	Chitosan-polyvinyl alcohol- silk electrospun fiber	-Skin
		Supporting cardiomyocyte differentiation, increased electrical conductivity, Overexpression of cardiac-associated genes	Conductive biopolymeric polyvinyl alcohol/chitosan/MWCNTs nanofibers	Heart
		Enhanced thermal stability, biocompatibility, and tensile	Polyvinyl alcohol/nano-	Ocular
		strength Enhanced biocompatibility and porosity, improved cells' education was mathematic and allowing constitution	hydroxyapatite/silk fibroin hydrogel Polyvinyl alcohol/collagen (I) mat	regeneration Liver
Graphene Oxide (GO)	Nanoparticle	Enhanced mechanical properties, improved cardiomyocyte elongated morphology, electroconductivity	Electrospun polyethylene/GO/ terephthalate nanofibers	Heart
()		Antioxidative properties, accelerated wound repair	N-acetyl cysteine-loaded GO-collagen	Skin
		Enhanced water permeation and accelerated hydrolytic degradation, improved mechanical stability	Reduced GO (rGO)-PCL	Neural regeneration

# 4. Conclusion

In this article, we have discussed different varieties of nanotechnology materials used for the regeneration of skin cells. We have also tried to cover some general aspects of the regeneration of different organ cells and injuries. So, in conclusion, although the subject of regenerative skin nanotechnology is still developing, there are already a lot of intriguing advancements and possible applications. To fully fulfill the promise of nanotechnology in skin regeneration, there are, nevertheless, several issues that must be resolved. These difficulties include enhancing the efficiency and security of nanoscale drug delivery systems, creating efficient nanoscale scaffolds for tissue engineering, and resolving moral and legal problems related to the use of nanotechnology in medical applications. Despite these difficulties, regenerative skin nanotechnology has a promising future, and current research and development efforts are probably going to result in brand-new, ground-breaking therapies for wounds and disorders of the skin. In the upcoming years, we may anticipate substantial advancements in the field of skin regeneration thanks to the continuous development of nanotechnology and its use in the field of tissue engineering.



Fig. 8. A comprehensive overview of the worldwide market for nanomedicine is being analyzed. [1].

# References

- Ray, S. S., & Bandyopadhyay, J. (2021). Nanotechnology-enabled biomedical engineering: Current trends, future scopes, and perspectives. In Nanotechnology Reviews (Vol. 10, Issue 1, pp. 728– 743). De Gruyter Open Ltd. https://doi.org/10.1515/ntrev-2021-0052
- Zheng, Y., Hong, X., Wang, J., Feng, L., Fan, T., Guo, R., & Zhang, H. (2021). 2D Nanomaterials for Tissue Engineering and Regenerative Nanomedicines: Recent Advances and Future Challenges. In Advanced Healthcare Materials (Vol. 10, Issue 7). John Wiley and Sons Inc. https://doi.org/10.1002/adhm.202001743
- Keirouz, A., Chung, M., Kwon, J., Fortunato, G., & Radacsi, N. (2020). 2D and 3D electrospinning technologies for the fabrication of nanofibrous scaffolds for skin tissue engineering: A review. In Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology (Vol. 12, Issue 4). Wiley-Blackwell. https://doi.org/10.1002/wnan.1626
- Abdollahiyan, P., Oroojalian, F., & Mokhtarzadeh, A. (2021). The triad of nanotechnology, cell signaling, and scaffold implantation for the successful repair of damaged organs: An overview on soft-tissue engineering. In Journal of Controlled Release (Vol. 332, pp. 460–492). Elsevier B.V. https://doi.org/10.1016/j.jconrel.2021.02.036
- 5. Mijanović, O., Pylaev, T., Nikitkina, A., Artyukhova, M., Branković, A., Peshkova, M., Bikmulina, P., Turk, B., Bolevich, S., Avetisov, S., & Timashev, P. (2021). Tissue engineering meets

nanotechnology: Molecular mechanism modulations in cornea regeneration. In Micromachines (Vol. 12, Issue 11). MDPI. https://doi.org/10.3390/mi12111336

- Abdollahiyan, P., Oroojalian, F., Hejazi, M., de la Guardia, M., & Mokhtarzadeh, A. (2021). Nanotechnology, and scaffold implantation for the effective repair of injured organs: An overview on hard tissue engineering. In Journal of Controlled Release (Vol. 333, pp. 391–417). Elsevier B.V. https://doi.org/10.1016/j.jconrel.2021.04.003
- Lee, M. K., Lee, H., Kim, H. E., Lee, E. J., Jang, T. S., & Jung, H. do. (2021). Nano-topographical control of ti-nb-zr alloy surfaces for an enhanced osteoblastic response. Nanomaterials, 11(6). https://doi.org/10.3390/nano11061507
- Kapat, K., Shubhra, Q. T. H., Zhou, M., & Leeuwenburgh, S. (2020). Piezoelectric Nano-Biomaterials for Biomedicine and Tissue Regeneration. In Advanced Functional Materials (Vol. 30, Issue 44). Wiley-VCH Verlag. https://doi.org/10.1002/adfm.201909045
- Cui, L., Liang, J., Liu, H., Zhang, K., & Li, J. (2020). Nanomaterials for Angiogenesis in Skin Tissue Engineering. In Tissue Engineering - Part B: Reviews (Vol. 26, Issue 3, pp. 203–216). Mary Ann Liebert Inc. https://doi.org/10.1089/ten.teb.2019.0337
- Rifat, T., Shahadat Hossain, M., Mahbubul Alam, M., & Shara Shamsur Rouf, A. (2019). A Review on Applications of Nanobots in Combating Complex Diseases. In Bangladesh Pharmaceutical Journal (Vol. 22, Issue 1).
- Mao, A. S., & Mooney, D. J. (2015). Regenerative medicine: Current therapies and future directions. Proceedings of the National Academy of Sciences of the United States of America, 112(47), 14452–14459. https://doi.org/10.1073/pnas.1508520112
- Glenn, L. M. D., & Boyce, J. S. (2012). Regenerative nanomedicine: Ethical, legal, and Social Issues. Methods in Molecular Biology, 811, 303–316. https://doi.org/10.1007/978-1-61779-388-2\_19
- Glenn, L. M. D., & Boyce, J. S. (2012). Regenerative nanomedicine: Ethical, legal, and Social Issues. Methods in Molecular Biology, 811, 303–316. https://doi.org/10.1007/978-1-61779-388-2\_19
- Thangadurai, D., Sangeetha, J., & Prasad, R. (n.d.). Functional Bionano-materials From Biomolecules to Nanoparticles. http://www.springer.com/series/15921

# Finite Element Analysis of the Orthogonal Machining Operations: A Review

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Abstract. Orthogonal Machining is defined as the machining process in which the tool moves in a direction perpendicular to the axis of the workpiece. Plain turning, taper turning, step turning, knurling and thread cutting are some of the well-known orthogonal machining operations. Finite Element Analysis (FEA) is an integral tool used to analyze various industrial manufacturing operations. FEA helps a manufacturer or an engineer to get an approximate value of machining parameters like heat generated, shear stress, deformation and many other parameters using a simulation software on a computer. Without using FEA, one would have to spend a lot of money and time on conducting the physical trials of the machining process. The applications of FEA in the manufacturing industry have been growing by leaps and bounds. The review article will provide insights on some of the recently published research papers on the application of FEA on orthogonal machining operation.

Keywords. Finite Element Analysis, ANSYS, Orthogonal Machining, Turning, ABAQUS, Deform 2D

## 1. Introduction

To Finite Element Analysis (FEA) is a numerical computational technique used to find an approximate solution for a given complex engineering problem. The problem must be modelled accurately to obtain an approximate solution converging with the actual solution [1]. The need to solve complex elasticity and structural engineering problems lead to the rise of FEA. In the year 1941, Hrennikoff published a work on using lattice analogy to discretise a continuous domain [2]. In the year 1943, Courant calculated the torsional deflection of a shaft was calculated by discretising the shaft into triangular elements and piecewise shape functions were used for interpolation purpose [3]. The contributions of mathematicians like Rayleigh, Ritz, Galerkin and many others to solve complex differential equations and partial differential equations must be appreciated. This played a vital role in the growth of FEA. The concept FEA was coined by Clough in 1960 and he was motivated to use FEA to analyse the plane shear stress distribution on the aircraft wings [4]. The first book on FEA was published in the year 1967 [5]. The 1970s saw the rise of new computer softwares to perform the Finite Element Analysis [6], [7]. There are six main steps involved in the analysis of any real-life engineering problem using FEA. There are a few advantages and disadvantages of FEA. It has been represented in Table 1. It has been shown as a flowchart in fig 1. The applications of FEA are as follows [8]:

- I. Structural Analysis
- II. Modal Analysis
- III. Fatigue Analysis
- IV. Heat Transfer Analysis
- V. Conjugate Heat Transfer
- VI. Manufacturing Process Analysis

- VII. Flow Simulation
- VIII. Interaction of the Fluid and Structure
- IX. Failure Diagnosis



Fig.	1. Steps Involved	In FEA [8]
5.	1. Steps moried	minnin

Table	1 Advantages	and Disadvantages	of FEA [1]
rabic	1. Auvantages	and Disadvantages	ULLA

Advantages of FEA	Disadvantages of FEA
• Problems with complex geometries can be solved easily.	• Only approximate solutions are obtained and not the exact ones.
• Wide range of complex engineering problems in various like solid mechanics, heat transfer, electrical flux etc can be analysed.	• The designers must validate the FEA results. They must not trust the results blindly.
• Problems with complex boundary conditions can be handled with ease.	• Numerical Computations and model idealizations may lead to inherent errors.
• Real-life engineering problems with time variant loads, distributed loads and other loading conditions can be analysed.	

# 2. Orthogonal Cutting: An Overview

Orthogonal cutting is defined as the process of material removal when the tool is perpendicular to the axis of the workpiece (refer Fig 2). The high intensity plastic shearing in the primary shear region [10]. There are six forces associated with orthogonal cutting. These forces can be represented on a "Merchant's Circle" (refer Fig 3). They are as follows:

- 1. Cutting Force (F<sub>C</sub>)
- 2. Thrust Force (F<sub>T</sub>)
- 3. Shear Force  $(F_S)$
- 4. Normal To the Shear Force  $(F_N)$
- 5. Frictional Force(f)
- 6. Normal to Friction Force(N)



Fig. 2.Orthogonal Machining Process [2]



Fig. 3. Merchant Circle Diagram

The above-mentioned forces must be analyzed to understand the impact of the cutting tool on the workpiece. The thermal parameters of the tool during the machining process must be understood. The temperature on each zone of the workpiece being machined is of high importance as the temperature affects the grain structure. The grain structure has a severe impact on the tensile strength, fatigue strength, toughness and stiffness of the workpiece. The thermal and mechanical properties can be analyzed by using Finite Element Analysis (FEA) on softwares like ANSYS, ABAQUS and many other softwares. This review article consolidates the latest work in the domain of using FEA in orthogonal cutting operations.

# 3. Model Formulations, Work Material Constitutive Models, Friction Models and Chip Separation Criteria in The Finite Element Analysis of The Orthogonal Machining Operation

The Before looking into the work done by researchers in the domain of application of FEA in orthogonal machining operation, one must know about the FEA formulation model used in analysing the orthogonal machining model. There are three main formulations[11].

They are:

I. Lagrangian Formulation: The lagrangian formulation is one of the most used models to analyze solid mechanics problems. The mesh is attached to the entire region under simulation. The shape of the chip formed from the machining operation can be obtained. The plastic deformation during the simulation of the machining operation leads to distortion of the elements. The mesh must be regenerated. The geometry of the chip can be analysed using the lagrangian formulation.

II. Eulerian Formulation: The finite element mesh in the eulerian formulation is spatially fixed. Only fewer elements are needed to perform the analysis using the eulerian formulation. The boundary and shape of the chip must be predefined before beginning the FEA analysis. The velocities associated with the machining process can be found out.

III. Arbitrary Lagrangian-Eulerian (ALE): Arbitrary Lagrangian-Eulerian (ALE) formulation has the advantages of Eulerian formulation and lagrangian formulation(refer Fig 4). The mesh is neither attached to the simulation region nor spatially fixed. The material flow and displacement analysis done using the lagrangian formulation method. The velocity measurements are done using the eulerian formulation method.



Fig. 4. The ALE Boundary Conditions To Analyze The Orthogonal Machining Process [3]

The There are three main types of work material constitutive models to analyze the flow stress during the orthogonal machining. They are as follows:

I. Oxley Material Model: The Oxley material model is used to analyze the high temperature flow stress or high strain rate based on the thermal properties of the material. Orthogonal cutting parameters like cutting forces, cutting edge deformation, cutting temperatures and tool life[4]. In equation (1), is the flow stress.  $\sigma_1$  is the flow stress when  $\varepsilon$  is 1.0. Equation (2) represents the variation in temperature.

$$\sigma = \sigma_1 \varepsilon^n \tag{1}$$
$$T_{\text{mod}} = T \left( 1 - V \log \left( \frac{\varepsilon'}{\varepsilon'_0} \right) \right) \tag{2}$$

II. Johnson & Cook Material Model: The torsion and dynamic Hopkinson bar test over a large range of strain rates and temperatures were the basis of the Johnson and Cook material model. This model assumes that the flow stress is affected by strain, strain rate and temperature independently.

$$\sigma = (A + B\varepsilon^n) + (1 + Cln(\frac{\varepsilon'}{\varepsilon'_0})(1 - T^m_{Mod})$$
(3)

$$T_{Mod} = \frac{1 - T_{Ref}}{T_{Melt} - T_{Ref}} \tag{4}$$

A, B, C, n and m are material constants found using various material tests. T is the temperature at which the test is conducted.  $T_{Ref}$  is the room temperature.  $T_{Melt}$  is the melting temperature of the material[5][6].

III. Zerilli and Armstrong Material Model: The Zerilli and Armstrong Material Model depends on the dislocation mechanics of the crystal structure of the give material. Dislocation mechanics has a profound influence on the thermal softening of the material, strain hardening and strain rate hardening[7][8]. Equation (5) can be for materials with BCC structure and equation (6) can be used for FCC materials.  $C_0$ ,  $C_1$ ,  $C_2$ ,  $C_3$ ,  $C_4$  and  $C_5$  are the material constants.

$$\sigma = C_0 + C_1 L + C_5 \varepsilon^n \tag{5}$$
  
$$\sigma = C_0 + C_2 \varepsilon^{-1/2} L \tag{6}$$

where 
$$L = \exp(-C_3T_3 + C_4Tln\left(\frac{\varepsilon'}{\varepsilon_0'}\right))$$

It is a tedious task to analyze the variation of coefficient of friction between the toolchip interface and tool-workpiece interface during the orthogonal machining process. To analyze parameters like cutting forces, temperature distribution, tool wear and tool life, friction between the tool-workpiece and tool-chip interface is important. There are three main types of friction modelling used in the orthogonal metal machining simulations. They are as follows:

I. Constant Coulomb: This model is one of the earliest friction models used in the orthogonal cutting simulation. According to this model, frictional stress is directly proportional to the normal stress in the contact region between the tool and workpiece. This is best suited for the simulation of low-speed machining. This model cannot be used with high-speed modelling process because the tool-workpiece interface friction is not constant. In equation (7),  $\tau$  is the frictional stress and  $\sigma_n$  is the normal stress.  $\mu$  is the coefficient of friction [9].

 $\tau = \mu \sigma_n \tag{7}$ 

II. Constant Shear: According to this model, the frictional stress on the rake face of the tool is constant during the machining process. The minor variations in  $\sigma_n$  and  $\tau$  are neglected. In equation (8), m is the friction factor and k is the shear stress flow of the material [10][11].

 $\tau = mk$  (8) III. Coulumb-Tresca Friction Model: This model analyses the variation of friction in the sliding and sticking region during the machining process [12]. According to Zorev [13], the normal stress is the highest at the tool tip and decreases to zero at a point where the chip gets detached from the rake face.  $\tau$  is the frictional stress.  $\tau_{ct}$  is the average shear flow stress and  $\mu$  is the coulomb's friction coefficient.

$$\tau = \begin{cases} \mu \sigma \text{ when } \mu \sigma < \tau_{ct} \text{ (Sliding Region)} \\ \tau_{ct} \text{ when } \mu \sigma \ge \tau_{ct} \text{ (Sticking Region)} \end{cases}$$
(9)

The chip separation model is used to analyze the shape and type of chip formed from the machining process[14][15]. There are two kinds of chip separation criteria. They are as follows [3]:

I. *Geometrical Criterion:* According to the geometrical criterion, the chip separation begins when the tool tip approaches a node along the parting line within a critical distance (refer Fig 5).

II. *Physical Criterion:* According to the physical criterion, the separation of the chip from the workpiece will begin when the value of the field variable exceeds a predefined threshold value at a node or an element.



Fig. 5. Geometric Chip Separation Criteria[16]

## 4. Applications of Finite Element Analysis to Simulate The Orthogonal Machining Process

The Wenyu Cheng and José C. Outeiro [17] developed a the Finite Element Analysis model for the orthogonal machining of Ti-6Al-4V Titanium Alloy with an uncoated carbide tool to find out critical machining parameters like distribution of temperature, machining forces, geometry of the chip, chip compression ratio and residual stresses. The development and simulation of the 2D orthogonal machining model was developed using the Lagrangian approach in the ABAOUS software. The Quadrilateral continuum elements (CPE4RT) in the  $\overrightarrow{ABAOUS}$  software were used to mesh(mesh size: 17 µm × 10 µm) the 2D model of the tool and workpiece(Refer to Fig 6). The VUMAT and UMAT subroutines in ABAQUS were used to implement the material constitutive model to analyze the state of stress [18]. The model proposed by Zorev [19] were implemented to analyze the variation of contact stresses between the tool and workpiece interface. The UMAT subroutine in ABAQUS was used to analyze the variation of residual stresses in the workpiece. The results from the ABAOUS simulations were compared with the results from the orthogonal cutting experimental analysis(for chip compression ratio, chip profile & cutting forces) and X-Ray Diffraction Analysis(for residual stresses). It was found that the cutting temperature increased to 600° C from the ambient temperature in less than 10<sup>-3</sup> seconds. The predicted thrust force was 53% higher than the experimental thrust force. The measured and predicted cutting force varied by 14%. The difference between the predicted and experimental maximum chip ratio was found to be less than 10%. The variation in the transversal residual stresses found using the experimental analysis and ABAQUS prediction was found to be 36% and the variation in the longitudinal residual forces was found to be 17%. The large variation in the measured values and the predicted calls for a need for better approaches than lagrangian methods to analyze the parameters in the orthogonal machining process. The mesh size can be reduced further to achieve a higher accuracy.



Fig. 6. The 2D Meshed Orthogonal Cutting Model In ABAQUS using the Quadrilateral continuum elements (CPE4RT) [17]

Zakaria Ahmed M. Tagiuri et al [20] developed a numerical model to analyze the impact of the tool nose geometries on the orthogonal machining parameters (cutting forces, tool wear rate, stresses and temperature distribution) of the AISI 1045 workpiece(30 x 5 x 1.5 mm) with Uncoated Carbide Tool. The FEA of the orthogonal machining of AISI 1045 with Uncoated Carbide Tool was performed using a commercial DEFORM-2D R V 11.3 software. The nose radius of the cutting tool was varied from 0.01 mm to 0.9 mm. The feed rate range, cutting speed range and rake angle range was varied between 0.1-0.3 mm/rev, 100-500 m/min and -5° to  $+10^{\circ}$ . The two-dimensional (2D) quadrilateral elements were used to mesh the orthogonal model. From the FEA simulation results (the feed rate was set at 0.1 mm/rev and rake angle( $\gamma$ ) was set at 5°), it was found that the shear stresses, maximum strain in the tool-workpiece interface, cutting force, and thrust force increases with the increasing nose radius(refer Fig 7). The cutting temperature remained unaffected by the nose radius of the tool. The values obtained from the FEA solution were compared with the data available in the research literature and it was found that the for a nose radius of 0.5mm, the error percentage in cutting stress between the previous research papers and the FEM solution was found to be 3.3% and the error percentage between the cutting tool temperature was found to be 16.2% [21][22].



