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FOREWORD

Ladies and gentlemen, you are receiving the proceedings of the traditional international conference IT for Practice 2021 (IT4P2021), which was organized as the 24th year. Due to the pandemic situation in the Czech Republic, the conference was organized on an unconventional date on November 18-19, 2021 with direct participation of speakers and audience. I would like to thank all the participants of the conference, who after a long time had the opportunity to listen directly interesting contributions and make new contacts.

The conference was organized by the auspices of EUNIS-CZ (Association of European University Information Systems of the Czech Republic), ČSSI (Czech Society for System Integration), CIT (Center for Information Technologies VŠB-Technical University of Ostrava) and IT Cluster z.s. Our conference has a long tradition and is appreciated within the European Union for its content focused on the practical use of information technology. The organizers are trying to register this conference in recognized databases.

According to the title of the conference, the participants come from academic staff, managers and employees of ICI, IS designers in companies and institutions, ICT providers and students. The programme areas of the 24th conference is based on the current needs and problems aimed at the successful digitalisation of our entire society, such as:

- Information Society and Education;
- Information Management and Innovation;
- Information Security;
- Digitalization of Public Administration

The purpose of the organizers is to create a platform for the exchange of knowledge and skills in the field of ICT innovation and the use of new knowledge in practice, as it is not easy to attract professionals willing to share their experiences.

Thanks also to all sponsors who contributed to the financial support of the conference.

We wish you successful use of the professional contacts and information you obtained at the conference in solving specific problems in your companies and institutions.

On behalf of the organizers

Ing Jan Ministr, Ph.D.
President of Czech Society for System Integration

C O N T E N T S

INFORMATION SOCIETY AND EDUCATION

The AI-solutions in Intelligent Organizations - Study of the Polish SMEs

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Abstract. Solutions Digital technologies are transforming operations, products and services in organisations large and small. Solutions of the Information and Communication Technology (ICT) are the foundation of modern economic organizations in a time of digital transformation. This article is aimed at describing the role of the AI and SMAC solutions in intelligent organizations. The arguments are illustrated with the results of own research conducted by the author in 2019-2020 in selected SMEs from the Polish Wielkopolska Province and their reference to the general development trends in this area.

Keywords: AI, Digital transformation, Intelligent organization, ICT, Knowledge management, SMAC.

1 Introduction

The expansion of Industry 4.0 through the Industrial Internet of Things (IIoT) and Edge Computing focuses on improving industrial and manufacturing operations by collecting and analyzing data from a wide range of sensors on production lines. This information enables factories to generate and implement valuable efficiency enhancements. Typically, data generated by IIoT sensors transmits via a gateway to centralized cloud applications such as a manufacturing execution system (MES), enterprise resources planning (ERP), and a wide range of other line-of-business and operational software. Distributing all that data, modeling it, and then running analytics requires a lot of computing power in a centralized system.

Establishing an artificial intelligence (AI) strategy before first testing the organization's readiness to adopt AI solutions is like establishing a battle strategy without knowing if troops have been trained and prepared (unknown skills), without any intelligence regarding the enemy movements and capabilities (unknown data), zero knowledge about the weapon systems at your disposal (unknown technology), and no understanding of the objectives (unknown goals). The practical introduction of AI-solutions within an organization of any size can be achieved through five steps:

- use cases — build a portfolio of impactful, measurable and quickly solvable use cases,
- skills - assemble a set of talents pertinent to the use cases to be solved,
- data - gather the appropriate data relevant to the selected use cases,
- technology - select the AI solutions linked to the use cases, the skills and the data,
- organization — structure the expertise and accumulated AI know-how.

This five-step formula is a tactical approach to the introduction of AI techniques, favoring a quick time-to-value perspective. It is not a strategic, longer-term outlook, which can be developed once the organization has established its current strengths and weaknesses, culturally and technologically, in terms of leveraging those techniques.