Fig 7. The Stress Variation In The Workpiece & Tool at a Cutting Speed of 400m/min, feed rate of 0.1 mm/rev, rake angle of 5° with varying Nose Radius(mm) (a)0.3mm (b)0.5mm (c)0.7mm (d)0.9mm [20]

A.B. Pop et al [23] studied the impact of different cutting radius and depth of cut on the orthogonal machining of C45 using Uncoated Carbide tool, A FEA model of the orthogonal operation was carried out using the Deform 2D software. The workpiece was discretised into 10037 elements and 10217 nodes. The cutting-edge radius was varied from 0.05mm to 0.4mm and the depth of cut was varied from 0.2mm to 0.5mm. It was found that the smaller wear craters on the tool were formed with the increasing cutting-edge radius because of the larger friction at the tool and workpiece interface. The higher cutting-edge radius allowed the stress to be distributed over a larger surface area over the workpiece. The cutting edge has a profound influence on the tool temperature(refer Fig 8).



Fig. 8. Effect of Cutting Edge Radius on The Wear Rate With Increasing Cutting Depth [23]

Liu et al [24] prepared four samples B<sub>4</sub>C with variable percentage by weight of  $TiB_2(0\%, 10\%, 20\% \text{ and } 30\%)$ . The performance of these tools in the turning operations of AISI 4340 steel was simulated using Deform-3D software. The workpiece (diameter of 40mm) and tool were meshed using equilateral four-corner grid elements. The cutting speed (150 to 300 m/min), feed rate (0.1 to 0.25 mm/rev) and depth of cut (0.3 to 1mm). It was found that with the increase in percentage of  $TiB_2$  in the tool, the main cutting force and tool temperature were decreasing despite the increasing operational parameters like cutting speed, feed rate and depth of cut. The tool surface hardness was found to be decreasing with the increase in  $TiB_2$  due to the formation of B<sub>2</sub>O<sub>3</sub> during the machining process leading to abrasive wear and oxidation wear. The tool life of the  $B_4C$  with 30% TiB<sub>2</sub> was found to be higher than the commercially used YD tungsten carbide tool. It was concluded that the B<sub>4</sub>C with 30% TiB<sub>2</sub> was the best tool to turn AISI 4340. Pop and Tîtu [25] used Deform 2D software to analyze the impact of cutting edge of the tool on the shape of the tool. The Deform 2D software is used to simulate the orthogonal machining operation of C45 workpiece(50mm diameter) with Titanium Carbide(TiC) tool (variable rake angle and fixed clearance angle). The higher the rake angle greater the temperature between the tool tip and workpiece interface. The increase in the cutting edge of the tool increases the thickness of the chip. Rittik Bhogal et al [26] simulated the orthogonal machining of a heat-treated 4140 Alloy Steel workpiece with a Cast Steel Silver Brazed Carbide tool using ANSYS Workbench. The tool temperature and cutting forces of the orthogonal machining operation was measured experimentally. The simulation results and the experiment results were compared. It was found that the von-mises stresses and cutting temperature of the tool were increased with the increasing depth of cut. It was also found that a 25% increase in cutting speed will lower the tool life by 50%. It was also concluded that the tool-chip interface temperature is predominantly affected by the cutting speed than the depth of cut and feed rate. The peripheral milling operation is an orthogonal cutting operation. Omole et al [27] developed a 2D finite element model to simulate the peripheral milling operation of Ti-6Al-4V alloy with a Tungsten Carbide cutting tool of variable rake angle(8<sup>0</sup>,12<sup>o</sup> and 16<sup>o</sup>). The lagrangian formulation was used to analyze the peripheral milling operations in the ABAOUS software. The CPE4RT element was used to mesh the tool and the workpiece. The data obtained from the ABAOUS simulations was compared with the values obtained from the experimental analysis. The Johnson and Cook Material Model was used to analyze the strain and strain rate hardening of the Ti-6Al-4V workpiece. The simulation analysis proved that the increase in the rake angle from 8° to 12° decreases the cutting force by 12% and the observation was found to be consistent with the experimental analysis. The simulation of increasing the rake angle from 12° to 16° showed a 2% increase in the cutting force that was contrary to the results from the experimental analysis. Neeraj Deswal and Ravi Kant [28] conducted the FEA to simulate the Ultrasonic vibration assisted turning (UVAT) and Conventional Turning(CT) of AZ31B magnesium alloy workpiece with tungsten carbide tool. The FEA simulation was conducted using the ABAOUS software. The workpiece and tool were meshed with a CPE4RT element. The ALE model was used to analyze the deformation in the cutting zone. The flow properties were analysed using the Johnson-Cook (JC) model [29], [30]. From the simulation, it was found that the stress distribution reduced by 40% while using UVAT than that of CT. The thrust force and cutting forces in UVAT were 65% and 69% lesser than the CT.



Anastasios Tzotzis et al [31] developed a 3D FEM approach to simulate the hard turning

Anastasios Izotzis et al [31] developed a 3DFEM approach to simulate the hard turning of AISI-52100 with a ceramic tool insert under variable feed rate(0.08 to 0.14 mm/rev), variable cutting speed(100 to 200 m/min),variable depth of cut and variable nose radius conditions using DEFORM 3D software(refer Fig 10). Approximately 60,000 to 120,000 tetrahedral elements were used to mesh the workpieces. The resultant force was found out using the simulation and experimental means. The error % between the experimental and simulation analysis was found to be in the range of -2% to 11%.
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Fig. 10. The FEM setup with the meshed tool and workpiece [31]

MALEA and u BĂDULESCU et al[32] developed a 2D simulation model to analyze the orthogonal machining process of NiCr19Nb5Mo3 alloy. They used ABAQUS software to develop the 2D orthogonal machining model. It was found that the chip removal rate is directly affected by the clearance angle. Lower cutting forces are obtained with the increasing clearance angle of the cutting tool. The tool tip radius would also increase the cutting forces. Aliemeke and Iyore [33] developed a FEM model to simulate the orthogonal machining of the Titanium workpiece with Aluminium shaping tool. They used ANSYS Design Modeller Environment to model and simulation the orthogonal machining operation. A mathematical model was developed using linear regression analysis. There were 21971 node and 41327 elements in the meshed model. Maximum stress and maximum strain of the shaping tool was found to be 495.42MPa and 79.49mm(refer Fig 11). The strain and stress obtained from the ANSYS analysis were compared with previous research work[34]. The values were found similar to the previous works.



Fig. 11. Deformation Results Obtained From ANSYS [33]

Rendi Kurniawan et al [35] did a comparative study UEVC (ultrasonic-ellipticalvibration-cutting) and a CC (conventional-cutting) process for the micro grooving operation of AISI 1045 steel alloy with Cubic Boron Nitride tool was analysed using FEA. Vital cutting parameters (stress distribution, cutting force, residual stress, and temperature distribution) were analysed using residual stress software. JC (Johnson–Cook) stress flow model was used to analyze the variation of flow stress during the orthogonal cutting operation. The maximum mesh size and minimum mesh size of the tool and work piece was set to be 10  $\mu$ m and 1  $\mu$ m respectively. From the simulation results, it was found that the stress concentration in the UVEC process was higher than the CC process because of the increase in the relative cutting speed of the tool. The sporadic cutting technique with transient DOC has been attributed to the decrease in cutting forces of the UVEC process. The cutting forces in the UVEC process is inversely proportional to the vibration intensity. The tensile stresses are predominantly seen in both CC and UVEC processes(refer Fig 12).



Fig. 12. The Shear Angle for UVEC and CC obtained using the experiment and simulation [35]

Mercy Ozakpolor et al [36] used FEM simulations to analyze the variation of tool temperature of the carbide inserted cutting tool while machining AISI 1010 steel alloy. The temperature was measured experimentally using a K-Type Thermocouple. The orthogonal machining process was also simulated using ANSYS. The tool was meshed with 46407 nodes and 28437 elements. The feed rate, depth of cut and spindle speed were varied during the ANSYS Simulation and experimental analysis. There was less than 1% error between the predicted tool temperature and experimental tool temperature. It was found that the spindle speed has a predominant influence on the tool temperature than other parameters like feed rate and depth of cut. Uma Maheshwera Reddy Paturi et al [37] used DEFORM 3D FEA software to analyze the machinability parameters(tool temperature, chip thickness, cutting force and wear rate) of the turning operation of Inconel 718 alloy using CVD coated TNMA 332 KC9025 tool under variable cutting speeds(60,80 and 100 m/min), feed rate(0.1,0.2 and 0.3 mm/rev) and depth of cut(0.05, 0.075 and 0.100 mm). The flow stress is analyzed using the John-Cook flow stress model[38]. The tool and workpiece were meshed with quadrilateral elements. The tool temperature is directly proportional to the feed rate and depth of cut. The tool wear is predominantly affected by the depth of cut of the tool. There was a very minimal difference obtained between the simulation results and the results obtained in the research done with the same material [39][40][41]. Oluwajobi and Egbebode [42] performed the simulation of the orthogonal cutting NST 37-2 steel(a Nigerian Steel Grade) with uncoated carbide tool with variable rake angles  $(-15^\circ, 0^\circ, 15^\circ, \text{ and } 30^\circ)$ . The simulations were carried out on ABAQUS/Explicit where 2D and 3D Arbitrary Lagrangian and Eulerian formulation were implemented. Coulomb's friction model was considered for modelling the tool-chip and the tool-work piece interface zones. It was found that the cutting forces decreased with the increase in rake angle. Bhople et al [43] use ABAQUAS/Explicit 6.12 software to simulate the results

of micro-milling of Ti-6Al-4V alloy with micro tungsten carbide end mill(with 10% Cobalt Binder) to measure the Von-Mises stresses and cutting forces. The micro-milling of the Ti-6Al-4V alloy with micro tungsten carbide end mill(with 10% Cobalt Binder) was also performed experimentally and the cutting forces were measured using a dynamometer. The Johnson-Cook equation was used to predict the cutting forces in the FEM model. Maximum error of 11.84% in the vertical cutting force was obtained between the experimentally measured obtained using simulations. Maximum error of 15.17% in the horizontal cutting force was obtained between the experimentally measured obtained using simulations.



Fig 13. FEM of the Micro Milling Process[43]

## 5. Conclusion

The Orthogonal machining operation is complex phenomenon. There are several parameters are associated with the orthogonal cutting operation. Finite element methods are a cost-effective and an easy way to simulate these parameters. The conclusions drawn from the inferred research papers are as follows:

I. The orthogonal machining of alloys that have low machinability can be analysed using a FEA analysis easily;

II. The orthogonal machining parameters obtained from FEA simulation and experimental simulations have a very minor difference in majority of the cases;

III. FEA can be used to simulate the orthogonal materials of materials in non-traditional methods (i.e., inducing a frequency to enhance the orthogonal machining process);

IV. The number of elements and the mesh size affects the accuracy of the simulated results;

V. DEFORM 2D and DEFORM 3D softwares are the most used FEA softwares for the simulations of the orthogonal machining operation followed by ABAQUS software;

VI. Quadrilateral element is the commonly used element to mesh the tool and workpiece in the FEM software for analysis;

VII. Johnson & Cook Material Model is the most used model in the FEA simulation of orthogonal machining process because it considers the effect of strain, strain rate and temperature on flow stress independently;

VIII. Arbitrary Lagrangian-Eulerian (ALE) formulation is the most preferred formulation in the FEA simulation of the orthogonal machining process because the mesh remains unaffected during the plastic deformation of the workpiece;

IX. Coulumb-Tresca Friction Model is the most preferred friction model because it caters to the variation of coefficient of friction in the sliding and sticking region.

### References

- 1. S. Elsheltat, A. Alshara, and W. Elshara, *Modeling and Finite Element Analysis of Leaf Spring Using Pro-Engineer and ANSYS Softwares*. 2018. doi: 10.21467/proceedings.4.30.
- 2. W. Y. H. Liew, "The effect of air in the machining of aluminium alloy," *Tribol. Lett.*, 2004, doi: 10.1023/B:TRIL.0000017417.06303.23.
- 3. B. D. Nelge and V. M. Kale, "Modelling And Simulation Of Metal Cutting By Fem," Int. J. Innov. Eng. Res. Technol., pp. 1–9, 2019.
- J. A. Arsecularatine and P. Mathew, "Oxley modeling approach, its applications and future directions," *Mach. Sci. Technol.*, 2000, doi: 10.1080/10940340008945716.
- F. Klocke, B. Döbbeler, B. Peng, and S. A. M. Schneider, "Tool-based inverse determination of material model of Direct aged Alloy 718 for FEM cutting simulation," 2018. doi: 10.1016/j.procir.2018.08.211.
- A. A. Lakshmi, C. S. Rao, and T. Buddi, "Chapter five Fractography analysis and constitutive modeling for dynamic plasticity of austenite stainless steel (ASS 304) at hot-working temperatures," in *Woodhead Publishing Reviews: Mechanical Engineering Series*, K. Kumar and J. P. B. T.-M. M. P. Davim, Eds. Woodhead Publishing, 2020, pp. 97–129. doi: https://doi.org/10.1016/B978-0-12-819496-6.00005-1.
- 7. F. J. Zerilli, "Dislocation mechanics-based constitutive equations," *Metall. Mater. Trans. A*, vol. 35, no. 9, pp. 2547–2555, 2004, doi: 10.1007/s11661-004-0201-x.
- 8. F. J. Zerilli and R. W. Armstrong, "Dislocation-mechanics-based constitutive relations for material dynamics calculations," *J. Appl. Phys.*, 1987, doi: 10.1063/1.338024.
- 9. T. Özel, "The influence of friction models on finite element simulations of machining," Int. J. Mach. Tools Manuf., 2006, doi: 10.1016/j.ijmachtools.2005.07.001.
- J. A. Schey, "Tribology in Metalworking: Friction, Lubrication, and Wear," J. Appl. Metalwork., vol. 3, no. 2, p. 173, 1984, doi: 10.1007/BF02833697.
- S. H. Molaei, M. Shahbaz, and R. Ebrahimi, "The Relationship between Constant Friction Factor and Coefficient of Friction in Metal Forming using Finite Element Analysis," *Iran. J. Mater. Form.*, Jan. 2014.
- L. Wan, B. Haddag, D. Wang, Y. Sheng, and D. Yang, "Effects of friction conditions on the formation of dead metal zone in orthogonal cutting-a finite element study," *Mach. Sci. Technol.*, 2018, doi: 10.1080/10910344.2018.1429469.
- 13. NN Zorev, "Inter-relationship between shear processes occurring along tool face and shear plane in metal cutting," *Int. Res. Prod. Eng.*, vol. 49, pp. 143–152, 1963.
- 14. J. Li, Z. Huang, G. Liu, Q. An, and M. Chen, "An experimental and finite element investigation of chip separation criteria in metal cutting process," *Int. J. Adv. Manuf. Technol.*, 2021, doi: 10.1007/s00170-021-07461-0.
- 15. L. Zhang, "On the separation criteria in the simulation of orthogonal metal cutting using the finite element method," J. Mater. Process. Technol., 1999, doi: 10.1016/S0924-0136(99)00023-0.
- A. Mamalis, M. Horváth, A. S. Branis, and D. Manolakos, "Finite element simulation of chip formation in orthogonal metal cutting," *J. Mater. Process. Technol.*, vol. 110, pp. 19–27, Mar. 2001, doi: 10.1016/S0924-0136(00)00861-X.
- 17. W. Cheng and J. C. Outeiro, "Modelling orthogonal cutting of Ti-6Al-4 V titanium alloy using a constitutive model considering the state of stress," *Int. J. Adv. Manuf. Technol.*, vol. 119, no. 7, pp. 4329–4347, 2022, doi: 10.1007/s00170-021-08446-9.
- W. Cheng, J. Outeiro, J. P. Costes, R. M'Saoubi, H. Karaouni, and V. Astakhov, "A constitutive model for Ti6Al4V considering the state of stress and strain rate effects," *Mech. Mater.*, 2019, doi: 10.1016/j.mechmat.2019.103103.
- V. P. Astakhov and J. C. Outeiro, "Metal Cutting Mechanics, Finite Element Modelling BT -Machining: Fundamentals and Recent Advances," J. P. Davim, Ed. London: Springer London, 2008, pp. 1–27. doi: 10.1007/978-1-84800-213-5\_1.
- 20. Z. A. M. Tagiuri, T.-M. Dao, A. M. Samuel, and V. Songmene, "A Numerical Model for Predicting

the Effect of Tool Nose Radius on Machining Process Performance during Orthogonal Cutting of AISI 1045 Steel," *Materials (Basel).*, vol. 15, no. 9, 2022, doi: 10.3390/ma15093369.

- 21. M. Shnfir, O. A. Olufayo, W. Jomaa, and V. Songmene, "Machinability study of hardened 1045 steel when milling with ceramic cutting inserts," *Materials* (*Basel*)., 2019, doi: 10.3390/ma12233974.
- Y. Rayadin, J. Syamsudin, M. Ayatussurur, N. Qomari, H. Pradesta, and R. O. Priahutama, A& Putri, "3-D Finite Element Analysis Of Effect Cutting Edge Geometry on Cutting Forces, Effective Stress, Temperature And Tool Wear In Turning," *J. Kerbala Univ.*, vol. 10, no. 2, pp. 82–98, 2012, [Online]. Available: https://www.iasj.net/iasj/download/9df62d2624384cca
- 23. A. B. Pop, A. V Sandu, A. Sachelarie, and A. M. Ţîţu, "Studying the Behavior of the C45 Material when Changing the Tool Geometry Using the Finite Element Method," *Arch. Metall. Mater.*, vol. 67, no. No 2, pp. 653–659, 2022, doi: 10.24425/amm.2022.137802.
- 24. C. Liu *et al.*, "Finite element analysis and wear mechanism of B4C-TiB2 ceramic tools in turning AISI 4340 workpieces," *Ceram. Int.*, 2022, doi: 10.1016/j.ceramint.2021.11.090.
- 25. A. B. Pop and A. M. Ţiţu, "Study about the chip formation in the turning process using the finite element analysis," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1235, no. 1, p. 012019, Mar. 2022, doi: 10.1088/1757-899X/1235/1/012019.
- R. Bhogal, M. Singh, and A. Madan, "Cutting force & thermal analysis during turning using Ansys," *Mater. Today Proc.*, pp. 3577–3584, 2022, doi: 10.1016/j.matpr.2021.12.001.
- S. Omole, M.-Y. Lam, A. J. G. Lunt, and A. Shokrani, "Simulation and experimental investigations into the effect of rake angle in peripheral milling of Ti-6Al-4V," *Procedia CIRP*, vol. 107, pp. 155– 160, 2022, doi: https://doi.org/10.1016/j.procir.2022.04.026.
- N. Deswal and R. Kant, "FE analysis of Ultrasonic vibration assisted turning of magnesium AZ31B alloy," *Mater. Today Proc.*, vol. 62, pp. 7473–7479, 2022, doi: https://doi.org/10.1016/j.matpr.2022.03.507.
- 29. R. Y. Nooraie, M. Safari, and A. Pak, "Tool wear estimation in machining based on the flank wear inclination angle changes using the FE method," *Mach. Sci. Technol.*, vol. 24, no. 3, pp. 425–445, May 2020, doi: 10.1080/10910344.2019.1698610.
- M. Yaich, Y. Ayed, Z. Bouaziz, and G. Germain, "A 2D finite element analysis of the effect of numerical parameters on the reliability of Ti6Al4V machining modeling," *Mach. Sci. Technol.*, vol. 24, no. 4, pp. 509–543, Jul. 2020, doi: 10.1080/10910344.2019.1698606.
- A. Tzotzis, N. Tapoglou, R. K. Verma, and P. Kyratsis, "3D-FEM Approach of AISI-52100 Hard Turning: Modelling of Cutting Forces and Cutting Condition Optimization," *Machines*, 2022, doi: 10.3390/machines10020074.
- 32. C. I. MALEA and C. BADULESCU, "Numerical simulation of the orthogonal cutting, using the finite element method," *Univ. Pitesti. Sci. Bull. Automot. Ser.*, 2020, doi: 10.26825/bup.ar.2020.007.
- 33. B. Aliemeke and A. Iyore, "Finite Element Analysis of An Aluminium Shaping Tool and Titanium Workpiece," Oct. 2021.
- 34. S. Ranganathan, T. Senthilvelan, and G. Sriram, "Mathematical modeling of process parameters on hard turning of AISI 316 SS by WC insert," 2009.
- 35. R. Kurniawan, S. T. Kumaran, and T. J. Ko, "Finite Element Analysis in Ultrasonic Elliptical Vibration Cutting (UEVC) During Micro-Grooving in AISI 1045," *Int. J. Precis. Eng. Manuf.*, 2021, doi: 10.1007/s12541-021-00554-6.
- M. OZAKPOLOR, C. ALİYEGBENOMA, and D. D. OLODU, "Prediction of cutting temperature in carbide cutting tool using finite element method," *Int. Adv. Res. Eng. J.*, 2021, doi: 10.35860/iarej.859488.
- U. M. R. Paturi, S. Methuku, S. S. Siripragada, Y. Sangishetty, and R. K. Gunda, "Finite element simulations of machinability parameters in turning of Inconel 718," 2020. doi: 10.1016/j.matpr.2020.08.275.
- E. Uhlmann, M. G. Von Der Schulenburg, and R. Zettier, "Finite element modeling and cutting simulation of inconel 718," CIRP Ann. - Manuf. Technol., 2007, doi: 10.1016/j.cirp.2007.05.017.
- 39. D. G. Thakur, B. Ramamoorthy, and L. Vijayaraghavan, "A study on the parameters in high-speed turning of superalloy inconel 718," *Mater. Manuf. Process.*, 2009, doi: 10.1080/10426910802714571.
- 40. S. Pradhan, S. Singh, C. Prakash, G. Królczyk, A. Pramanik, and C. I. Pruncu, "Investigation of

machining characteristics of hard-to-machine Ti-6Al-4V-ELI alloy for biomedical applications," J. Mater. Res. Technol., 2019, doi: 10.1016/j.jmrt.2019.08.033.