This article is aimed at presenting the latest condition of digitalization and development tendencies in supporting the intelligent organizations with AI (Artificial Intelligence) and SMAC solutions (Social, Mobility, Analytics, and Cloud), which is a sine qua non condition of enterprises from this sector to operate in a modern way and to take part in the process of digital transformation. ICT implementation in every organization depends on numerous factors, mostly organizational, human, and technical, but also on the needs of the management, which can be more or less conscious. Unlike large organizations, where the implementation of advanced SMAC is perceived positively, it seems that an opposite approach can occur to this trend in the SME sector. Hence, the objective of the research has been defined to test the readiness of Polish SMEs to implement and use systems within the so-called 3rd ICT platform. In order to fulfil the objective, the following research hypotheses have been formulated:

- elements of AI and SMAC solutions are used on an increasing scale in SMEs,
- SME management pay growing attention to the implementation of AI and SMAC systems.

The analyses are illustrated with survey results and direct observations of the author from 2019-2020 in selected 120 SMEs from Wielkopolska province, Poland, with reference to the general development trends in the studied area. The survey sample was made up of micro (9%), small (56%) and medium sized enterprises (35%). Surveyed companies represent a wide range of industries: retail and wholesale trade, discrete and process manufacturing, transport, HoReCa, utilities, finance, construction, telecommunication and ICT.

2 Intelligent organizations in the digital transformation

The most important characteristics of a intelligent organization include, among other [9], [14]:

- fast and flexible operation,
- the ability to monitor the environment,
- the capacity to diagnose early market signals and to react to changes in the environment, and
- the ability to implement new knowledge-based solutions and achieve economic benefits therefrom.

The growing volume of information used in a intelligent organization is accompanied by its increasing importance. Peter Drucker indicated already that traditional factors of production, such as growth, labour, and capital, are losing their importance in favour of a key resource, namely knowledge applied in the creative operation of an organization. It constitutes intangible resources that are related to human actions, whose use may be the basis for gaining a competitive advantage [14]. Knowledge has to be treated as information embedded in the context of an organization and a skill to use it effectively in the organizational activity. It means that knowledge resources are data about its customers,

products, processes, environment, etc. in a formalised form (documents, databases) and in non-codified forms (knowledge of staff).

In the practical dimension, the effective collaboration of such elements means the necessity to use advanced ICT solutions. Technical, technological, and organizational innovations, which have appeared in recent years, are all utilised [3]. They encompass almost all areas of a modern organization operation, starting from means of transport and equipment, through organization and material and raw material flow management, to the development of system structures that implement business processes, i.e. within logistics systems that are the essence of modern management based on ICT solutions.

The present effect of the ICT evolution in the form of the so-called third ICT platform, has been treated since 2013 as the foundation of the 4th industrial revolution, being the natural development stage of the 3rd revolution of 1969 (its symbol being electronics with its transistor and automated production). The main distinguishing element of new changes has become the redefinition of the present course of business processes that contributes to new operating models of economic organizations facing new challenges to maintain their position and expand on the market further. The industrial revolution of the 4th stage is breaking out due to [2]. [5], [8]:

- the introduction of the all-present digitalization,
- decision processes based on virtual simulations and data processing in real time, and
- machine-machine and machine-man communication.

The digital transformation means a change of the present approach to a customer and a comprehensive process where an organization moves to new methods of operation using the state-of-the-art AI and SMAC digital technology, including social media, mobility, big-data – analytics, and cloud computing. However, it has to be kept in mind that the role of digital technologies in that process is to enable the necessary changes and open an organization to new opportunities. Therefore, they should be a tool rather than the aim of transformation. The centre of the process has to be the customer and his needs, as the main driver for manufacturers and service providers. The digital transformation is no longer the method of gaining a competitive advantage - it is becoming a factor that enables to stay on the market [8] - Figure 1.

3 Trends in the digital transformation

Digital transformation is being spearheaded through a combination of software and hardware advancements. While the list of advancements is endless, the most promising technologies fall under one of the four umbrella terms described below briefly [1], [10]. [11].