- 41. K. Gok, "Development of three-dimensional finite element model to calculate the turning processing parameters in turning operations," *Meas. J. Int. Meas. Confed.*, 2015, doi: 10.1016/j.measurement.2015.07.034.
- 42. A. O. Oluwajobi and O. E. Egbebode, "The finite element modelling of machining of NST 37-2 steel," 2021. doi: 10.1088/1757-899X/1037/1/012005.
- 43. N. Bhople, S. Mastud, and S. Satpal, "Modelling and analysis of cutting forces while micro end milling of Ti-alloy using finite element method," *Int. J. Simul. Multidiscip. Des. Optim.*, 2021, doi: 10.1051/smdo/2021027.

# Spectral Analysis the Tension Signal of Electronic Sphygmomanometer

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Abstract. The pressure signal of electronic sphygmomanometer, recorded in personal computer provides whole information for the blood flow. The corresponding function can be processed by discrete Fourier transformation in order to describe the spectral character of the signal. The algorithm consists of reducing the digital function to an acceptable size, discrete Fourier transformation and its graphic presentation. The frequency response covers wide range of the spectrum without specific components but varies for different measurements with bringing of various issues.

Key words: Electronic sphygmomanometer, Spectral analysis, Blood pressure signal.

#### 1. Introduction

The Fourier transformation is a mathematic tool for researches in the physics and engineering. There are transformations on the material axis, on the periodic function and on the discrete function. The last one is applied in engineer practice and in the current exploration.

The comprehensive medicine applies abundance of approaches and models of studies. In [1] "Multivariate models – which allow evaluation modulation the interactions between changes in blood pressure, heart rate, and other biological signals in the time and frequency domains – offers a more comprehensive approach than that represented by separate analysis of fluctuations in blood pressure or heart rate only." The authors also emphasize on: "proper interpretation of power spectra is highly dependent on the presence of signal stationary." In parallel, "Interpretation of the spectra also depends on an appropriate degree of spontaneous fluctuations of the parameters that influence the signal under evaluation so that the risk of having no input data in the frequency range of interest is avoided." The exploration is based on signal of limited frequency range of 0.15 Hz, what is different from the heart rate, which varies around 1 Hz and some more.

In [2] "Laser Doppler flowery, a non invasive technique for the coetaneous blood flow monitoring, was utilized together with local temperature tests and wavelet analysis."

These studies are complex and multifunctional. They bear preliminary character, which encourage our exploration with spectral analysis of individual algorithm.

In the current research a new non invasive tool, like electronic sphygmomanometer provides stationary well repeatable input data about accidental blood pressure. It is spontaneous and in the same time precise measurement. The input frequency domain of tension sensor up to 500 Hz of recording covers physiological frequencies of 62 Hz, what could serve for more accurate exploration. The stationary of the measurement process is presented in [3].

The mathematic spectral characteristics are described in [4] and one of them is the discrete Fourier transformation. In the computer literature, for example [5], the discrete Fourier transformation is presented for the microprocessor applications. Following that algorithms the

developed solution is programmed in VBA – a high level computer language for applications and the results are graphically exposed.

### 2. Methods

**A.** The mathematic model of the discrete Fourier transformation is presented as a sum [5] as follows:

$$X_{s} = 1/N \left( \sum_{0}^{N-1} x_{i} * e^{jin} \right)$$
(1)

Each one discrete image represents a sum of the real and imaginary components of the all data averaged by their number.

$$e^{jin} = \cos(in) + j\sin(in)$$
<sup>(2)</sup>

The equation 2 manifests the complex entity of the Fourier transformation. Thus, two procedures of summation are going in parallel: the sum of real addends and the imaginary addends. The corresponding process can be described by the matrix multiplication:

$\left( X_{0} \right)$		$\left( \begin{array}{ccc} e^0 & e^0 & e^0 & e^0 \end{array} \right)$		
<b>X</b> <sub>1</sub>	=	$e^{0*1} e^{1*1} e^{2*1} e^{3*1}$	* x1	(3)
X2		$e^{0*2}$ $e^{1*2}$ $e^{2*2}$ $e^{3*2}$	<b>x</b> <sub>2</sub>	
$X_3$		$e^{0*3} e^{1*3} e^{2*3} e^{3*3}$	X3	

where the square matrix has real and imaginary components.

This procedure can be reduced by the mathematic property  $e^{in} = e^{in \mod(N)}$  or if i\*n > N-1 the order begins from the start. This operation can be completed with integer division, whose result is residual of it: for example, 9%4=1, 6%4=2 and so on. The real and imagine results can be summed in the complex area, following the Pythagoras theorem.

$$S_x = (1/N) * (X_c 2 + X_s 2)^{(1/2)}$$
(4)

The spectrogram contains inversed relatively to the start number  $x_0$  values of the above result for each one image of the complex domain.

 $\mathbf{S}_{\Sigma} = \mathbf{x}_0 - \mathbf{S}_{\mathbf{x}} \tag{5}$ 

If the spectrum must be verified by back Fourier transformation, one and the same ort plane will be found for every image.

Finally, the graphics of spectrogram shows the distribution of wave and phase results, characterizing the wave properties of the tension signal until 62.5 Hz.

The frequency result can be computed by the next expression:

$$F_{x} = \frac{10^{*}(R_{f} * t / \Delta t)}{N * T}$$
(6)

where  $R_f$  – frequency range, t,  $\Delta t$  – time moment and time discrete, N – the array for Fourier transformation, T – time range of the Fourier array.

# 3. Results

The spectral method is applied over twelve files of different input discrete data array for the pressure signal of the tension sensor of electronic sphygmomanometer. The program is written on VBA for Excel. It is one and the same for all files. The algorithm includes: reduction of data by reading by 4-th values; computation the table of trigonometric functions, computation the spectral images by recursion and inversion. The results of it are exposed in Table 1. Thus, the software works until 5 minutes for each one spectral result of a file.



Table 1. Original and spectral graphic of the pressure signal of electronic sphygmomanometer



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The spectrograms cover almost whole range of frequencies until 62.5 Hz. They vary by array length of input data, number of extremes, corresponding frequencies, and widths of extremes. Thus they show the variability of tension signal the artery. They can be described quantitatively by new parameters shown on Table 2. This software program is also one and the same for all files.

Table 2 represents generalized number description of the spectral period grams. Only most extremes are given with amplitudes on column 3. Their corresponding frequencies are on the next column, followed by frequencies widths around extremes and the numbers of discrete for widths. Four last extremes of the file 8 belong to one and the same wide range of extremes. The last extreme of the spectrum is ignored when not finished. The energy spectrums vary and the spectral analysis cannot serve for classification of this blood characteristics.

File	Real signal in time domain			Spectral result in frequency domain		
	No	Amplitude extreme, V	Frequency of extreme, Hz	Frequency width around extreme, Hz	Width, discrete	Energy spectrum, V <sup>2</sup>
File 1	1	0.15	5.64	0.36	2	60.61
	2	0.17	8.09	0.975	42	
	3	0.577	18.177	1.936	145	
	4	0.464	28.75	0.803	35	
	5	0.583	38.804	2.0657	86	
File 2	1	0.687	5.216	1.546	49	249.5528
	2	0.753	11.526	1.32	41	
	3	0.8199	16.45	1.803	52	
	4	0.815	22.891	1.577	50	
	5	0.822	25.048	3.316	104	
	6	0.802	29.748	3.22	91	
	7	0.819	36.51	1.577	50	
	8	0.655	38.956	2.865	190	
	9	0.675	45.17	3.348	105	

Table 2. Number description of spectral parameters: extremes and frequencies.

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File	Real signal in time domain		Spectral result in frequency domain			
	No	Amplitude	Frequency of	Frequency width	Width,	Energy
		extreme, V	extreme, Hz	around extreme, Hz	discrete	spectrum, V2
File 3	1	0.3507	9.7	2.07	90	28.8619
	2	0.317	13.28	1.186	52	
	3	0.36	18.19	1.279	56	
	4	0.35	27.512	3	130	
	5	0.33	34.49	0.953	42	
	6	0.294	36.47	1	44	
	7	0.3	40.16	1.209	53	
File 4	1	0.389	45.11	28.303	831	60.4492
File 5	1	0.477	8.91	1.358	49	116.0488
	2	0.46	15.13	4.016	143	
	3	0.492	24.184	1.556	56	
	4	0.465	31.539	1.273	48	
	5	0.494	33.07	3.252	116	
	6	0.495	36.94	2.574	92	
	7	0.478	48.68	4.799	170	
File 6	1	0.499	33.244	20.787	772	141.2238
File 7	1	0.217	12.57	1.074	35	74.97
	2	0.414	22.34	2.584	199	
	3	0.509	34.855	12.89	410	
File 8	1	0.442	4.45	3.16	99	142.7834
	2	0.475	14.61	3.354	105	
	3	0.569	37.86	3.834	110	
	4	0.563	46.6	12.414	386	
	5	0.569	48.246	12.414	386	
	6	0.57	49.02	12.414	386	
	7	0.57	49.15	12.414	386	
File 9	1	0.4355	5.155	0.804	32	82.0762
	2	0.49351	10.388	0.495	20	
	3	0.502	14.892	2.968	115	
	4	0.501	20.28	2.365	92	
	5	0.5031	24.89	1.04	41	
	6	0.502	29.576	1.745	68	
	7	0.496	33.53	2.525	98	
	8	0.447	36.995	0.91	35	
	9	0.3896	40.067	0.495	20	1
	10	0.448	44.546	1.51	59	

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File	Real signal in time domain			Spectral result in frequency domain		
	No	Amplitude extreme, V	Frequency of extreme, Hz	Frequency width around extremes, Hz	Width, discrete	Energy spectrum, V <sup>2</sup>
File 10	1	0.479	7.845	4.214	88	79.31161
	2	0.479	23.487	5.568	216	
	3	0.503	36.71	17.824	369	
	4	0.459	67.184	1.07	23	
File 11	1	0.477	11.319	2.24	63	148.381
	2	0.559	28.86	14.32	397	
	3	0.552	42.46	11.086	307	
File 12	1	0.4287	9.11	4.32	130	137.52
	2	0.514	21.101	11.254	337	
	3	0.507	34.733	14.407	431	

It rather reflects the variability of the blood pressure. The additional exploration of the spectral analysis on random input amplitudes had shown that the spectrum depends mainly on the trigonometric values and does not vary by amplitudes of the signal when they are around single 1.

### 4. Conclusions

The mathematics expressions of the spectral analysis are given in the paper. It is a discrete spectral analysis. The input data are reduced by density and the discrete number of input is around 6 thousands for a file. The spectral period grams of the pressure signal from electronic sphygmomanometer are rich in content about variability of the blood pressure. Some period grams consist of abundance of narrow extremes. Other ones contain wide range extremes. There is not some single united them spectral parameter. The energy spectrum is not constant for different files of blood pressure measurements. The frequency range of spectral period grams is defined by elementary time period of the discrete values of the blood pressure or 0.008 - 0.016 seconds. For different files the array of values varies by number of discrete. The software consumes less than 5 minutes for spectrum computation and less than a minute for number description of every file.

## References

- Parati G, J.Philip Saul, M. Di Rienzo, G. Mancia Spectral Analysis of Blood Pressure and Heart Rate Variability in Evaluating Cardiovascular Regulation. Hypertension. 1995; 25: 1276 – 1286. https://doi.org/10.1161/01.HYP.25.6.1276
- Mizeva I., E. Zharkikh, V.Dremin, E. Zherebtsov, I. Makovik, E. Potapova, A. Dunaev Spectral Analysis of the Blood Flow in the Foot Microvascular Bed During thermal Testing in Patients with Diabetes Mellitus. Microvascular Research, Volume 120, November 2018, Pages 13 – 18. https://doi.org/10.1016/j.mvr.2018.05.005 Get Rights and Content.
- Lahtchev L, Verification of Hypothesis about Blood Pressure by Statistic Estimations and Distributions. Proc. of Int. Conference Automatics and Informatics 2013, 3 – 7 Oct, Sofia, Bulgaria, pp. I 33 – I 36.
- Jablon C., J.-C. Simon Application des Modeles Numeriques en Physique. Birkhäuser Verlag Basel, 1978, In Russian, Moscow, "Nauka", 1983, 236 p.
- 5. Yuen C.K., K.G. Beauchamp, G.P.S. Robinson. Microprocessor Systems and Their Application to Signal Processing. Academic Press, 1982, Second Printing. In Russian. Moscow, "Radio i Svyaz", 1986, 296 p.

# Approaches for Parsing of Pages in Web Based Information Systems

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**Abstract.** The report examines possible solutions for data parsing from web-based information systems. The essence of the concepts data parsing, web data parsing and web scrapping is presented. Existing methods for web scrapping in the context of web-based information systems are indicated. The report also examines the Python programming language in the context of parsing of pages in web-based information systems and covers the different ways to implement a web scraper programmatically. Finally, conclusions summarized from the study are presented regarding the possibilities for parsing pages in web-based information systems.

**Keywords:** Data parsing, Web data parsing, Web scrapping, Regex, Tml dom, Xpath, Web-based information system.

### 1. Introduction for web data parsing

With the introduction of big data into our modern business model, the need to address, analyze and process data is becoming increasingly important for companies in all industries. As data collection increases, it must be read and understood. Just as natural languages require translation for effective human communication, computer languages and language programming also require such processes. This is where the data analysis begins. In the simplest form of data analysis, unstructured and sometimes unreadable data is transformed into structured and easy-to-read data. Regardless of the field, the activities of recognizing data and discovering ways to transform it are important to corporate business [3]. The recognition and transformation of data is associated with the concept of data parsing.

Data parsing is the process of taking data in one format and converting it to another format. Such processes are performed by the so-called parsers. Parsers are found in a wide variety of computer programs and software. Parsers have a wide range of applications. They are present in compilers when computer code needs to be analyzed and machine code generated. This process is carried out very quickly in today's world and is very important for the transition to digitization and electronization. Therefore, data collection and processing, in current reality, play an important role in all services.

The concept of data parsing in the context of the Web is called web parsing. Web parsing in literature is described as a major part of the web scrapping information extraction process. The two terms are interchangeable and in this paper we will use the term web scrapping. The process of web scrapping from a web-based information system is presented in Fig. 1.

There are various sources of data on the Internet that can be used when conducting research. The process of taking data or information from sites and systems on the Internet is called web scraping [8], [6], web mining [11], web collection [7]. Web scraping is also widely used for various purposes including online price comparison, monitoring weather data,

detecting changes in websites, research, integrating data from multiple sources, extracting offers and discounts, extracting listing information from portals for job finding, brand monitoring, government data collection and market analysis [7].



Fig. 1. Web scraping process

Web parsing is a method of obtaining a large amount of publicly available data from websites and web-based information systems. It automates data collection and converts the collected data into various formats such as HTML, CSV, Excel, JSON, txt. This process basically consists of 3 parts: HTML page parsing, data extraction and data storage. The most important thing in data analysis is programming. Because of this, many companies have a need to hire developers with experience and knowledge in the field of web crawling [3].

# 2. Web scraping methods

Various web scraping methods have been developed, including traditional copy and paste, regular expression (Regex) [7], hypertext markup language object model (HTML DOM) [11], and XPath [6]. The copy and paste method can be implemented using a web browser, with which a web site is loaded and the output text is manually copied and pasted to another medium. This method is very simple and not difficult, but it cannot be done if the website has a barrier program. It is performed manually. Regex, HTML DOM, XPath methods are more complex and require an additional program before they can be used [7].

Examples of the use of web scraping are related to its application to a scientific article or literature from the Internet, such as: web scraping for Indonesian-English parallel corpus using HTML DOM method, web scraping software in gray literature search, application of web scraping techniques to search engines for scientific articles, application of web scraping to multiple text sources for plagiarism detection. Each of the Regex, HTML DOM, XPath methods has an algorithm. Each algorithm has its own characteristics and therefore a good understanding is required before it is implemented. The regular expression algorithm requires less memory than the HTML DOM and Xpath methods, and the HTML DOM takes the least time and uses the least data compared to the regular expressions and Xpath [10].

A brief description of each method follows:

- Regular Expressions (Regex);
- Hypertext Markup Language Object Model (HTML DOM);
- XPath.

A regular expression (Regex) is a formula with a specific pattern that describes a set of words using an alphabet. Regex can be used to match certain character patterns in a set of strings [2]. There are two types of regular expressions namely ordinary characters and metacharacters [7].

Regular expressions are tools, and like all tools, they are designed to solve a very specific problem. The best way to understand regular expressions and what they do is to first understand the problem they solve.

Examples of using regular expressions are validating email addresses, searching files by keyword with a certain condition (for example, a word that must not appear in the middle of a file name), replacing individual words in text with other text strings, and etc. [5]. A regular expression that recognizes an email address is illustrated in Fig. 2.



Fig. 2. Regex email validation

The Hypertext Markup Language Object Model (HTML DOM) is a standard for obtaining, modifying, adding, or deleting HTML elements. The DOM performance is by having objects and properties defined on all HTML elements, with methods to access them. With the DOM, JavaScript can access all elements in an HTML document. HTML DOM uses programming languages to access objects, usually JavaScript. All HTML elements are treated as objects. The programming interface is the method and property of each object A program interface is a method and property of each object [7]. A web browser does not require the use of the DOM to display HTML documents. But with the DOM, JavaScript can access all the elements in the HTML document [4]. An example of an HTML DOM Tree of Objects is presented in Fig. 3.

XPath is the main element in the XSLT (Stylesheet Language Transformation) standard. XPath can be used to navigate elements and attributes in eXtensible Markup [7]. XPath 2.0 is an expression language that is fundamental to XSLT 2.0 in several important ways. A common use of XPath in XSLT is to select nodes in an XML document using XPath expressions. XPath expressions are also used by an XSLT processor to map the nodes of the source tree to the rule template. XPath's capabilities include a wide range of functions that allow you to manipulate strings, dates and times, numbers, and nodes [12].

Example XPath expressions for selecting certain elements from an HTML document are shown in Fig. 4.







Fig. 4. XPath expressions for selecting elements from an HTML document

### 3. Web parsing in programming

According to numerous scientific sources, one of the most popular and widely used programming languages for web scraping is Python. Since Python is a popular language, it means that there is a huge community that can lend a helping hand when an issue or problem arises. Also, many solutions to various problems in working with this language are available on the Internet. Python's accessibility and long-standing popularity have led to one of the largest and most diverse user communities among today's major programming languages. Many literary sources in the field of programming point out that Python is a fantastic choice for web scraping (or learning any programming skill, for that matter) because Python code is readable by people with little programming experience [9].

Existing approaches to implementing a web scraper can be structured into two main categories: general purpose programming language libraries and frameworks:

- Libraries;
- Frameworks.

One of the most common approaches used by computer scientists is to build their own web data scrapers using the programming language they are most familiar with. In this case, the scraper logic and the result are implemented as conventional software programs, i.e., using the control and data structures of the language. Typically, third-party libraries provide access to web sources by implementing the client side of the HTTP protocol, whereas the retrieved content is parsed using built-in string functions such as regular expression matching, tokenization, and slicing. Third-party packages can also provide for more sophisticated parsing, such as HTML tree building and XPath matching.

Using a general-purpose language to create web crawlers has some drawbacks. It is often necessary to integrate several libraries, one for web access and others for parsing and extracting content from HTML documents. In addition, web crawler implementations are known to be weak pieces of software that are significantly affected by changes in the HTML of accessible resources and therefore require continuous maintenance. In compiled languages such as Java, any change to the robot implementation requires recompilation and even redeployment of the entire application. Scraping frameworks represent a more integrative solution. For example, Scrapy is a powerful web scraping framework for Python, where crawlers are defined as classes inheriting from BaseSpider class, which defines a set of starting URL addresses and a parsing function called on each crawling process. Web pages are automatically parsed and web content is extracted using XPath expressions. Scraping frameworks provide a more integrative solution. There are frameworks that present domain-specific languages (DSLs), which are specific programming languages designed for a specific domain, and crawlers are treated as independent and external artifacts [1].

# 4. Conclusion

In conclusion, from the presented research of the possibilities for data parsing in webbased information systems, we can summarize the following notes:

- Analyzing and processing textual data from text requires its recognition and transformation. This process of recognition and transformation is called data parsing;
- The application of data parsing in the context of web-based information systems is called web parsing and is closely related to the process of fetching data from the web called web scrapping;
- There are different methods for web scrapping, such as traditional copy and paste, regular expression (Regex), hypertext markup language object model (HTML DOM), and XPath;
- One of the most popular and widely used programming languages for web scraping is Python;
- General programmatic ways to implement web scrapper are through program libraries and frameworks.

## References

 Asikri, M., Krit, S., Chaib, H., Using Web Scraping In A Knowledge Environment To Build Ontologies Using Python And Scrapy, European Journal of Molecular & Clinical Medicine, 2020, Volume 7, Issue 3, ISSN: 2515-8260

- Backurs, A., Indyk, P., Which Regular Expression Patterns Are Hard to Match, 2016 IEEE 57th Annual Symposium on Foundations of Computer Science, Volume 2016 – December, pp. 457–466, 2016
- 3. Britvin, A., Alrawashdeh, J., Tkachuck, R., Client-server system for parsing data from web pages, Advances in cyber-physical systems, Vol. 7, No. 1, 2022, ISSN: 2524-0382
- Darmawan, I., Maulana, M., Gunawan, R., Widiyasono, N., Evaluating Web Scraping Performance Using XPath, CSS Selector, Regular Expression, and HTML DOM With Multiprocessing Technical Applications, International Journal on Informatics Visualization, Vol 6, No 4, 2022, ISSN: 2549-9610
- Forta, B., Learning Regular Expressions 1st Edition, Addison-Wesley Professional, 2018, ISBN-10: 0134757068
- 6. Grasso, G., Furche, T., Schallhart, C., Effective Web Scraping with OXPath, https://www.researchgate.net/publication/262282162\_Effective\_web\_scraping\_with\_OXPath
- Gunawan, R., Rahmatulloh, A., Darmawan, I., Firdaus, F., Comparison of Web Scraping Techniques: Regular Expression, HTML DOM and Xpath, Atlantis Highlights in Engineering (AHE), volume 2, 2019, ISSN: 2589-4943
- Gupta, G., Chhabra, I., Optimized Template Detection and Extraction Algorithm for Web Scraping of Dynamic Web Pages, Global Journal of Pure and Applied Mathematics, Volume 13, Number 2, 2017, ISSN: 0973-1768
- Khder, M., Web Scraping or Web Crawling: State of Art, Techniques, Approaches and Application, International Journal of Advances in Soft Computing and its Applications, Vol. 13, No. 3, 2021, ISSN: 2074-8523
- Rahmatulloh, A., Gunawan, R., Web Scraping with HTML DOM Method for Data Collection of Scientific Articles from Google Scholar, Indonesian Journal of Information Systems (IJIS), Vol. 2, No. 2, February2020, ISSN: 2623-2308
- Uzun, E., Yerlİkaya, T., Kirat, O., Comparison Of Python Libraries Used For Web Data Extraction, Journal of the Technical University – Sofia Plovdiv branch, Bulgaria, Fundamental Sciences and Applications, Volume 24, 2018, ISSN: 1310-8271
- 12. Williams, I., Beginning XSLT and XPath, Wrox, 2009, ISBN-10-0470477253

# Trends in AI Models for Image Generation

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**Abstract**: This conference paper traces the captivating evolution of image generation models, taking the reader on a journey through the transformative progress from initial concepts of Autoencoders and Convolutional Neural Networks (CNNs) to the more recent innovations of Generative Adversarial Networks (GANs) and Diffusion models. We put into perspective how this relentless march of technology, characterized by breakthroughs and improvements, has given rise to groundbreaking models like Midjourney, DALL-E 2, and Stable Diffusion, which now define the contemporary paradigm of image generation. Providing a rich, historical backdrop, this work serves as a compass to navigate the current state-of-the-art, inviting readers to reflect on the implications and potentials for future explorations in this dynamic field.

**Keywords:** Image Generation, Autoencoders, Convolutional Neural Networks, Generative Adversarial Networks, Diffusion Models.

### 1. Introduction

The dawn of image-generation models signified a critical step forward in the pursuit of harnessing the creative potential of artificial intelligence. As these technologies advanced, they transformed from tools that could generate simple patterns into sophisticated platforms capable of producing intricate, photorealistic images. Initially, basic structures like Autoencoders and Convolutional Neural Networks (CNNs) paved the way, by automating repetitive tasks and recognizing complex patterns in visual data. Soon, Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) emerged, improving the quality of generated images and offering new ways to encode and decode visual information. Recently, Diffusion models have attracted attention for their ability to model the distribution of training data and generate novel images. Among these new-age solutions, Midjourney, DALL-E 2, and Stable Diffusion represent the most cutting-edge innovations, providing unprecedented capabilities in AI image generation. This paper aims to chart this exciting journey, outlining the evolution of image generation models and illustrating the transformative power of the most recent developments in this space.

#### 2. Background

The evolution of image generation methodologies has been a cumulative process, with distinct techniques building upon or complementing one another throughout the years. The following offers a chronological overview of these methodologies.

#### 2.1. Autoencoders

Originating in the late 1980s, autoencoders emerged as an unsupervised learning technique for neural networks (Hinton & Zemel, 1994). They consist of an encoder and a decoder. The encoder compresses the input data into a lower-dimensional representation or latent space, while the decoder reconstructs the input data from this latent representation

(Hinton & Salakhutdinov, 2006). The training objective is to minimize the difference between the input and reconstructed data, which is often measured by a loss function such as mean squared error. Applications of autoencoders have spanned various tasks, such as dimensionality reduction and image denoising.



Fig. 1. The Autoencoder system as defined by Hinton et al. (2006) - pretraining consists of learning a stack of restricted Boltzmann machines (RBMs), each having only one layer of feature detectors. The learned feature activations of one RBM are used as the "data" for training the next RBM in the stack. After the pretraining, the RBMs are "unrolled" to create a deep autoencoder, which is then fine-tuned using backpropagation of error derivatives [Hinton, G. E., & Salakhutdinov, R. R. (2006). Reducing the dimensionality of data with neural networks. Science, 313(5786), 504-507]

#### 2.2. Convolutional Neural Networks (CNNs)

Yann LeCun introduced CNNs in the late 1980s and early 1990s. While the development of CNNs drew upon earlier work on autoencoders and other neural network techniques, CNNs were specifically tailored to process grid-like data, including images (LeCun et al., 1998). As a result, CNNs have achieved exceptional success in image recognition tasks, forming the basis for numerous subsequent advancements in computer vision. The architecture of a CNN typically comprises multiple layers, including convolutional layers, pooling layers, and fully connected layers. Convolutional layers apply filters to the input data to learn local features while pooling layers aggregate these features to reduce the spatial dimensions of the data. The hierarchical learning process of CNNs enables them to

recognize increasingly complex features as they progress through the layers. Lower layers learn simple features such as edges and textures, while higher layers capture more complex and abstract concepts like object parts and entire objects. This multi-level representation allows CNNs to generalize effectively across diverse tasks and datasets, making them highly efficient for image recognition tasks, including object classification and detection (Krizhevsky et al., 2012; Girshick et al., 2014).

The creative potential of CNNs was exemplified in 2015 by the so-called "AI Dreams", a technique popularized by DeepMind. Researchers leveraged a trained CNN to generate images, rather than recognizing them, resulting in dream-like renditions that appear to contain objects and scenes from different categories (Mordvintsevet al., 2015). This technique, known as DeepDream, involves feeding an image through a trained CNN and modifying the input image to maximize the activation of specific neurons or layers. Consequently, the generated images exhibit hallucinatory patterns and textures reminiscent of the categories on which the CNN was trained.



Fig. 2. Neural net "dreams" — generated purely from random noise, using a network trained on places by MIT Computer Science and AI Laboratory. The process is started with random-noise image, so that the output becomes purely the result of the neural network.
[Mordvintsev, A., Olah, C., Tyka, M. (2015). Inceptionism: Going Deeper into Neural Networks. Google Research Blog, https://ai.googleblog.com/2015/06/inceptionism-going-deeper-into-neural.html]

#### 2.3. Variational Autoencoders (VAEs)

Kingma and Welling (2013) presented VAEs as an enhancement of traditional autoencoders by incorporating a probabilistic framework. This development allowed VAEs to learn a continuous latent space and generate new images by sampling from said space. They assume that the latent space follows a specific distribution, usually a Gaussian distribution. During the encoding process, VAEs learn the parameters of this distribution, and during the decoding process, they sample from this distribution to generate new data. The training objective is to maximize the evidence lower bound (ELBO), which consists of the reconstruction loss and a regularization term that encourages the latent space to follow the assumed distribution.

Despite their utility, autoencoders and VAEs have limitations that impact the quality of generated images. One of the main issues is that they often produce blurry images due to the pixel-wise reconstruction loss used in the training process (Larsen et al., 2015). This loss encourages the model to average over multiple possible outputs, resulting in a blurry reconstruction. Additionally, autoencoders and VAEs may not capture complex data distributions adequately, leading to suboptimal generated images.

#### 2.4. Generative Adversarial Networks (GANs)

As proposed by Goodfellowet al. (2014), Generative Adversarial Networks (GANs) are regarded as a significant breakthrough in image generation methodologies and have emerged as a powerful alternative to autoencoders and VAEs for image generation. GANs consist of a generator and a discriminator engaged in an adversarial game, wherein the generator strives to create realistic images and the discriminator attempts to discern between real and generated images. This adversarial process encourages the generator to produce increasingly realistic images.

Significant advancements have been made in the architectures, training stability, and conditional GANs. Novel architectures such as progressive GANs and StyleGAN have improved performance and stability, allowing for the generation of high-quality images with diverse styles and content (Karras et al., 2017; Karras et al., 2019). Improved training techniques, including spectral normalization and Wasserstein GANs, have addressed the challenges of mode collapse and convergence, resulting in more stable and consistent training (Miyato et al., 2018; Gulrajani et al., 2017).

Furthermore, conditional GANs have expanded the capabilities of GANs by enabling more targeted and controlled image generation. By conditioning the generated image on additional information, such as class labels or textual descriptions, these models can generate images with specific attributes (Mirza & Osindero, 2014). Domain adaptation techniques, such as CycleGAN, have found applications in style transfer and data augmentation by allowing for unpaired for that time image-to-image translation (Zhu et al., 2017).



Fig. 3. Examples of Image-to-Image Translation with Conditional Adversarial Networks developed by online community based on the pix2pix codebase: #edges2cats by Christopher Hesse,Sketch → Portrait by Mario Kingemann, "Do As I Do" pose transfer by Brannon Dorsey, Depth→ Streetview] by Jasper van Loenen, Background removal by Kaihu Chen, Palette generation by Jack Qiao, and Sketch→ Pokemon by Bertrand Gondouin. [Isola, P., Zhu, J. Y., Zhou, T., & Efros, A. A. (2017). Image-to-image translation with conditional adversarial networks. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 1125-1134).] GANs have found widespread use in various fields, including art, medical imaging, and level generation for video games (Isola et al., 2017; Zhu et al., 2017; Volz et al., 2018). In medical imaging, GANs have been used for tasks such as MR to CT synthesis and generating realistic X-ray images (Wolterink et al., 2017). Furthermore, GANs have been employed in the creation of AI-generated art, opening up new possibilities for artistic expression and collaboration between humans and machines (Elgammal et al., 2017).



Fig. 4. Level with increasing difficulty. The LVE approach (by Volz et al. (2018) can create levels composed of multiple parts that gradually increase in difficulty. In the future this approach could be used to create a level in real-time that is tailored to the particular skill of the player (dynamic difficulty adaptation). [Volz, V., Schrum, J., Liu, J., Lucas, S. M., Smith, A. D., & Risi, S. (2018). Evolving mario levels in the latent space of a deep convolutional generative adversarial network. In Proceedings of the Genetic and Evolutionary Computation Conference (pp. 221-228).]

#### 2.5. Diffusion models

Inspired by a concept in Non-Equilibrium Statistical Physics, and initially described in 2015 by Sohl-Dickstein et al. diffusion models have emerged as a promising alternative for image generation. They rely on the idea that a Markov chain can be used to progressively transform one distribution into another. The concept gained popularity in 2020 with the publication of "Denoising Diffusion Probabilistic Models" (DDPMs) by Ho et al. and comprises two counteracting processes: Forward and Reverse Diffusion.

During the Forward Diffusion Process, noise is incrementally introduced to the images in the training set, causing them to gradually depart from their current subspace. The objective of this process is to change the intricate and unfamiliar distribution of the training set into one that is more comprehensible and easier to sample from. As a result of the forward process, the images lose their recognizability, and the initial complex data distribution is entirely converted into a chosen simplistic distribution. Each image is subsequently located in a space beyond the data subspace.



Fig. 5. The directed graphical model considered in the work of Ho et al. (2020) [Ho, J., Chen, X., Srinivas, A., Duan, Y., & Abbeel, P. (2020). Denosing diffusion probabilistic models. arXiv preprint arXiv:2006.11239.]

In contrast, the Reverse Diffusion Process attempts to counteract the Forward Diffusion Process by repeatedly attempting to undo the image corruption. Where the forward process ends, this process begins, initiating from a simplistic space. The advantage of beginning in a simplistic space is the ease with which a point can be sampled from this distribution, with the end goal of returning to the data subspace. Only a small fraction of the infinite paths leading from a point in this simplistic space will lead back to the data subspace, which presents a challenge.

To address this issue, diffusion probabilistic models reference the minor iterative steps taken throughout the forward diffusion process. The probability density function (PDF) corresponding to the corrupted images during the forward process exhibits minor differences at each step. Thus, in the reverse process, a deep learning model is employed at every step to predict the PDF parameters related to the forward process. Following training, the model c an initiate from any point in the simplistic space and iteratively undertake steps that lead back to the data subspace. In reverse diffusion, denoising occurs iteratively in small increments, beginning with a noisy image.

Compared to Generative Adversarial Networks (GANs) and earlier techniques such as variational autoencoders (VAEs), this method of training and generating new samples has demonstrated increased stability and superior performance. Denoising Diffusion Probabilistic Models have formed the basis for state-of-the-art image generation systems, including DALL-E 2, Stable Diffusion, and Midjourney.

## 3. Recent Trends

Between 2022 and 2023, we observed a significant shift towards photorealism in generated images and their adoption in society. Popular models such as Midjourney, DALL-E 2, and Stable Diffusion use diffusion processes for image generation based on text descriptions, each with its own strengths and applications.

DALL-E 2, created by OpenAI, is the successor to DALL-E and is known for its ability to create realistic, high-resolution images. It combines concepts, attributes, and styles and has been trained on a vast dataset of 650 million image-text pairs. DALL-E 2 primarily consists of two parts: Prior (which converts user input into an image representation) and Decoder (which converts the representation into an actual image). It uses the CLIP network to learn the connection between visual and textual representations. DALL-E 2 is best suited for enterprise use due to its sophisticated image generation capabilities, especially when dealing with multiple characters. It has already been added by Microsoft to its Bing search engine where anyone can access and use it.

Stable Diffusion, released by StabilityAI, is trained on a subset of the LAION-5B database and uses a frozen CLIP ViT-L/14 text encoder for conditioning. The model is relatively lightweight and can run on GPUs with a few GB of VRAM. Stable Diffusion leverages the Latent Diffusion Model (LDM) and separates the imaging process into a diffusion process at runtime, starting with noise and gradually refining the image. The Stable Diffusion model is Open Source allowing everyone to use it if they can run it locally.

Midjourney, created by an independent research lab of the same name, is known for generating surrealistic images and is popular among artists. It is particularly adept at creating fantasy and sci-fi scenes with dramatic lighting. Relying on the ease of use and accessibility, Midjourney operates through a Discord bot, and the images it generated in its early versions tended to resemble paintings more than photographs. In the latest versions, Midjourney has made a lot of progress toward photorealism as described later in this paper.

This technology, however, still has certain limitations. Due to the stochastic nature of the process, the resulting image generated from a given prompt will never be precisely reproduced which limits its usability for uses expecting the recurrence of the same characters, like for example mascots or comic books. Furthermore, different models, developed by different people and trained on different datasets, will yield significantly dissimilar images despite being prompted with identical input.

Below is a showcase of the steps the Midjourney model goes through (Figures 6-13) to create a new concept of a logo.

### Image Generation Steps in Midjourney

**Prompt:** A modern and minimalist logo for a health and fitness brand. The logo should evoke feelings of energy, vitality, and transformation. Use a color palette consisting of vibrant shades of green, blue, and orange to represent health, growth, and energy. Incorporate a symbol that combines elements of both nutrition and exercise, such as a stylized leaf intertwined with a dumbbell or a silhouette of a person holding a plate of healthy food while performing a fitness pose. The font for the brand name should be clean, bold, and easy to read, complementing the chosen color palette and imagery. Aim for a unique and memorable design that sets the brand apart from competitors in the Bulgarian market.





## 4. Conclusions

In this conference paper, we have journeyed through the developmental narrative of image generation models. We traced the evolution from the seminal works of Autoencoders and Convolutional Neural Networks to the ground-breaking Generative Adversarial Networks and, more recently, Diffusion models. Arriving at our current vantage point, we have been introduced to the transformative capabilities of current leading models such as Midjourney, DALL-E 2, and Stable Diffusion.

These innovative models present us with a realm of potential previously unimagined. They extend far beyond just technological advancements, embodying the shared creativity, commitment, and innovation that persistently push the industry forward. Yet, with these remarkable developments comes the responsibility to thoroughly comprehend their implications.

With the growing capabilities of models like Midjourney, DALL-E 2, and Stable Diffusion, it is inherent that researchers and practitioners in this field understand their applications and the ethical dimensions they produce. This comprehension is crucial, not only to optimally leverage their potential but also to formulate the necessary ethical and regulatory guidelines that will ensure their responsible usage.

As we continue to learn, adapt, and innovate in this rapidly evolving field, let us remain mindful of the dual responsibility we carry - to advance and to safeguard. With this balanced approach, the future of image generation technology promises to be as exciting as it is challenging.

# References

- Elgammal, A., Liu, B., Elhoseiny, M., & Mazzone, M. (2017). CAN: Creative Adversarial Networks, Generating "Art" by Learning About Styles and Deviating from Style Norms. arXiv preprint arXiv:1706.07068.
- Girshick, R., Donahue, J., Darrell, T., & Malik, J. (2014). Rich feature hierarchies for accurate object detection and semantic segmentation. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2014), 580-587.
- Goodfellow, I., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., ... & Bengio, Y. (2014). Generative adversarial nets. In Advances in Neural Information Processing Systems (pp. 2672-2680).
- Gulrajani, I., Ahmed, F., Arjovsky, M., Dumoulin, V., & Courville, A. C. (2017). Improved training of Wasserstein GANs. In Advances in Neural Information Processing Systems (pp. 5767-5777).
- 5. Ho, J., Chen, X., Srinivas, A., Duan, Y., & Abbeel, P. (2020). Denosing diffusion probabilistic models. arXiv preprint arXiv:2006.11239.
- 6. Hinton, G. E., & Salakhutdinov, R. R. (2006). Reducing the dimensionality of data with neural networks. Science, 313(5786), 504-507.
- Hinton, G. E., & Zemel, R. S. (1994). Autoencoders, minimum description length, and Helmholtz free energy. In Advances in Neural Information Processing Systems (pp. 3-10).
- Isola, P., Zhu, J. Y., Zhou, T., & Efros, A. A. (2017). Image-to-image translation with conditional adversarial networks. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 1125-1134).
- 9. Karras, T., Aila, T., Laine, S., & Lehtinen, J. (2017). Progressive growing of GANs for improved quality, stability, and variation. In Proceedings of the International Conference on Learning Representations.
- Karras, T., Laine, S., & Aila, T. (2019). A style-based generator architecture for generative adversarial networks. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 4401-4410).
- 11. Kingma, D. P., & Welling, M. (2013). Auto-encoding variational Bayes. In Proceedings of the International Conference on Learning Representations.
- Krizhevsky, A., Sutskever, I., & Hinton, G. E. (2012). ImageNet Classification with Deep Convolutional Neural Networks. In Advances in Neural Information Processing Systems 25 (NIPS 2012).
- 13. Larsen, A. B. L., Sønderby, S. K., Larochelle, H., & Winther, O. (2015). Autoencoding beyond pixels using a learned similarity metric. arXiv preprint arXiv:1512.09300.
- LeCun, Y., Bottou, L., Bengio, Y., & Haffner, P. (1998). Gradient-based learning applied to document recognition. Proceedings of the IEEE, 86(11), 2278-2324.
- 15. Mirza, M., & Osindero, S. (2014). Conditional generative adversarial nets. arXiv preprint arXiv:1411.1784.
- 16. Miyato, T., Kataoka, T., Koyama, M., & Yoshida, Y. (2018). Spectral normalization for generative adversarial networks. In Proceedings of the International Conference on Learning Representations.
- Mordvintsev, A., Olah, C., & Tyka, M. (2015). Inceptionism: Going Deeper into Neural Networks. Google Research Blog. Retrieved from https://ai.google.blog.com/2015/06/inceptionism-going-deeper-into-neural.html
- Sohl-Dickstein, J., Weiss, E. A., Maheswaranathan, N., & Ganguli, S. (2015). Deep unsupervised learning using nonequilibrium thermodynamics. In International Conference on Machine Learning (pp. 2256-2265).