I. The Data Science Trio refers to three advancements related to data science that are arguably causing the greatest disruptions across various industries at present. These three technologies are [6], [13]:

- Data Analytics and Big Data Analytics refers to a set of qualitative and quantitative methodologies used to study and extract knowledge from raw data and use it to guide business decisions. Big Data refers to gargantuan data sets that contain important information and patterns hidden among large heaps of supplemental data. Both finite data analytics and big data analytics are applicable in virtually any scenario involving a database and sufficiently large amounts of data. Scores of companies are currently hiring

armies of Data Analysts to crunch through their datasets and help them improve/organize their practices and services.

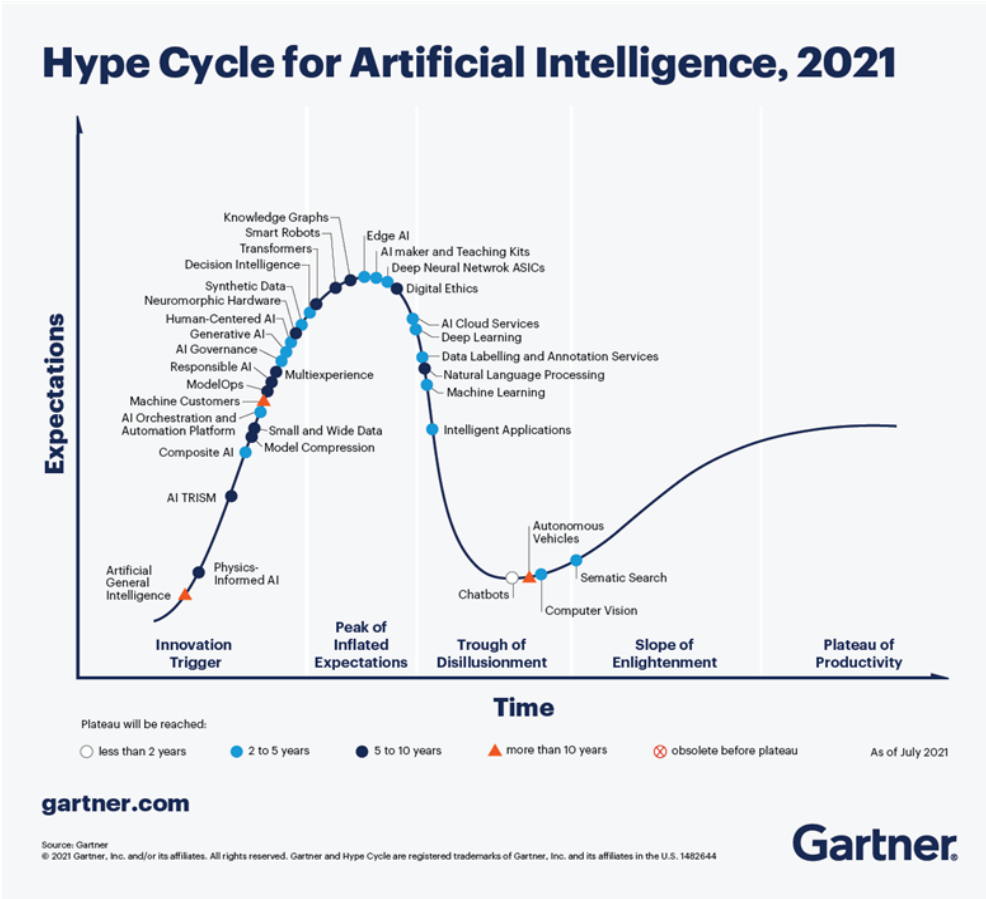

Fig. 1: Hype Cycle for Artificial Intelligence Source: [8]

- Machine Learning refers to the concept of giving computers the ability to learn on their own without human intervention. The primary usage of machine learning is to teach computers to recognize patterns on their own in cases where human analysis is too slow, expensive, or even impossible. Machine learning has thus seen itself being employed in recommendation engines, market analyses, spam filters, network security solutions, and more. Any organization that has data-based assignments which are large & repetitive (or) involve some form of identification tasks (or) a combination of both the above, should consider exploring machine learning solutions.
- Artificial Intelligence (AI) refers to a computer possessing the ability to perform a task or tasks in a manner that is just as effective or even more effective than a human being doing the same. While machine learning deals with a computer studying data and merely outputting what it has learned, Artificial Intelligence deals with a computer studying data and taking decisions/executing tasks based on certain pre-programmed instructions. AI is best implemented in any scenario requiring high speed and high precision decision making and task execution.

II. Internet of Things (IoT) refers to a network of interconnected physical devices and sensors that collect data and exchange it with one another using the internet as a communication platform. IoT networks allow for low cost embedded systems to be deployed into physical environments where they can continuously collect information, relay it, interpret it, and act on it accordingly. IoT helps in achieving a scenario where all variables of a physical environment can be mapped and each constituent device's functioning can be made to depend on said variables or outputs from other device(s). For this reason, IoT has found immense value in health-care, smart cities, and smart homes.

III. Remote Work Environments. High skilled employees are very often not available at the desired location of a firm or may sometimes prefer to work from home. In the digital age, it makes no sense to compromise on talent by restricting hiring & work to a single physical location. Whether it is employees situated halfway across the world in a satellite office, or an employee situated half way across town in their own house, technological advancements such as video calls and internet-connected project management software allow us to send work to employees themselves when the reverse is not possible.

IV. Block Chain Technology. The finance industry is currently undergoing one of its largest transformations in history – thanks to blockchain. Blockchain refers to a distributed global database spanning across millions of computers all over the globe. It is not controlled by any central authority and uses state of the art cryptography to prevent unauthorized access to sensitive information such as transaction history. Blockchains have already been implemented to create cryptocurrencies (e.g. Bitcoin) which are unregulated digital currencies that offer alternatives to traditional currencies. Cryptocurrencies are used widely due to the unmatched security and freedom they offer in trading any amount of money, big or small, without having to face any bureaucratic trouble.

V. Other Promising Trends. Beyond the technologies discussed above, there are several other technologies promising digital disruption of legacy industries. Some of the most promising trends are [17]:

- Virtual Reality and Augmented Reality VR works by simulating entirely new environments digitally while AR works by imposing simulated elements onto real environments. Both VR and AR find already finding application in the fields of gaming, health-care, and warfare.
- Internet-Based Media & Advertising. Although internet-based media & advertising is already mainstream, most companies still prefer to spend more on print and TV platforms. As the world continues its tectonic shift to Internet-based consumption, firms such as Netflix and InMobi are already capitalizing lucratively on internet revenues for media and advertising content respectively.

4 Case Study of the Polish SMEs

Research carried out by the author shows that the popularity of ICT support in management processes in SMEs can be presented as follows (percentage of analysed enterprises):

- finance and accounting – 97%,
- human resources – 85%,
- warehouse management – 79%
- production management – 38%,
- customer relationship management – 82%,

- office work support – 99% (including e-mail 98%), and
- procurement and sale process service – 81%.

The readiness of the studied entities to face the challenges of digital transformation is as follows:

- 22% of respondents answered positively, confirming the implementation of such tasks,
- 12% of respondents answered that such actions would be taken soon,
- 20% of responses indicated that such actions would be taken in the near future, and
- according to 46% of respondents such actions were not being conducted and there were no such plans.

As regards the use of SMAC solutions, the statistics of the analysed entities reflect the general global trend in this respect, i.e. [12], [15]:

- a cloud is used in 58% organizations (38% of analysed population plans to start using it),
- mobility is utilised in 49% of organizations (with 15% of analysed population planning to launch it),
- analytics is applied by 29% of organizations (while 16% of studied population have plans to start it), and
- social media are declared by as many as 55% of organizations already, and their use in the near future is declared by 55% of respondents.