- 19. Volz, V., Schrum, J., Liu, J., Lucas, S. M., Smith, A. D., & Risi, S. (2018). Evolving mario levels in the latent space of a deep convolutional generative adversarial network. In Proceedings of the Genetic and Evolutionary Computation Conference (pp. 221-228).
- Wolterink, J. M., Dinkla, A. M., Savenije, M. H., Seevinck, P. R., van den Berg, C. A., & Išgum, I. (2017). Deep MR to CT synthesis using unpaired data. In International Workshop on Simulation and Synthesis in Medical Imaging (pp. 14-23).
- 21. Zhu, J. Y., Park, T., Isola, P., & Efros, A. A. (2017). Unpaired image-to-image translation using cycle-consistent adversarial networks. In Proceedings of the IEEE International Conference on Computer Vision (pp. 2223-2232).

# **Opportunities to Develop Digital Financial Services**

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Abstract. Creating new financial services is a complex and responsible task. Its good implementation can only be achieved with a very good knowledge of the stages in the implementation of new services. For these reasons, in the present study, efforts are concentrated in the direction of clarifying the individual phases and stages in the process of creating new financial services. In conclusion, the main achieved results are formulated.

Keywords: Financial services, Digital financial services, Software technologies.

### 1. Theoretical background

Modern societies invest a lot of effort, financial and human resources in creating and managing digital financial services. With the development of information technology, web applications and artificial intelligence, it is becoming easier to build a new type of payment instruments. There are several studies proving the strong relationship between citizens' attitudes towards online payments and the strong development of fintech solutions. They not only create a new kind of convenience for customers, but also improve financial literacy, increase the speed of exchange of funds and increase the efficiency of financial markets. Over the years, the European Commission has created mechanisms for the development of digital payments through various platforms and connecting services [1] (Fig. 1).



Fig. 1. Fintech mapping [1]

Companies from this type of industry are very diverse, both in terms of their activity and the offered portfolio of services.

# 2. Research methodology

Creating digital financial services is a difficult and responsible task. Its realization is possible only if a certain research methodology is observed and applied. Its application should be carried out at a certain stage (Fig. 2).



Fig. 2. Stages in the creation of new digital financial services

The proposed stages should be perceived in a broader sense of phases for the application of the methodology. They are:

- Analysis and planning of the creation of the new digital financial service;
- Designing the new digital financial service;
- Implementation and testing of the new digital financial service.

In the first phase, analysis, and planning of the creation of the new digital financial service should be carried out. Analysis covers all aspects of work and business processes, as well as creating a timeline for implementation. In the second phase, attention is paid to the creation of a complete project of the new service, including the design of the components for the technical implementation of the software solution. In the third phase, a full program implementation of the digital financial service is carried out, as part of an existing package of services or in an independent module. A very important issue in this phase is the testing of the developed service before it is officially presented on the service market.

# 3. Empirical study

As a member of the European Union, Greece has highly developed technologies for digital payments. Strongly positive trends are observed regarding the application and use of digital payments in various aspects of economic life in connection with the development of electronic government (Fig. 3).



Fig. 3. E-Government Services Portal in Greece [2]



Fig. 4. Trends in digital payments [3]

As can be seen from the presented Fig. 4, in Greece there is a positive upward trend in digital payments. Transaction growth in 2022 is seen to be around 50% higher than 2017.

Growth was also seen in mobile POS payments per user. This means that cashless payments are also becoming more widespread (Fig. 5).



Fig. 5 Transaction value [3]

The expansion of payments related to e-commerce, digital payments for various services, as well as virtual and physical POS payments also raises several questions for the protection of citizens' data.

## 4. Conclusions

At the conclusion of the conducted research related to digital financial services, the following results can be drawn:

- The development of socio-economic life necessitates the creation of new digital financial services;
- Modern digital services should meet all data security requirements.

### References

- 1. https://digital-finance-platform.ec.europa.eu/
- 2. https://www.gov.gr/en
- $3. \ https://www.statista.com/outlook/dmo/fintech/digital-payments/greece\# transaction-value$

# **Insider Threats - Problems and Solutions**

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**Abstract.** People, intentionally or unintentionally, affect cybersecurity. They can contribute to its maintenance and development, but very often they compromise it. Without pretending to be comprehensive, the paper sheds light on the role of people and in particular the employees' role in ensuring cybersecurity in the organizations and also as a source of threats. Some basic ideas about building and maintaining cybersecurity culture are presented.

Keywords: Cybersecurity, Human factor, Insider threats, Cybersecurity culture.

#### 1. Introduction

Despite the fact that cyberspace is mainly perceived as a set of different components, such as: hardware, software, data, nets and ongoing processes within the Internet, people present in this cyberspace and not only present but they play a significant role in it.

Human factor is crucial regarding cybersecurity. In a broadest sense, cybersecurity could be defined as a presence of threats to cyberspace and to its components in particular and the interaction between them, as well as a presence to threats to ongoing processes in this space. People could be a threat to cyberspace when they, intentionally or unintentionally, compromise its security with their behaviour. On the other hand, they could work consciously and purposefully to keep and raise the different dimensions of cybersecurity.

The purpose of this paper is to draw attention to the importance of the human factor regarding cybersecurity and especially cybersecurity at company level. The people are presented as a threat to the organization, where they work for. The motivation of the employees, so called ,,insider threats", who cause cybersecurity breaches, is clarified. The paper is also focused on some approaches and some measures, in the context of the corporate security management, which could be undertaken to reduce the insider threat risk, coming mainly from the staff. Development and maintaining an appropriate cybersecurity culture is among these main approaches.

The study presents results obtained from the author's research work, carried out within the framework of the National Science Program Defence and Security, funded by the Ministry of Education and Science.

### 2. "Insider threats" - characteristics and motivation

The people's role as a cybersecurity threat could be clarified in the best way at organizational level (of course, not only) and especially within a company level.

People, who by virtue of certain circumstances have legal access to internal organizational environments, could be insider threats. These are mainly different categories of employees, including former employees, as well as partners, clients etc. All of them are called "insider threats" or just "insiders". Persons, who do not have direct access to the organization, are external threats. They organize and conduct their attacks from outside.

Counteracting "insider threats" is rather difficult because they may remain unnoticed for years. It is not easy to distinguish the malicious actions from daily duties performance. This is especially true for IT specialists, though not only for them. The intentional malicious actions may be hidden [5].

The motivation of persons, who are part of a given organization or having access to it, the so-called "insider threats", can be: financial gain, unfair competition, revenge or moral reasons. In many cases, the motives can be combined.

Most often, obtaining some financial benefit is the leading motive for improper and even criminal behaviour of persons having access to the given business organization. For example, employees may steal and sell confidential information to interested parties. Such behaviour could be demonstrated by customers or partners as well, who have access to the internal environment of the organization.

Some employees of the organization could use their access to official information to gain benefits within an additional activity carried out by them in parallel with the performance of their official duties. In this case, they enter into unfair competition with their employer. A conflict of interest is also possible.

Some employees' behaviour, who feel that they are unfairly treated in certain ways by the organization or by specific individuals within it, mostly in leadership positions, could be driven by so-called ,revenge motive". For example, current or former employees, especially if they were fired or ,cut", or did not receive the desired promotion and salary increase.

Dissatisfied clients or partners could cause harm due to revenge. All of them, apart from aiming to get some satisfaction after causing damages, would try to get financial gain as well.

Moral motivations can also trigger actions directed against an organization's security and specifically its cyber security. They arise when the perceived values in the organization and corresponding organizational behaviour are in conflict with the understandings of an employee.

Employees' unintentional behaviour could also lead to negative consequences for the organizational interests. In general, the breaches can be caused by mistakes that are the result of: poor awareness of different categories of employees, low level of their training, poorly developed and even absence of cyber security culture, careless attitude or excessive conceit, including underestimating given circumstances or situations. In all these cases the employees are "insiders".

In the 2022 Cost of Insider Threats Global Report, developed by the Ponemon Institute, 5 signs are proposed regarding the employees' attitudes, preparation, awareness and behaviour in the organization that indicate that it is at risk and its security is likely to be compromised. These signs are:

- Employees are not trained to fully understand and apply laws, mandates, or regulatory requirements related to their work and that affects the organisation's security.
- Employees are unaware of the steps they should take at all times to ensure that the devices they use—both company issued and BYOD (Bring Your Own Devices)—are secured at all times.
- Employees are sending highly confidential data to an unsecured location in the cloud, exposing the organisation to risk.
- Employees break your organisation's security policies to simplify tasks.
- Employees expose your organisation to risk if they do not keep devices and services patched and upgraded to the latest versions at all times. [4]
# 3. Approaches and measures to reduce the "insider threat" risk

The researchers do not have a common opinion about the essence of the concept of "risk". One of the understandings is that "risk" can be presented as a situation of uncertainty, in which several or many consequences may occur and at least one of which is undesirable [3]. In this paper, the term "risk" means the probability of the occurrence of circumstances/events related to conscious or unconscious actions or inaction of employees or other persons, who have legal access to the organization, which have the potential to violate the state of cybersecurity and cause harm to the interests of this organization.

There are different approaches to ensuring cybersecurity [2]. One of the main approaches to ensuring cybersecurity and protection against ,insider threats" is related to building and maintaining an appropriate cybersecurity culture.

Cybersecurity culture is an aspect of security culture. In general, security culture can be defined as a set of ideas, customs and social behaviour of a people or a group of people that helps them to be free from threats and dangers [6].

It can be assumed that the security culture in the company is a way of thinking and perception on the part of its employees, based on their beliefs, values, principles, etc., on other persons' behaviour, on events or processes, part of the internal and external environment of the organization, which could be in favour or could hinder the achievement of its interests and appropriate reaction (behaviour) towards them.

Security managers have the main responsibility for planning and organizing the activities related to building and maintaining "a robust security culture" or " a strong security culture") and, in particular, a cybersecurity culture. They interact with managers engaged in other activities, e.g. human resource managers.

Cybersecurity culture development methods may be part of a cybersecurity culture building program as detailed in ENISA publications. They could be as follows:

- *Education and training* Education and training, unlike other methods, not only contribute to building and maintaining a cybersecurity culture based on security awareness. They are mostly related to acquiring a complex of knowledge and practical skills related to different aspects of cyber security, e.g. the management of cyber security, the economic aspects of cyber security, the various technical and technological solutions. Education and training could be in different forms and could have different durations. They can be conducted within the organization and can be led by its employees, representatives of other competent organizations or a team of internal and external trainers. It is not uncommon for the company's employees to participate in longer-term education for acquiring of educational and qualification degrees, based on specialized university curricula. Many organizations conduct cybersecurity training, and after their completion the trainees should mastered certain practical skills, which is certified by the acquiring of a certificate.
- *Briefings (instructions)* By its very nature, briefing is a method of building and maintaining a cybersecurity culture based on informing company's employees about existing risks and correct behaviour to avoid, eliminate or minimize them. The briefing, depending on the existing situation in and around the organization, as well as the specifics of its activity, can be initial, daily, periodic or in case of emergency.
- *Personal example* There is nothing more powerful than a personal example. A person tends to trust and follow more concrete behaviour and less only words that tell him/her what he/she should or shouldn't do. The example is even stronger when demonstrated by individuals occupying higher positions in the company hierarchy. Thus, managers have not only a formal, but also a moral right to require employees to comply with the

accepted security rules, which they apparently perceive as valid for everyone in the organization.

In the context of all this, it can be noted that security managers, incl. cybersecurity managers must think ahead, form values, set priorities, take initiative, take chances, act decisively, implement reforms, resolve crises, delegate rights, carry responsibilities, instil hope, inspire confidence, provide freedom, appreciate effort, respect opponents, motivate people, etc. [1].

- *Personal experience* Employees develop their security culture while doing their job. They find themselves in different situations, which later, if they analyse well, can be a corrective to their behaviour. In this case, the "trial-error" principle applies. It should be noted that this way of building a security culture, and in particular a cybersecurity culture, can be the most expensive as possible, since mistakes, which have to be corrected, can have very serious consequences for the company.
- *Punishments and incentives* Activities related to motivating staff within human resource management also contribute to building and maintaining a cybersecurity culture. Incentives to comply with security and safety rules, materially or morally, would further encourage employees to adhere to these rules. Penalties for underestimating and failing to comply with security and safety rules, in ceteris paribus, may force employees to be more responsible and strive to follow existing security regulations.

Apart from building and maintaining a strong security culture, where education and training play a crucial role, other approaches and specific measures can be applied to counter ,insider threats", which are mainly related to employees. In this regard, human resource management is extremely important. Everything starts with the right selection and appointment of motivated and competent staff. The fair criteria for promotion, fair assessment of working performance, as well as the regular salary update based on working performance will reduce the probability of employee dissatisfaction and will prevent the transformation of the loyal and motivated staff into "insider threat".

# 4. Conclusions

People spend more and more time in cyberspace. They work in it, study, inform themselves, have fun and communicate. Under these conditions, cybersecurity issues come to the fore with particular relevance and importance.

People, by their actions or inactions, intentionally or unintentionally, affect cybersecurity. They can contribute to its maintenance and development, but very often they compromise it.

Depending on whether they are part of the organization or outside of it, people, who intentionally (in the most cases) or unintentionally act against its security and cyber security in particular, can be seen as an internal, insider or external threat. The motivation for launching deliberate attacks by individuals inside or outside the organization can be different

The concept of security culture, and in particular cybersecurity culture, is fundamental to the concept of security at the organization level. It suggests that employees perceive security as important and demonstrate appropriate behaviour to avoid potential hazards and counter specific threats. A cybersecurity culture can be developed and maintained. It is a process that is part of security management in the organization.

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# References

- Dimitrov N. (2021) Managerial roles in ensuring security in corporations. Eighth chapter in Corporate security (Authors: Dimitrov D., Ivanov T., Tsvetkov Ts., Pavlov G., Pudin K., Dimitrov N., Tsenkov, Y., Bogomilova E., Gechkova T., Dimitrov, A., Ivanov N.), pp. 206-225, Publishin g complex-UNWE, Sofia (in Bulgarian).
- 2. Tagarev N. (2021) Contemporary approaches to cyber security management. Part I, Avangard Prima Publishing House, Sofia (in Bulgarian).
- Tsvetkov Ts., Y. Tsenkov (2021) Risk management in the corporation. Seventh Chapter in Corporate security (Authors: Dimitrov D., Ivanov T., Tsvetkov Ts., Pavlov G., Pudin K., Dimitrov N., Tsenkov, Y., Bogomilova E., Gechkova T., Dimitrov, A., Ivanov N.), pp. 179-205, Publishing complex-UNWE, Sofia (in Bulgarian).
- Ponemon Institute (2022) Cost of Insider Threats Global Report. Online, Available at: https://protectera.com.au/wp-content/uploads/2022/03/The-Cost-of-Insider-Threats-2022-Global-Report.pdf [Accessed: 12 December 2023]
- Poudin K. (2019) The Human Factor in Business Security. UNWE Yearbook, online, pp. 287-304, 2019. Available at: http://unwe-yearbook.org/en/journalissues/article/10171 [Accessed: 20 February 2024]
- Roer K. (2015) Build a Security Culture. [Online], Available at: https://news.asis.io/sites/default/files/Build% 20a% 20Secuirty% 20Culture% 20% 28Fundamentals% 20Series% 29% 20by% 20Kai% 20Roer.pdf [Accessed: 20 July 2018]

# Analysis of the Relationship between Climate Change and the Number and Intensity of Forest Fires – a Literature Review

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Abstract. This paper quantitatively examines the publications that can be found in the Scopus databases on the very current topic of the relationship between climate change and the number and intensity of forest fires. The authors see this report as a first step in a more complex literature review of the issue, based on a combination of analysis of additional quantitative indicators and an in-depth examination of the logic of a more limited number of publications. The paper presents a detailed problem analysis of the interrelationship between climate change and the number and intensity of forest fires, the research methodology is presented, and a search for literary sources on the subject in the Scopus databases is performed. The 7 361 results obtained were subjected to a systematic quantitative analysis, and the following indicators were examined: annual scientific production (articles in Scopus); average citations per year; a list of sources (journals that publish most actively in the selected research area); h index and g index of these journals; sources' production over time; authors who publish most actively in the chosen research area; impact strength of these authors, according to their h-index, g-index, m-index, and total citations; number of citations of publications in journals that publish most actively in the selected research area. An analysis of the results was made, and conclusions were formulated.

Keywords: Climate change, Forest fires, Publications, Literature review.

# 1. Introduction

This paper is the first step towards conducting a subsequent systematic in-depth study of the publications devoted to a significant research issue – the presence and significance of the interrelationship between climate change and the number and intensity of forest fires worldwide. The paper is in fulfillment of the objectives of the Scientific project "Intelligent risk management for business from adverse events and natural disasters", financed by the Scientific Research Fund, Ministry of Education and Science, under the Competition for Funding Fundamental Scientific Research - 2021.

The object of research is the publications on the selected research issue in one of the most popular worldwide databases with scientific publications – Scopus. The subject of research is the quantitative indicators that can be used to assess the strength and dynamics of the interest of researchers, scientific organizations, and scientific journals in the selected research issue. The research objective is to quantify the interest of researchers, scientific organisations, and scientific journals in the chosen research issue, and to identify the main authors and scientific journals that publish in this field. To achieve the objective, the following tasks were performed: 1. performing a problem analysis. 2. development of the methodological framework of the study. 3. selection of suitable sources of information and suitable software

for its processing. 4. collection and processing of information. 5. formulation of research conclusions.

## 2. Problem Statement

Forest fires have been a significant scourge for nature and humans for centuries. They have caused tremendous damage, destroying vast areas of forest, causing material damage, destroying human lives, and emitting large amounts of poisonous and greenhouse gases. Forest fires can be considered as one of the very high-priority disasters.

Much controversy has been going on worldwide in recent decades about the extent to which climate changes are due to human activity or non-human processes. In this paper, we will not focus on these discussions, but on publications about how climate change affects the number and intensity of forest fires globally.

Climate changes in recent decades are an indisputable fact. Numerous statistical observations prove this. Fig. 1 shows the dynamics of temperature anomalies. Even without more in-depth analysis, it is evident that since 1980 there has been a clear and steady trend towards an increase in temperature anomalies. It is logical to expect that the tendency towards an increase in temperatures will lead to changes in other phenomena on the planet. Fig. 2 presents the average monthly global sea ice extent for a period between 1980 and 2023.

There is a long-term trend of decreasing sea ice extent, which is particularly indicative of the year 2023.



Fig. 1. Annual anomalies in global land and ocean surface temperature from 1880 to 2022, based on temperature departure (in degrees Celsius) Source: National Oceanic and Atmospheric Administration, ncei.noaa.gov





Fig. 2. Average monthly global sea ice extent from January 1980 to June 2023 (in million square kilometers) [National Oceanic and Atmospheric Administration, ncei.noaa.gov]

On the other hand, statistical observations show a trend to increase the impact of disasters related to weather, climate, and water on the economies of countries around the world. Fig. 3 presents the dynamics of economic losses from these phenomena worldwide. Again, one can see the growth of this indicator for the period 1970-2019 without further analysis. Bulgarian authors consider that "the global temperature can be raised between  $1.8^{\circ}$ C and  $4^{\circ}$ C by 2100 and the temperature in Europe is expected to be even higher than the estimated global average" [7].



Fig. 3. Economic losses of weather, climate, and water-related disasters between 1970 and 2019 (in billion U.S. dollars) [World Meteorological Organization]

Wildfires have a strong negative impact on multiple systems. On the one hand, they cause significant injuries and, in certain cases, human casualties. On the other hand, economic damage is caused – the destruction of forest areas, crops, and property. On the third hand, fires affect the environment by emitting large amounts of greenhouse gases and, in many cases, other poisonous gases. Globally, the number and especially the intensity of forest and field fires is increasing over time. For the period 1983 – 2021, the areas destroyed by fires in the USA increased by an average of 4.6% per year (see Fig. 4).

Many authors believe that there is a direct causal relationship between climate change and the number and intensity of forest and field fires.



Fig. 4. Annual Acres Burned, 1983-2022 [National Interagency Fire Center, https://www.nifc.gov/fire-information/statistics/wildfires]

# 3. Research methodology

When researchers systematically undertake the study of a certain topic, their logical first step is to analyse in-depth the available scientific literature on the issues. Thus arose the first research question we asked ourselves: what are the characteristics of the publications on the issue of the relationship between climate change and the number and intensity of forest fires? At the same time, we also ask ourselves a series of other questions, such as: who are the authors actively working on the issue, how their publication activity on these problems develop over time, whether there is a collaboration between them, whether and to what extent they have built a research network or networks among themselves. We also ask ourselves other questions regarding the institutions in which the authors of these publications are engaged – who are the main research organisations working on these issues, and whether and to what extent there is an established research network between them.

The present research is carried out according to the following logic. An in-depth problem analysis is carried out first, which outlines the main issues regarding the need to establish the strength and nature of the relationship between global climate changes and the number and intensity of forest and field fires. Next, a search is made for literary sources published in authoritative world-renowned publications. The Scopus database was chosen for this purpose. The arguments for choosing this database are that it presents systematized and reliable publication information, the data can be downloaded without significant difficulty and is presented in a form that allows for a variety of analyses. Metadata on individual publications are presented in a sufficiently systematic way.

Next, a quantitative analysis of the identified literary sources was made, analyzing the publication activity in the selected scientific field, based on the number of literary sources published by year, as well as the number of citations of these sources over time. Specifically, the dynamics of the indicators: annual scientific production and average citations per year were analyzed. Next, the scientific sources in which the researched works were published were analyzed. These indicators were analyzed: most relevant sources, sources' local impact, and sources' production over time.

The research focuses on the analysis of the authors who publish in the chosen scientific field. Specifically, were analysed: most relevant authors, most locally cited authors, authors' production over time, and authors' local impact - h-index, g-index, m-index. Based on the analyses made, conclusions of the study were formulated.

# 4. Systematic analysis of publications on the relationship between climate change and forest fires

A Scopus search was performed using the following keywords: wildfires, forest fires, and climate change. The search results were analysed using the Bibliometrix [2] software running in the R environment. Further analyses were based on the results of the Bibliometrix treatments.

The search yielded 7 361 results, including 5 572 articles, 502 conference papers, 61 books, and 462 book chapters, and others. The number of published sources for the period 1952 - 2023 is presented in Fig. 5. One can see that since the beginning of the century, the number of publications on the subject on an annual basis has increased dramatically. This is clear evidence that the chosen topic is growing in popularity worldwide. The same conclusion can be drawn when analysing the indicator of average citations per year (Fig. 6).









Fig. 6. Average citations per year

The analysis continues with determining those journals that publish articles in the researched area. The statistical analysis shows that the researched scientific publications were published in total in 1 880 literary editions. The following journals publish most intensively in the researched area (Table 1.):

Table 1. List of journals that publish most actively in the field of the relationship between climate change and forest fires

Journal	Number of publications
Forest Ecology and Management	294
Environmental Research Letters	143
Global Change Biology	142
Science of The Total Environment	133
Forests	116
International Journal of Wildland Fire	107
Climatic Change	104
Ecosphere	100
Holocene	89
Ecological Applications	87

The impact of the journals ranks them in a slightly different way, compared to the ranking by the number of publications. According to their h-index and g-index, the top ten journals are ranked as follows (Table 2):

Journal	h_index	g_index
Forest Ecology and Management	65	138
Global Change Biology	59	113
Climatic Change	44	85
Proceedings of the National Academy of Sciences of the United States of America	42	61
Ecological Applications	41	83
Environmental Research Letters	38	66
International Journal of Wildland Fire	36	59
Ecology	34	46
Ecosphere	33	53
Plos One	33	58

Table 2. H\_index and g\_index of journals publishing most actively in the field of the relationship between climate change and forest fires

The dynamics of the production of the five most active journals for the last ten years are presented graphically in Fig. 7.



Fig. 7. First five sources' production over time

We focus on authors who are actively publishing in the research area. It is noteworthy that the average number of authors per document is 5.07. One can conclude that in the studied area there is a tendency for a large group of authors to develop a single publication. It is no

coincidence that the total number of authors is 23,115. According to the number of publications in the field, the authors are arranged as follows (Fig. 8.)



Fig. 8. Authors publishing most actively in the field of the relationship between climate change and forest fires sorted by the number of published articles

We analyse the impact of authors using the following indicators: h-index, g-index, mindex, and total citations. Information on these values for the ten authors with the highest impact is presented in Table 3. The articles with the highest citation level are presented in Table 4.

Author	h-index	g-index	m-index	total citations
Flannigan, Md.	35	49	1.061	6 744
Bergeron, Y.	30	62	0.909	4 002
Whitlock, C.	30	44	0.968	2916
Abatzoglou, Jt.	26	42	2	4 700
Mcguire, Ad.	25	28	1.042	3 005
Chapin, Iii Fs.	24	24	0.857	4 044
Fulé, Pz	24	42	1.091	1 892
Swetnam, Tw.	24	27	0.923	9 520
Tinner, W.	24	35	1.333	1 868
Veblen, Tt.	24	34	0.889	2978

 Table 3. The impact of the authors publishing most actively in the field of the relationship between climate change and forest fires

DOI	Total citations
10.1126/science.1244693	6964
10.1016/j.foreco.2009.09.001	5 1 5 1
10.1126/science.1128834	3 846
10.1007/s00442-004-1788-8	1 959
10.1016/j.foreco.2009.09.023	1615
10.1073/pnas.1607171113	1 443
10.1038/nature06777	1 406
10.1038/nature01131	1 365
10.1038/nclimate1693	1364
10.1038/nclimate3303	1338

 Table 4. Publications in the field of the relationship between climate change and forest fires with the highest number of citations

#### 5. Comments and conclusions

The analysed information gives grounds for the conclusion that the issue of the relationship between climate change and the characteristics of forest fires around the world is attracting the attention of researchers more and more. Searching for a combination of the keywords "forest fires", "wildfires", and "climate change" reached 7 361 results. We believe that this is a very large number of publications, which confirms the opinion of a large and growing interest in the topic. At the same time, one researcher can hardly cover all these publications in a limited time. This means that it is necessary to seek help from tools that support the analysis of large data sets.

At the end of the last century, from the late 1990s, the researchers' interest began to gradually increase, and from the beginning of the 21st century to the present, the interest has been increasing at a high rate. This conclusion is also confirmed by the increase in average citations per year, as well as by the large number of literary sources (1 880) and authors (23 115) who publish on this topic.

It is likely that the interest of researchers increases with the increase in indicators of the presence of climate changes such as annual anomalies in global land and ocean surface temperature, average monthly global seaice extent, and the size of economic losses of weather, climate, and water-related disasters.

The researched topic is interdisciplinary and multifaceted. In order to be able to create a quality scientific production, it is necessary for the authors to have knowledge in various scientific fields. Perhaps this is the explanation for the large average number of authors of one document -5.07.

Of course, the publication activity of individual authors, as well as their popularity, is different. A limited number of authors have multiple publications (30 - 90) and have achieved a very high number of citations (some over 9 000). At the same time, some of the authors have published one or two articles.

The publications also vary in their popularity and impact. Some articles have 3 000 to nearly 7 000 citations, while many articles have one to two citations or no citations at all by other authors.

# 6. Conclusion

Many authors have written about the relationship between climate change and forest fires, and interest in it is growing dramatically. The sheer number of publications on the subject does not allow them all to be examined equally thoroughly in order to reach a comprehensive picture of the state of research. It is necessary to use tools to analyse and summarise large amounts of information. A suitable tool for such analysis is software running in the R environment. There is a wide variety of such products in world practice. Biblioshiny and Bibliometrix are suitable software products for the analysis of publication activity on the selected topic. They enable the automation of the researcher's efforts by providing statistical and analytical information to publications indexed in Scopus and Web of Science. This quantitative analysis can be perceived as a first orienting step in the researched area. It should be followed by further steps towards going deeper, by analysing a limited number of publications and systematizing the ideas embedded in them.

# Acknowledgement

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# References

- Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam, Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity, SCIENCE, 18 Aug 2006, Vol 313, Issue 5789, pp. 940-943, DOI: 10.1126/science.1128834.
- Aria, M., C. Cuccurullo, Bibliometrix: An R-tool for comprehensive science mapping analysis, Journal of Informetrics, 2017,11(4), pp. 959-975.
- Craig, A. D., A. K. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, Th. Kitzberger, Andreas Rigling, David D. Breshears, E.H. (Ted) Hogg, Patrick Gonzalez, Rod Fensham, Zhen Zhang, Jorge Castro, Natalia Demidova, Jong-Hwan Lim, Gillian Allard, Steven W. Running, Akkin Semerci, Neil Cobb, A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests, Forest Ecology and Management, Volume 259, Issue 4, 5 February 2010, Pages 660-684, DOI: 10.1016/j.foreco.2009.09.001.
- Abatzoglou, J. T., A. Park Williams, Impact of anthropogenic climate change on wildfire across western US forests, PNAS (Proceedings of the National Academy of Sciences of the United States of America, October 10, 2016, 113 (42) 11770-11775, DOI: 10.1073/pnas.1607171113.
- Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend, High-Resolution Global Maps of 21st-Century Forest Cover Change, Science, 15 Nov 2013, Vol 342, Issue 6160, pp. 850-853, DOI: 10.1126/science.1244693.
- Lindner, M., M. Maroschek, S. Netherer, A. Kremer, A. Barbati, J. Garcia-Gonzalo, R. Seidl, S. Delzon, P. Corona, M. Kolström, M. J. Lexer, M. Marchetti, Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems, Forest Ecology and Management, Volume 259, Issue 4, 5 February 2010, Pages 698-709, DOI: 10.1007/s00442-004-1788-8.
- Zlateva P., N. Dimitrova, R. Shukerska, Weather Derivatives as Tools for Financial Management of Natural Disaster Risk. In: 19th International Multidisciplinary Scientific Geoconference, (SGEM 2019 – Albena), 30 June-6 July 2019, Albena, Bulgaria, vol. 19, issue 5.3, pp. 945-952, ISSN: 1314-2704, DOI: 10.5593/sgem2019/5.3/S21.119

#### Internet sources

- 1. National Interagency Fire Center, https://www.nifc.gov/fire-information/statistics/wildfires
- 2. National Oceanic and Atmospheric Administration, ncei.noaa.gov
- 3. World Meteorological Organization, https://public.wmo.int/en

# Development of the Network of Higher Education Institutions According to the Needs of the Regions

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**Abstract.** The article examines the problems of regional specialization of higher education institutions. It is based on the analysis of the National Map of Higher Education. Data analysis was done with an emphasis on the needs of the regions. Conclusions and recommendations are made.

Keywords: Data Analysis, Higher Education, education, Students.

## 1. Theoretical background and regulations

In 2020, the National Assembly of the Republic of Bulgaria adopted changes to the Law on Higher Education. This gives reasons with the decision of the Council of Ministers No. 538 of July 22, 2021 to adopt a National Map of Higher Education in the Republic of Bulgaria [1]. It is the main strategic document for the development of the network of higher education institutions.

The national map of higher education should be perceived as:

- Methodological basis for the development of the network of higher schools. This is done based on the demand for certain educational services; the students by regions; the need for trained regional specialists, etc.;
- Prerequisite for carrying out regional analyses, regarding: the realization of the students; the provision of educational services; the search by specialties, etc.;
- A document that provides forecasts for the demand for educational services and the development of the system of higher education institutions.

# 2. Regional specialization

The map provides opportunities for many interesting analyses. According to the data in it, the distribution of higher schools and affiliates by regions and as follows [1]:

- Southwestern region 27;
- South Central region 13;
- Southeast region -6;
- Northwest region 5;
- North Central region 7;
- Northeast region 8.

These data show that the distribution by regions is also unbalanced. The largest concentration is in the southwestern region, where the city of Sofia is located (Fig. 1). This distribution cannot show whether there are many or few higher education institutions in the Republic of Bulgaria. Each of them has a different number of students studying.



Fig. 1. Number of higher schools and affiliates

Analysis of the number of active students in 2021 shows that it is also very unbalanced:

- Southwestern region 102 945;
- South Central region 38 125;
- Southeast region 12 996;
- Northwest region 4 902;
- North Central region 27 071;
- Northeast region 30 331.

The graphical representation of the data is given in Fig. 2.



Fig. 2. Number of active students in 2021

# 3. Creation of national and regional policies

The development of the higher education system requires a careful analysis of data from various sources. They can be in two directions:

- Data from the National Map of Higher Education [1];
- Data from the National Statistical Institute [2].

Summary information on the development of the higher education system is presented in Fig. 3.



Fig. 3. Summary information [1]

In addition to the data from the national card for higher education, it is necessary to analyze data for:

- Changes in occupations on a national and global scale;
- Changes and forecasts for technological development;
- The demand for specialists on the labor market by region;
- Migration processes by region;
- Employment by regions;
- Incomes by regions, etc.

All these data can allow the creation of national and regional policies for the development of the network of higher education institutions. The creation of such policies should go through a certain sequence of stages. Each of them builds on the achievements of the previous one. In theory and practice, there is no unified opinion regarding the number and content of the stages. For these reasons, we propose the following sequence of stages and tasks (Fig. 4):



Fig. 4. Stages in the creation of national and regional policies

The starting point is related to defining the main parameters of the policy. At this stage, the main goal and sub-goals are defined. Key indicators of policy success are also defined. The following is the provision of the main sources of information for the relevant periods. This is a difficult process because in most cases it is necessary to use data from different sources. The next stage is an analysis of the data from the provided sources. The relevant methodology and toolset should be applied here. The results of the performed analyzes allow determining the specific characteristics of the policy. The last stage is the implementation of the policy. This is related to the implementation of specific actions to achieve the initially set indicators.

# 4. Conclusions

The analyzes and studies made give grounds for the following conclusions:

- The national card for higher education should be interpreted on a case-by-case basis;
- Creating a comprehensive policy mandates the use of data from as many sources as possible;
- It is necessary to constantly take into account the many external factors, such as unemployment, migration, etc.;
- The national card for higher education can be a limiter for the creation of new technological directions related to an innovative and green economy.

# References

- 1. National map of higher education in the Republic of Bulgaria, https://web.mon.bg/bg/101031
- 2. Internet site of the National Statistical Institute, https://www.nsi.bg/bg.

# Opportunities to Improve the Graduate School Application Process

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**Abstract.** The article examines the issues of applying to higher education institutions. An attempt has been made to provide a comprehensive description of the application process. On this basis, process modeling is carried out. Corresponding proposals for improvements in individual elements are also made, the study concludes with conclusions and recommendations.

Keywords: Application process, Modeling processes, Students.

### 1. Theoretical issues of application process modeling

Process modeling is a difficult and responsible task. It is associated with very good knowledge of the subject area. This also includes knowledge of the legal basis that regulates the activity. A mandatory condition for process modeling is to use a corresponding software tool. In the specific case, it was chosen to model the application process in the higher school in a broad plan. This does not include the particularities of individual types of candidates – bachelors, masters and doctorates. The general process is presented, with the modeling done with Power Designer.

The process always begins with the young person's desire to apply to higher education. His first action is to find out about the educational services offered by different types of organizations. This usually happens based on information from the university's website, social network profiles, career fairs, etc.

A final decision on the application follows. It is usually based on the correspondence between the wishes and expectations of the applicants and the educational programs offered. In the event that the application decision is positive, the application documents must be filled out. In them, the candidate describes his personal data, education acquired to date, desired specialties, etc. The next step is to pay an application fee. This action is usually done by bank transfer, through various payment methods. The fee is administrative and includes the administrative costs of the graduate school in the application process.

One of the very important actions carried out in recent years is the verification of the candidate's diploma. This is done thanks to the automatically provided interface by the Ministry of Education and Science [1]. Through a specific API, the higher education institution receives from the Ministry's register the original data on the applicant's grades [2].

After the verification of the diploma grades, the process continues with the ranking of the candidates. In most universities, this process takes place in several stages, known as: first ranking, second ranking, third ranking, etc. The next steps in the process are to enroll as a student and submit data about the enrolled students to the records of the National Information and Documentation Center. This register maintains information on all current and suspended students in the Republic of Bulgaria (Fig. 1).

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Fig. 1. Application process

This process is an example to demonstrate the capabilities of process modeling and analysis. In each specific case, a different software tool can be used for the graphical representation of the process.

# 2. Improving the graduate school application process

Opportunities to optimize and improve the process should increase its efficiency. For these reasons, bottlenecks in the process should be analyzed. Their improvement provides opportunities for general improvement of the entire process (Fig. 2).

The specific proposals for improving the process are in the following directions:

- Electronic application and submission of documents;
- Payment of the application fee electronically;
- Automated verification of applicant grades;
- Ranking of candidates, through specialized software.

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Fig. 2. Application process with suggestions for improvement

Digitizing these processes is a difficult task. Solving it requires preliminary preparation. In addition, it is necessary to select an appropriate software development environment for the application. Its choice is also important in terms of information security. For these reasons, we propose that the digitization of document reception go through the following stages (Fig. 3):

- Preparation of digitalization
- Choice of technological environment;
- Development of the software system;
- Testing and deployment;
- Implementation analysis.

The beginning of the process is related to preparatory activities. These include preparing the project schedule, budget, selecting a team, creating a communication plan, etc.

Next is the choice of technological environment for the development of the application. At this stage, requirements for the development environment should always be defined.

The possibilities of creating a mobile application should be explored. Need to do security analysis etc. The next stage is the actual development of the application software platform. When this activity is completed, it is necessary to perform system testing. Implementation for real use should always allow usability analysis to be performed as well.



Fig. 3. Stages of digitization of the application

One of the most important issues in this life cycle is usability evaluation. In this regard, it is appropriate to develop a model of key indicators. Thus, through their implementation, the general use of the created system can be evaluated. This also provides opportunities for setting future project goals, improvement and development.

# 3. Conclusions

The analyzes and studies made give grounds for the following conclusions:

- Process modeling is only possible with a very good knowledge of the subject area;
- Any particular process modeling is related to the choice of software tool for analysis;
- The life cycle of any university application digitization project involves a series of stages;
- Very important for process modeling is the creation of a relevant indicator framework.

# References

- 1. Internet site of the Ministry of Education and Science, https://www.mon.bg/
- 2. Internet site of the University of National and World Economy, https://www.unwe.bg/

# Analysis of Representing Excel Formulas in SQL Server Database

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Abstract. In today's world, various companies and institutions often store valuable information in Excel workbooks. The amount of data and logic in these files inevitably increases. Managing the information becomes increasingly challenging, and companies are forced to consider moving the data and logic from Excel to an information system. Consequently, a software architect of such an information system is faced with the challenge not only of how to store data but also of how to transfer and implement the logic from Excel logic in a database, such as an SQL server. The study outlines directions for future research.

Keywords: Excel formulas, Data storage, SQL server.

## 1. Introduction

In modern organizations, where data is crucial for making strategic decisions, the integration between different systems and platforms is vital. One of the challenges that enterprises face is the analysis and transfer of formulas and data from one of the primary spreadsheet platforms like Microsoft Excel to a powerful SQL Server database.

This report focuses on studying approaches and challenges in analyzing and

representing Excel formulas in an SQL Server database. We will explore various strategies for migrating logic from Excel formulas to SQL Server stored procedures and functions, emphasizing their advantages and challenges.

Through its analysis, the report will examine how different aspects such as syntax, error handling, and query optimization play a crucial role in the successful integration between these two environments. Additionally, we will investigate ways to effectively manage metadata and the complex logic often present in Excel formulas during their transfer to SQL Server. A proposed metadata model can also be used to assist in risk management from adverse events and natural disasters for the business.

With this report, we aim to provide an overview of existing approaches, challenges, and practical solutions in the analysis and migration of Excel formulas to SQL Server, emphasizing the importance of flexibility and effective data management throughout the process.

# 2. Existing Approaches for Presenting Excel Data and Logic in SQL Server Database

Representing Excel data and logic in an SQL Server database can be done in various ways, depending on the specific requirements and characteristics of the business. There are several approaches for migrating the data itself; some of them include:

✓ Data Import/Export: Utilizing a SQL Server data import tool (e.g., SQL Server Import and Export Wizard) to transfer data from Excel files or CSV to SQL Server tables.

✓ Linked Servers: Creating linked servers in SQL Server pointing to Excel files. Using OPENQUERY or OPENROWSET to extract data from Excel files and virtually represent them as tables.

 $\checkmark$  SQL Server Integration Services (SSIS) or other ETL tools: Creating SSIS packages to automate the transfer of data from Excel to SQL Server. Employing Data Flow tasks for transforming and transferring data.

✓ Using Queries from Excel to SQL Server: Leveraging Excel's functionality to directly extract data from the SQL Server database. Establishing a connection to the database and using Power Query or other query tools.

✓ Scheduled Refresh: Directing to Excel files stored in cloud services (e.g., OneDrive, SharePoint, etc.) that support automatic data refreshing. Using SQL Server Agent for regular data updates in the SQL Server database.

These approaches can be combined based on the specific business requirements and architectural preferences. It is important to note that businesses should consider potential risks and aspects during data migration and management. A thorough investigation and analysis of Excel formulas should be conducted in advance to determine their structure and functionality.

Planning steps for transferring logic to T-SQL should prioritize efficiency and readability. When transferring logic from Excel formulas to functions or stored procedures in SQL Server, it is often advisable to break down large and complex formulas into smaller parts and transfer them gradually.

# 3. Challenges and Limitations in Representing Excel Formulas in SQL Server Databases.

The representation of Excel formulas in a SQL Server database involves storing the formula logic and dynamically recalculating values when needed. SQL Server is primarily designed for storing and manipulating structured data, but it is possible to represent and work with Excel formulas in a database with certain considerations.

Integrating Excel formulas into a SQL Server database may encounter various challenges and limitations. Here are some of them:

# 3.1. Differences in Functionality Between Excel and SQL Server

Excel offers various functions and formulas that can be complex to convert or implement in SQL Server. Some functions may have different implementations or may not exist. The differences in functionality between Microsoft Excel and SQL Server are due to their distinct purposes and architectural approaches. [1],[2]

Some of the main differences include:

✓ Data Usage and Processing:

Excel is primarily designed for individual users and small to medium-sized offices. It mainly works with structured data in tables and supports a wide range of formulas for calculations and data manipulations. SQL Server, as a relational database, is designed for storing, managing, and extracting large volumes of data. It serves a large number of users in a corporate environment, providing powerful relational data processing and using SQL for various data operations.

✓ Data Storage:

In Excel, data is stored in files that can be easily shared and modified, suitable for small to medium data volumes.

In SQL Server, data is stored in a centralized database with support for multiple tables and relationships, suitable for large data volumes and complex structures.

Transaction Support:

Excel does not offer built-in transaction support, which can be a problem in scenarios where data consistency is required. In contrast, SQL Server supports transactions, addressing this issue.

✓ Server-Side Operations:

In Excel, calculations and data processing occur locally on the user's computer.

In SQL Server, server-side operations are performed, potentially leading to more efficient management of large volumes of data by the server.

There are additional significant functional differences between Excel and SQL Server, including differences in data security, access management, optimization processes, indexing, and more.

The integration between Excel and SQL Server requires careful management of these functional and architectural differences. This process necessitates thorough planning, documentation, and optimization to achieve successful integration of data and formulas into SQL Server. [3]

# **3.2. Expression of Complex Formulas**

Expressing some complex Excel formulas in Transact-SQL, especially those that involve built-in functions, conditional operators, and loops, can be a challenge for interpretation in Transact-SQL. On the other hand, many formulas such as VLOOKUP, IF, SUMIF, AVERAGEIF can be achieved with different analogous SQL operations using appropriate constructs like JOIN, CASE WHEN, GROUP BY, SUM with a WHERE clause, AVERAGE with a WHERE clause, etc., to achieve the desired results.

# 3.3. Calculations at Different Levels of Detail

Excel formulas can be configured to calculate values at different levels of detail, while in a SQL Server database, operations typically occur at the level of rows and columns. This can pose a challenge when transferring calculation logic. Dealing with this challenge can be achieved through the use of:

✓ Aggregation in SQL Server:

Utilizing aggregate functions such as SUM, AVG, COUNT, etc., in SQL Server to calculate summarized values by groups. This is accomplished through the GROUP BY operator in SQL Server.

✓ Using Nested Queries:

In SQL Server, nested subqueries can be employed to calculate values at a higher level based on the results of subqueries at a more detailed level.

✓ Common Table Expressions (CTE):

Employing CTE in SQL Server to create temporary tables that can be used for calculations at different levels of detail.

✓ PIVOT and UNPIVOT:

Using data transformation functions to pivot data and transform it at various levels in SQL Server.

# 3.4. Error handling

SQL Server can handle errors and deviations from the standards differently than what is typical in Excel. Issues such as error control, handling of zero values, and data type management require attention during integration.

Typically, Excel formulas return an error value (such as #DIV/0! or #VALUE!) when dividing by zero or encountering other errors. Functions like IFERROR can be used to control errors and provide alternative values. In SQL Server, constructs like TRY...CATCH blocks can be used for error handling, providing alternative values or logic to address the error. [4]

Data types in Excel can be automatically determined based on the format and structure of the data. Errors indata types are often managed with automatic conversions. In SQL Server, data types must be explicitly defined when creating tables. Type correspondences should be considered, and in case of deviation, CAST or CONVERT can be used for explicit conversion.

# 3.5. Computation Speed and Optimization

Differences between Excel and SQL Server can result in varied query and computation behaviors. Query optimization and the use of indexes are crucial aspects when integrating complex formulas.

There are various techniques for optimizing SQL queries, including indexing, precomputed columns, utilizing Query Execution Plans, indexed views, result caching, and many others. [5]

# 3.6. Metadata Complexity

Managing metadata related to formulas and data connections between Excel and SQL Server can pose a significant challenge. For successful integration, it is crucial to maintain upto-date documentation and ensure a clear definition for each formula and integration element.

Addressing these challenges requires careful planning, logic adaptation, and the incorporation of best practices in data and database management. Metadata management is a key element of the integration process. Through clear documentation and active version control, it can be ensured that formulas and connections are easy to maintain and understand, easing the transition between Excel and SQL Server.

# 4. Conclusion

In summary, representing Excel formulas in a SQL Server database involves storing the formula logic as text and dynamically recalculating values using SQL queries or defined user functions. While a similar solution can be developed, achieving a complete reproduction of Excel's functionality and user experience, especially with complex formulas and functions, may not be straightforward. Careful consideration of requirements and compromises is crucial before implementing such a solution.

# Acknowledgement

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# References

- 1. Nevarez B., Microsoft Sql Server 2014 Query Tuning & Optimization 1st Edition, McGraw-Hill Education, 2014
- 2. Radoev M., Savremenni tendentsii v razvitiyeto na bazite ot danni, https://www.unwe.bg/doi/alternativi/2021.1/ISA.2021.1.01.pdf
- 3. Milev P., Opportunities for Presentation of Tag Cloud in Public Information Systems, 9th International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE-2019), October 24-26th, 2019, UNWE, Sofia, Bulgaria.
- 4. Tsaneva M., "Applicability of ASP.Net Frameworks for Developing Web-based Business Information Systems, 11th International Conference on Application of Information and Communication Technology and Statistics in Economy and Education (ICAICTSEE-2021), November 25-26th, 2021, UNWE, Sofia, Bulgaria.
- 5. Gordon S. Linoff, Data Analysis Using SQL and Excel, John Wiley & Sons, 2015

# Challenges in Using the Methods of Bifurcation and Stability Analisis to Study Nonlinear Economic Models

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**Abstract.** An analysis of the mathematical methods: Lyapunov's theory of stability and theory of bifurcations, as well as their possibility to be applied in the study of economic models, has been made. Mathematical examples are given that explain how to apply these methods. The possibility of their use in system-critical phenomena has been analyzed.

Keywords: Dynamical systems, Stability theory, Bifurcation theory.

## 1. Introduction

The use of mathematics for modeling economic processes is widely advocated in optimization tasks, tasks related to determining the economic equilibrium, etc. Due to the influence of many factors, some of them with probabilistic changes, the behavior of the economic system, considered as a dynamic system is difficult to analyze. Here we will focus on mathematical methods studying the stability of the attractor's equilibrium state and methods studying bifurcations - that is, a qualitative change in the behavior of the system.

Bifurcation theory has an important place in the study of critical modes of the system. The study of critical phenomena leading to disasters and accidents, not only in an economic aspect, poses several heterogeneous mathematical tasks in system analysis:

1. To determine the critical parameters of the system at which there will be a departure from the equilibrium state or a qualitative change in the behavior of the system.

2. In the event of unfavorable conditions, to minimize the risk of catastrophic consequences.

3. In the event of a disaster, minimize the negative consequences for the system if it still exists.

In the present work, an overview of the mathematical methods that respond to the first of the set problems is made. Mathematical theories have been examined, which enable, on the one hand, to assess the stability of the equilibrium states of the system, and on the other hand, to assess at what critical values of the parameters catastrophic consequences may occur.

# 2. Basic definitions and Lyapunov function

We will briefly review the theory of resilience, following the work [1].

Let the function  $V(x_1, ..., x_n)$  be continuous, in some domain D, including the origin of the coordinate system, and have continuous partial derivatives.

We say that the function  $V(x_1, ..., x_n)$  is positive definite if it is V > 0 for the entire domain except for the coordinate origin V(0, ..., 0) = 0. Analogously, a negative definite function V < 0 is defined in the entire domain, except for V(0, ..., 0) = 0. Such functions are said to be signed.

We say that the function is constant in sign  $V \ge 0$  sign positive,  $V \le 0$  sign negative.

Let the system of differential equations be given:

$$\dot{y}_{1} = Y_{1}(y_{1}, \dots, y_{n}, t),$$
  
$$\vdots \\ \dot{y}_{n} = Y_{n}(y_{1}, \dots, y_{n}, t).$$
(1)

We will call a certain solution of the system undisturbed by subjecting its stability to investigation. Let such a solution be:

$$y_i = f_i(t), i = 1..n.$$

Let the unperturbed solution satisfy the initial conditions:

$$y_{i0} = f_i(t_0), i = 1..n.$$

We define the norm of  $Y = (y_1, ..., y_n)$  as follows:

$$||Y(t)|| = \sqrt{\sum_{i=1}^{n} [y_i(t)]^2}.$$

Since we will consider a system describing the movement of physical objects, the solutions of the equations will be called motion.

Let's write the undisturbed motion in the form  $F = (f_1(t), ..., f_n(t))$  and take another solution of the same system:  $Y = (y_1, ..., y_n)$ . Unperturbed motion is called stable in the sense of Lyapunov, if for every  $\varepsilon > 0$ , there exists  $\delta > 0$  such that from  $||Y(t_0) - F(t_0)|| < \delta$ , follows  $||Y(t) - F(t)|| < \varepsilon$ .

An undisturbed motion is called asymptotically stable in the Lyapunov sense if it is stable and there exists a positive number h such that for  $||Y(t_0) - F(t_0)|| < h$  it follows

$$\lim_{t \to \infty} \|Y(t) - F(t)\| = 0.$$

Usually, the deviation from the unperturbed solution is examined:

$$X(t) = Y(t) - F(t), X = (x_1, \dots, x_n).$$

Let the equations of deviation from undisturbed motion have the form:

$$\dot{x}_1 = X_1(x_1, \dots, x_n),$$
  
 $\vdots$   
 $\dot{x}_n = X_n(x_1, \dots, x_n).$ 

These equations are called differential equations of perturbed motion.

Theorem: (of Lyapunov on the stability of the solution) If for the differential equations of the perturbed motion, a sign-definite function V can be found, the derivative of which  $\dot{V}$ , by virtue of these equations is a constant sign function with the opposite sign of V, or is identically equal to zero, then the undisturbed motion is stable.

If for the differential equations of the perturbed motion, one can find a signed function V, the derivative of which  $\dot{V}$ , by virtue of these equations is a signed function with the opposite sign of V, then the unperturbed motion is asymptotically stable.

Theorem: (of Chetaev on instability of motion) If for the differential equations of perturbed motion, a function V can be found for which, in an arbitrarily small neighborhood of zero, there exists a region in which V is positive and the derivative  $\dot{V}$  of V, in power of

these equations, is a positive sign function for the points of the domain in which V is positive, then the undisturbed motion is unstable.

An example. The solution  $x_1 = x_2 = 0$  of the perturbed system:

$$\dot{x_1} = x_2 + \alpha x_1$$

$$\dot{x_2} = -x_1 + \alpha x_2 \qquad \alpha \neq 0,$$

is asymptotically stable for  $\alpha < 0$  and unstable for  $\alpha > 0$ .

We take the Lyapunov function:

$$V = \frac{1}{2}(x_2^2 + x_1^2).$$

The function V is signed.

The time derivative of this function is:

$$\dot{V} = x_1 \dot{x_1} + x_2 \dot{x_2} = \alpha (x_2^2 + x_1^2).$$

From here it can be seen that the derivative of the Lyapunov function is sign-definite with the opposite sign V of for  $\alpha < 0$ . From the Lyapunov theorem it follows  $\alpha < 0$  that the solution is asymptotically stable. It follows  $\alpha > 0$  that the solution is unstable.

#### 3. Stability to a first approximation

Often the stability of the system can be judged after performing linearization. Let the equations of the perturbed motion be given in the form:

$$\begin{aligned} \dot{x}_1 &= a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + X_1, \\ \dot{x}_2 &= a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + X_2, \\ \dot{x}_3 &= a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + X_3. \end{aligned}$$
(2)

The terms  $X_i$  i = 1,2,3 are non-linear.

Let us consider only the linear part of the system. We are looking for a solution in the form:  $x_i = A_i e^{\lambda t}$ , where  $A_i$  and  $\lambda$  are constant numbers. Substituting into the system yields:

$$(a_{11} - \lambda)A_1 + a_{12}A_2 + a_{13}A_3 = 0,a_{21}A_1 + (a_{22} - \lambda)A_2 + a_{23}A_3 = 0,a_{31}A_1 + a_{32}A_2 + (a_{33} - \lambda)A_3 = 0.$$
 (3)

The determinant of this homogeneous system must be equal to zero:

$$\begin{vmatrix} a_{11} - \lambda & a_{12} & a_{13} \\ a_{21} & a_{22} - \lambda & a_{23} \\ a_{31} & a_{32} & a_{33} - \lambda \end{vmatrix} = 0.$$
(4)

Let us assume that there are two complex conjugate roots and one real:

$$\lambda_1 = \nu_1 + i\mu_1, \lambda_2 = \overline{\lambda}_1 = \nu_1 - i\mu_1, \lambda_3, \nu_1, \mu_1 \in \mathbb{R}.$$

A non-singular linear transformation can be found:

$$z_{k} = \sum_{j=1}^{3} \alpha_{kj} x_{j}, k = 1, 2, 3, \alpha_{kj} = const;$$
(5)

which will bring the system of differential equations into the form:

$$\dot{z}_k = \lambda_k z_k, k = 1,2,3. \tag{6}$$

For a linear system that has no multiple roots, it follows from the above system that the following propositions hold. An undisturbed motion is asymptotically stable if all real parts of the characteristic equation are negative. If at least one of the roots of the characteristic equation has a positive real part, then the undisturbed motion is unstable.

If  $v_1 = 0$  and  $\lambda_3 < 0$  then the undisturbed motion is stable, but not asymptotically stable.

Theorem. (of Lyapunov for stability of the motion to the first approximation) If the real parts of the characteristic equation for the first approximation are negative, then the undisturbed motion is asymptotically stable, regardless of the terms higher than the first order.

Theorem. (of Lyapunov for first approximation instability). If even one positive real part can be found among the roots of the characteristic equation, then the undisturbed motion is unstable, regardless of terms higher than the first order.

To determine the signs of the real parts, of the solutions, of the characteristic equation, the Hurwitz criterion is used. Let us have a characteristic equation of the form:

$$a_0\lambda^n + a_1\lambda^{n-1} + \dots + a_{n-1}\lambda + a_n = 0.$$

We form a matrix of the form:

1	$a_1$	$a_3$	$a_5$	$a_7$	 0 \
[	$a_0$	$a_2$	$a_4$	$a_6$	 0
1	0	$a_1$	$a_3$	$a_5$	 0
	0	$a_0$	$a_2$	$a_4$	 0
					 ]
/	0	0	0	0	 $a_n/$

Theorem: (of Hurwitz). For the roots of the algebraic equation with  $a_0 > 0$  to have a negative real part, it is necessary and sufficient that all major diagonal minors of the matrix are positive

$$\Delta_1 = a_1 > 0, \Delta_2 = \begin{vmatrix} a_1 & a_3 \\ a_0 & a_2 \end{vmatrix} > 0, \dots, \Delta_n = a_n \Delta_{n-1} > 0.$$

#### 4. Bifurcations of dynamical systems

The theory of bifurcations of dynamical systems describes the qualitative, jump-like changes of the phase portraits of the differential equations, with a continuous, smooth change of the parameters.

Two systems of first-order differential equations are said to be qualitatively equivalent if there exists a continuous reciprocal and one-to-one transformation that transforms the phase portrait of one system into the phase portrait of the other system.

An important role in the theory of bifurcations is played by the theorem on implicit functions.

Let the equation be given:

$$\dot{x} = F(x, \lambda) \tag{7}$$

where  $\lambda$  is a parameter.

Let us, following Malinetsky [2], assume that equation (7) generates only solutions that  $t \rightarrow \infty$  tend to a constant value. Moreover, for these decisions, the following is fulfilled:

$$F(x,\lambda)=0.$$

Let's assume that we know such a solution  $(x_0, \lambda_0)$ . To find a solution close to the solution we know, we decompose the function in Taylor series:

$$F(x_0 + \Delta x, \lambda_0 + \Delta \lambda) = F(x_0, \lambda_0) + \frac{\partial}{\partial \lambda} F(x_0, \lambda_0) \Delta \lambda + \frac{\partial}{\partial x} F(x_0, \lambda_0) \Delta x + \frac{1}{2} \left[ \frac{\partial^2}{\partial \lambda^2} F(x_0, \lambda_0) (\Delta \lambda)^2 + \frac{\partial^2}{\partial x^2} F(x_0, \lambda_0) (\Delta x)^2 + 2 \frac{\partial^2}{\partial \lambda \partial x} F(x_0, \lambda_0) \Delta \lambda \Delta x \right] + R$$
(8)

It can be seen from the formula (8) that the new state of the system can be uniquely

determined at  $\frac{\partial}{\partial x}F(x_0,\lambda_0) \neq 0$ . When  $\frac{\partial}{\partial x}F(x_0,\lambda_0) = 0$ , the following addends must be taken into account and then the formula is obtained:

$$\Delta x = \pm \sqrt{-2\Delta\lambda}, \frac{\partial^2}{\partial x^2} F(x_0, \lambda_0) \neq 0.$$
(9)

Two solutions appear at  $\lambda > \lambda_0$ , and no solution exists at  $\lambda < \lambda_0$  - provided that

$$\frac{\frac{\partial}{\partial\lambda}F(x_0\lambda_0)\Delta\lambda}{\frac{\partial^2}{\partialx^2}F(x_0\lambda_0)} < 0 \tag{10}$$

The point  $(x_0, \lambda_0)$  where it  $\frac{\partial}{\partial \lambda} F(x_0, \lambda_0)$  changes sign is called a regular extremal point. The existence of solutions in a neighborhood of a regular extremal point is guaranteed by the implicit function theorem.

When

$$\frac{\partial}{\partial\lambda}F(x_0,\lambda_0) = \frac{\partial}{\partial x}F(x_0,\lambda_0) = 0, \qquad (11)$$

such points satisfying (11) are called singular points.

A double point of a curve  $F(x, \lambda) = 0$  is a special point through which two and only two branches of the curve having different tangents pass. At such a point, not all second derivatives simultaneously zero. A particular extreme point of the curve  $F(x, \lambda) = 0$  is a double point where  $\frac{\partial}{\partial \lambda} F$  it changes sign on one branch.

Conjugate point – it is an isolated point solution of  $F(x, \lambda) = 0$ .

For double points, the equation is valid:

$$\frac{\partial^2}{\partial \lambda^2} F(x_0, \lambda_0) (\Delta \lambda)^2 + \frac{\partial^2}{\partial x^2} F(x_0, \lambda_0) (\Delta x)^2 + 2 \frac{\partial^2}{\partial \lambda \partial x} F(x_0, \lambda_0) \Delta \lambda \Delta x = 0$$
(12)

The solution of an equation depends on the value of

$$D = \left[\frac{\partial^2}{\partial \lambda \partial x} F(x_0, \lambda_0)\right]^2 - \frac{\partial^2}{\partial x^2} F(x_0, \lambda_0) \frac{\partial^2}{\partial \lambda^2} F(x_0, \lambda_0)$$
(13)

At D < 0 there exists a conjugate point, at D > 0 exists a double point. If D = 0, then the higher order terms must be analyzed.

A large part of the studied systems have an equilibrium state of the limit cycle type.

We may consider:  $q = (q_1, q_2, ..., q_n)$ .

We follow Aerosmith and Place [3].

A closed trajectory  $\Gamma$  of the phase portrait is called a limit cycle if it is isolated from all other closed trajectories, i.e. if there exists a tubular neighborhood of  $\Gamma$  containing no other closed trajectories.

An example: The system:

$$\begin{aligned} \dot{q}_1 &= -q_2 \omega + q_1 \left[ \gamma - \sqrt{q_1^2 + q_2^2} \right]', \\ \dot{q}_2 &= q_1 \omega + q_2 \left[ \gamma - \sqrt{q_1^2 + q_2^2} \right]'. \end{aligned} \tag{14}$$

has a limit cycle with equation:

$$q_1^2 + q_2^2 = \gamma^2$$
.

Indeed, let us put:

$$q_1 = rcos\theta, q_2 = rsin\theta,$$

then the system (14) takes the form:

$$\dot{r} = r(\gamma - r), \dot{\theta} = \omega,$$

where  $\gamma$  and  $\omega$  are constants. From here it is clear that  $\gamma = r$  they set a closed trajectory. At that  $\gamma > r > 0$  follows  $\dot{r} > 0$  that the trajectory also develops in a spiral, and at  $\gamma < r$  follows  $\dot{r} < 0$  that the trajectory turns.

Theorem: (Hopf Bifurcation): Let the system with parameter:

$$\dot{x}_1 = X_1(x_1, x_2, \mu), \dot{x}_2 = X_2(x_1, x_2, \mu).$$
(15)

has a stationary point at the origin for all values of the real parameter  $\mu$ . Furthermore, let us assume that the eigenvalues of the linearized system  $\lambda_1(\mu)$  and  $\lambda_2(\mu)$  are imaginary at  $\mu = \mu_0$ . If the condition  $\frac{\partial}{\partial \mu} Re\lambda_1(\mu_0) > 0$  is satisfied for the real parts of the eigenvalues the coordinate origin is an asymptotically stable singular point at  $\mu_0$ , then

1.  $\mu_0$  a bifurcation point for the system appears;

2. there exists an interval  $(\mu_1, \mu_0)$  such that a stable focus appears  $\mu \epsilon(\mu_1, \mu_0)$  at the coordinate origin;

3. there exists an interval  $(\mu_0, \mu_2)$ , such that, at  $\mu \epsilon(\mu_0, \mu_2)$  the coordinate origin, is an unstable focus surrounded by a limit cycle, the size of which grows as  $\mu$ .

An example: The parameter system  $\mu$ :

$$\dot{q}_1 = q_2 - q_1^{3},$$
  
 $\dot{q}_2 = \mu q_2 - q_1 - q_2^{3}.$  (16)

undergoes a Hopf bifurcation at the origin.

The linearized system has the form:

$$\dot{q}_1 = q_2, \, \dot{q}_2 = \mu q_2 - q_1. \tag{17}$$

The eigenvalues are:

$$\lambda_{1,2} = \frac{\mu \pm \sqrt{\mu^2 - 4}}{2}$$

At  $\mu = 0$  are imaginary, moreover:

$$\frac{\partial}{\partial \mu} Re\lambda_1(\mu_0) = \frac{1}{2}.$$

At = 0, the system has a Lyapunov function:

$$W = -(q_1^4 + q_2^4) \tag{18}$$

Since both functions are sign-defined with a different sign, it follows from the Lyapunov theorem that the coordinate origin is asymptotically stable at  $\mu = 0$ . In agreement with the conditions of Hopf's theorem, it follows that the system undergoes a Hopf bifurcation at the origin at  $\mu = 0$ .

# 5. Conclusion

Mathematical methods make it possible to solve various thematic problems related to economic processes as well as the occurrence of disasters, accidents and catastrophes in them. The development of the digital technique and its application to similar tasks containing a large number of parameters and variables leads to a quick and easy achievement of the required goal. Often, the precise analysis with the methods of mathematics can reduce the damage even in the case of catastrophic phenomena that have already occurred, namely by optimizing the actions and measures counteracting unfavorable development [4]. The mathematical apparatus on which all this is based has been developed, but its application to the various models simulating the system is challenging and requires a multidisciplinary approach.

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# References

- 1. Merkin D.R. Introduction to the theory of motion stability. Moscow, "Science" 1987. (In Russian).
- 2. Malinetsky, G. G. Mathematical foundations of synergetics. Moscow. URSS, 2011. (In Russian).
- 3. Arrowsmith, D, Place, K. Ordinary differential equations. Chapman and Hall, 1982.
- 4. Pontryagin, L., Boltyansky, V., Gamkrelidze, R., Mishchenko, E. Mathematical theory of optimal processes. Moscow, "Science", 1969. (In Russian).

# Practical Application of Software in Revenue, Cost and Cash Flow Analysis in Real-Estate Companies

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Abstract. The report provides an overview of real estate companies and presents the basic value parameters and levels in these companies. The practical analysis of said parameters and values can be made promptly and efficiently by using the respective software. It is necessary that real estate companies have such software to allow teams to conduct the financial management of such companies relatively quickly while establishing precisely the different values of the basic value parameters and value levels, respectively, namely 'financial result from sales' and 'financial result of the company', as well as gaining a general approximation for the other two value levels - company liquidity and solvency. The report is based on the applicable accounting legislation in Bulgaria while also taking into account certain theoretical premises. Therefore, it has considerable practical implications.

**Keywords:** Real estate companies; Software; revenue; Cost; Financial result liquidity; Solvency.

### 1. Introduction

Real estate companies are companies whose main profit is generated directly from activities related to real estate. In other words, the relative share of such revenue usually accounts for the majority of the total revenue. These companies may have different legal forms, such as a joint-stock company, a limited liability company, etc. As regards their activity, they may be real estate agencies, facility companies, property companies, special purpose investment vehicles, or companies directly involved in activities related to real estate construction or improvement of acquired real estate (a special purpose investment vehicle may not conduct the above activities), companies providing services relating to the maintenance and exploitation of real estate, specialized construction companies, or companies involved in real estate evaluation, etc.

It is advisable that real estate companies use a software programme to monitor their basic value parameters and levels. It serves as a good basis for taking any decisions whose aim is to guarantee the successful operation of the companies. The report looks into the different ways in which the parameters and levels can be operated using the respective software.

### 2. Basic value parameters and levels in real estate companies

Similarly, to any other company, real estate companies generate profit and expenses, as well as cash inflows and outflows. Certain revenues and costs constitute basic value parameters for the company which correspond to certain value levels. More specifically, sales revenues and total costs correspond in terms of value levels to 'financial result from sales', while company revenues (total) and expenses (total) correspond in term of value levels to 'financial result of the company'. Cash in-flows and cash outflows are also basic value

parameters which correspond to certain value levels, namely 'company liquidity' and 'company solvency'. The main value parameters and levels of a company are shown in the diagram below (Fig. 1):



Fig. 1. Main value parameters and levels in real estate companies

Note: The value parameters and levels above are applicable not only for real estate companies, but for other companies in the real sector of the economy (production, trade, and services, such as repair, transport, etc.). Current revenues and expenses are taken into account.

Sales revenues generated by real estate companies are revenues from the sale of services, revenues from the sale of products, revenues from the sale of goods, revenues from rental agreements, land lease agreements, lease agreements, and real estate management agreements (in essence, these are revenues from services such as renting out real estate under rental, land lease or lease agreements or from management agreements). Revenues from sale of services are, for example, generated by real estate agencies, facility and property companies, as well as by companies providing services related to the maintenance and exploitation of real estate owned by special purpose investment vehicles and companies involved in real estate evaluation. Revenues from the sale of production are generated by construction companies, which also generate revenues from services (for instance, from works such as laying the foundations of a building). Special purpose investment vehicles which have acquired real estate property typically generate income by virtue of rental agreements and agreements for land lease, lease, or real estate management. It is also possible that real estate agencies may acquire real estate property which is then resold, in which case they do not generate revenue from the sale of goods. This may also be the case with special purpose investment vehicles which have acquired real estate property (there are special purpose investment vehicles investing in receivables).

Total expenses relating to the sale of services for the respective period of time include the cost value of the services sold during said period, all administrative expenses incurred by the company during the period, and any expenses directly associated with the sales. Total expenses relating to the sale of production for the respective period of time include the cost value of the production sold during said period, all administrative expenses incurred by the company during the period, and any expenses directly associated with the sales. It is not impossible for the total expenses to include another type of valuation of the production sold, i.e., a value other than the cost value.

Total expenses relating to the sale of goods for the respective period of time include the book value of the goods sold during the period, the administrative expenses for the period, as well as all expenses incurred by the respective agency or special purpose investment vehicle associated with the sales.

The financial result from the sales (of services, production, or goods), which is the difference between the respective sales revenues and the respective total expenses, can be either positive, i.e., Sales profit, or negative, i.e., sales loss. It can also equal zero. The same can be said about the financial result from transactions with real estate (rent, land lease, lease or real estate management agreements) conducted by special purpose investment vehicles.

The financial result of the company is the difference between the sum of company revenues and company expenses. It can be either a profit, a loss, or a zero. Profit in this case constitutes income for the owners of the company, which they can allocate in different ways. Profit is the source of dividends for the owners. Therefore, the profit is a collective income, i.e., income for all owners, while dividends constitute individual income.

The ability of a company to settle in a timely manner any current expenses constitute its liquidity. Liquidity is the value level which corresponds to receipts and payments. It should be noted that when determining a company's ability to settle its current expenses, it is important to consider not only receipts and payments during the current period, but also the cash amounts owned by the company as of the end of the previous period.

The solvency of a company is its ability to settle its expenses in the long term (long-term expenses), i.e., expenses which are due in more than 12 months after 31st December of the previous year.

Thus, as of 31 December 2021, current expenses are expenses which are reflected in the ac-counting balance as of 31 December 2021 and which are due by 31 December 2022. Long-term expenses are expenses which are reflected in the balance sheet as of 31 December 2021 and which are due in 2023. In the context of this example, when considering the settlement of long-term expenses, it is important to take into account receipts and payments in 2023, as well as all cash amounts which the company has at its disposal as of the end of the year 2022.

# **3.** Time of realization of revenues and receipts and time of realization of expenses and payments

In short, current revenues are an increase in the capital of the company, while current expenses are a decrease in capital. That is different from receipts and payments. When there are receipts, it means that the company receives assets such as cash, while a payment means that assets, such as cash amounts, are leaving the company. That is at least the general case (although specific cases exist). Later, we will look into the most common situations when a company generates revenue from sales, expenses for the creation and realization of production or services (and expenses relating to the trade of goods), cash inflows and cash outflows in relation to the revenues and expenses specified above.

The following situations are possible with respect to current revenues and receipts:
Current revenues are income which can have impact on the financial result of the company for the current year.

It is possible for the moment of realization of a current revenue to coincide with the moment of realization of the receipt, which is a form of revenue. For example, the company may conduct a sale and receive the respective cash amount.

It is also possible for the moment of realization of a current revenue to happen before the moment of realization of the receipt, which is a form of revenue. For example, the company may conduct a sale, but may not receive the respective cash amount because the sales agreement states that the amount is to be received after six months. In this case, after the sale, the company reports current revenues, as well as receivables from clients - such receivables are a form of current revenue. After six months the receivables are transformed into cash amounts, i.e. The company realizes receipt.

Another possibility is for the moment of realization of a current revenue to happen after the moment of realization of the receipt. For instance, the company may receive money, which it reports as cash received, as well as revenue for future periods, which has no impact on the financial result for the current period. This is a period which is not current but is related to a future period or periods. In the following period or periods, the revenue is transformed into current revenue. In other words, the moment of realization of the current revenue happens after the moment of realization of the receipt. In the following period or periods, the current revenue will have impact on the financial result of the company.

The above can be summarized as seen in the following diagram (Fig.2):



Fig. 2. Moments of current revenues from sales and associated receipts

The following situations are possible with respect to current expenses and payments:

CURRENT EXPENSES

Current expenses are expenses which can have impact on the financial result of the company for the current year.

It is possible for the moment of realization of a current expense to coincide with the moment of realization of the payment, which is a form of expense. For example, the company receives materials on a certain date and on the same date the materials are used for conducting the main activity of the company (industrial activities). On the same date, the company also pays the supplier. In this case, it can be assumed that the two moments coincide - the moment of realization of a current expense and the moment of payment.

It is also possible for the moment of realization of a current expense to happen before the moment of realization of the payment. For example, the company receives materials on a certain date and on the same date the materials are used for conducting the main activity of the company. According to the sales agreement, the payment will be made in six months. In this case, the current expense is realized before the respective payment.

It is also possible for the moment of realization of a current expense to happen after the moment of realization of the payment. For instance, the company may realize a payment during the cur-rent period by reporting it as an expense for a future period or periods. This expense has no impact on the financial result for the current period, and it impacts the financial result for the respective future period or periods. This is an expense which is realized now but is related to a future period or periods. In the following period or periods, the expense is transformed into current expense. In other words, the moment of realization of the current expense happens after the moment of realization of the payment. In the following period or period or periods, the current expense happens after the moment of the payment. In the following period or period or periods.

The above can be summarized as follows (Fig. 3):



Fig. 3. Moments of current expenses for the creation or realization of production or services, current expenses relating to trade with goods, and associated payments.

Knowledge of the moments mentioned above is particularly important in view of the fact that revenues and expenses realized during a certain period can have impact on the financial result of the company during the same period (with the exception of expenses for future periods), which is of particular interest to owners. On the other hand, receipts and payments are directly related to company liquidity and also to its solvency. In case of inability to settle liabilities on time, the company will face future problems.

## 4. Software as a tool for quick analysis to enable decisions with regard to the basic value parameters and levels in real estate companies

The software which the company possesses allows the company to determine operationally revenues from sales and total expenses (for example, by month). On this basis, it can monitor monthly financial results from sales. If the trend is a negative one, meaning there is decrease in revenues from sales and in financial results from sales, then the experts in charge of the financial management of the company need to inform its management and work, in coordination with the experts from the marketing department of the company, on measures to turn the negative trend. For example, it is possible to have approximately the same sales revenues for January, February and March, while also having approximately the same monthly financial results from sales for the months of April, May and June; at the same time, there may be a decreasing trend over the following three months, i.e., monthly sale revenues and monthly financial results from sales for the months of April, May and June may be on the decrease. In such situations, certain measures need to be taken, respectively.

It is also possible to establish another negative trend - an increase in the amount of total expenses with no change in the level of sales revenues, where the financial result from sales decreases. Such situations require searching for opportunities to counter the negative trend. For example, a company may have approximately equal sales revenues for the months of January, February and March, with approximately equal amounts of total expenses, and register a trend towards increase in total expenses over the following three months, while sales revenues remain approximately the same as the ones from the first quarter of the year. Financial results from the sales will drop respectively for the months of April, May, and June. In this case, the company would need to take certain measures.

Any decrease in the financial results from sales has a negative impact resulting in decrease in the financial result of the company as it is determined by the financial result from sales and other amounts. It can also be noted here that the software allows for quickly determining not only the trends specified above, but also any trends in terms of sales revenues, total expenses and financial results from sales compared to the same months from previous years or by year. In this way, the company can monitor, for example, sales revenues, total expenses, and financial results from sales for March 2022 relative to March 2021, March 2020, etc. On this basis, the financial experts in the company can draw conclusions and potentially make recommendations to the company management. In addition, it would be possible to compare sales revenues, total expenses and financial results from sales and financial results from sales in 2022 to those in 2021, 2020, etc. and take the measures mentioned above.

Cash inflows (receipts) can be quickly determined using the respective software, similarly to cash amounts available as of a certain date. This can serve as basis for determining company liquidity. For instance, if on 25 March the company needs to settle a debt of the amount of 80,000 BGN and has 50,000 BGN available as of 10 March, there may be several courses of action. One option is for the company to realize the respective sales by 25 March and receive, for example, 40,000 BGN, in which case it would be able to settle its liability of 80,000 BGN. Expectations may be, however, to receive 10,000 BGN from sales by 25 March, in which case the company will not be able to settle its debt of the amount of 80,000 BGN. Therefore, the company would need to consider negotiating with its creditor to postpone the payment of the entire amount of 80,000 BGN or pay 60,000 BGN and de-fer the remaining 20,000 BGN for a future period. Another possible course of action would be for the company to draw a loan from a commercial bank in the period between 10 March and 25 March, which would allow it to settle its debt of 80,000 BGN. Other options for the timely settlement of the liability may be present as well. Receipt of cash amounts after 10 March, regardless of the reason, can be monitored using the respective software and it can be determined that the company would have, as of 25 March, the necessary funds to cover its liability. It can also be determined what cash amounts will remain after the settlement of the liability for the company to operate in the future. These funds should be sufficient to guarantee, together with future receipts after 25 March, the normal operation of the company.

By using the respective software, the company can enter data about amounts payable after 25 March and the due dates for the respective payments. That allows for an estimation of the funds the company would be required to have as of said dates. The software also allows the company to monitor future receipts and analyses, respectively, what opportunities the company has for the timely settlement of its liabilities. If it is determined that it would not be

possible to settle certain liabilities in full on their respective due dates, the company would need to seek opportunities to redeem the situation. Several such options were already mentioned above.

## 5. Conclusion

Good knowledge of the value parameters and levels presented above, combined with the use of a respective software, is an opportunity for real estate companies to realize the expected financial results and also maintain liquidity and solvency. Company liquidity and solvency are prerequisites for achieving financial stability of the companies (other conditions are also present). The software allows for promptly determining trends with respect to revenues, expenses, financial results, company liquidity and company solvency for real estate businesses. On such basis, companies can take the necessary measures and steer the company into a more favorable direction, causing a positive impact on value parameters and levels.

## References

- 1. Ivanova, R. Analysis of the financial status of the enterprise, Ed. complex -UNSS, 2015
- Dimitrova. R., Iv. Daneva, E. Kalchev, Cv. Marinova, Kr. Kostenarov, R.Dimitrova, I. Nikolova, N. Kanaryan, N. Nenkova. Introduction to Finance, New Bulgarian University, 2019
- Milanova, E., D. Petrova, M. Nachkova, R. Ivanova, L. Todorov. Financial and accounting management, Ed. complex - UNSS, 2018
- 4. Brealey. R., St. Myers, Al. Marcus, Fundamentals of Corporate Finance, Tenth edition, McGraw-Hill Education, 2020
- 5. Mondello. E., Corporate Finance: Theorie und Anwendungsbeispiele, Springer Gabler, 2022
- 6. Watson, D., A. Head, Corporate Finance: Principles and Practice, Eight edition, PLS, 2019
- 7. Hillier, D., St. Ross, R. Westerfield, J. Jaffe, Br. Jordan, Corporate Finance, 4. Edition, McGraw-Hill Education Ltd, 2020
- 8. Asquith, P., L. Weiss, Lessons in Corporate Finance: A Case Studies Approach to Financial Tools, Financial Policies, and Valuation, 2. Edition, John Wiley & Sons, Inc., 2019
- 9. Berk, J., P. Demarzo, Corporate Finance: The Core, 5. Edition, Pearson PLC, 2022
- 10. Welch, I., Corporate Finance, 5. Edition, IAW, 2022
- 11. Ross, St., R. Westerfield, J. Jaffe, B. Jordan, Corporate Finance, 13th edition, McGraw-Hill Education; 2022.