The development trends of Polish intelligent organizations in AI-solutions is supplemented with the following declared initiatives [7]:

- as much as 90% of respondents participating in the survey carried out agreed with the statement that the digital transformation redefines industries in a fundamental way, giving business new opportunities for action, unattainable in the past;
- companies still associate digital transformation only with technological transformation. They forget about other factors (social, environmental, economic, legal and regulatory) which have a huge impact on changes, and lose sight of the consumers and their needs. This attitude has impact on the fact that digital transformation – despite 20 years of ongoing works – is still ineffective in most cases (research shows that 70% of activities carried out in connection with digital transformation are ineffective);
- 28% of the respondents of the quantitative survey conducted for the purposes of this article found that improving customer satisfaction was a result of a successful transformation. The vast majority (61%) considered improvement of the company's functioning as the primary success of the digital transformation;
- 34% of respondents agreed that their organization, working on transformation analyzes non-technological trend areas (social, economic, environmental, legal and regulatory) to a large or very large extent. In the largest companies (employing over 250 people) this indicator is even lower and amounts to only 28%;
- 55% of respondents agreed that their organization analyzes technology trends to a large and very large extent. This ratio is even higher for companies employing between 50 and 250 people and amounts to as much as 68%;
- 70% of respondents participating in the survey carried out for the purposes of this report indicated that social factors of change will have a large or very big impact on transformation in their industry. The three most commonly addressed today include privacy, aging society and digital nomadism. According to the respondents, the most

pressing social factors requiring addressing in the next decade will be the culture of nanosecond privacy and aging society;

- 82% of respondents participating in the survey carried out for the purposes of this article indicated that technological factors have a large or very large impact on the process of digital transformation in their organization. The ones primarily addressed today are social media, cloud computing and automation. In the next 10 years, top3 are in turn: artificial intelligence (AI), Big Data and automation;
- well-chosen technology and dedicated solutions (39% of responses) were considered to be the most important factors enabling success in carrying out the digital transformation. Well-prepared employees came only second (36%). Meanwhile, it is known that even the best technology will not provide success if it does not include engaged and changed people.

The fact of placing a customer in the centre was confirmed by responses about catching up with the dynamically evolving needs of contemporary consumers. Moreover, half of the respondents indicated the necessity to follow the changing expectations of their customers, declaring it to be their top business priority. The continuous improvement of customer satisfaction level is possible mostly owing to investments in new ICT solutions. Only owing to them shopping can be comfortable, fast, and possible at any time and place, while customer service can be effective. It also means the new opportunities in acquiring knowledge about needs, behaviour, and opinions of customers. In general, the above-mentioned study results show that Polish modern business organizations are becoming more confident in using advanced solutions of AI and SMAC solutions, to meet the challenges of digital transformation [1], [10].

5 Conclusions

The dynamic economic changes and the evolution of business relationships devaluate traditional sources of competitive advantages in the SME sector, such as capital, infrastructure, access to outlets, and the quality of offered products and services. Modern enterprises that want to compete on the market effectively have to give priority to flexibility of their organization and its ability to implement innovative business models and reorganise logistics processes. Examples of numerous Polish SMEs show that the vision of a business managed in a modern way has come into the dynamic phase of realization, while the effective knowledge management with advanced ICT solutions is growing to the role of paradigm. There is no doubt that reserves still present in the SME sector can be utilised, through supporting its operation with advanced ICT systems with the dominant role of SMAC solutions.

Nevertheless, it has to be remembered that the creation and development of such smart technologies has one basic aim for businesses, namely to accelerate the development pace and improve the quality of offered products and services, while reducing operating costs. Although it seems apparently simple, paradoxically innovation of Polish business organizations from the SME sector is burdened with the concern about the unknown. SMEs are afraid of investing in solutions that are not popular yet. Nevertheless, the strategic vision of the management in such organizations will determine the directions and pace of popularising modern and effective solutions in knowledge management, which may contribute to the improvement of their competitiveness on the global market.

Acknowledgements

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References

1. Adamczewski, P. (2020) 'The Top ICT-Trends to Accelerate Digital Transformation in VUCA-Environment',[in]: IT for Practice 2020, Ed. J. Ministr, Technical University Ostrava, pp. 5-17, Ostrava.
2. Adamczewski, P. (2019) 'Digital Transformation of Business Entities in Competitive Environment', [in]: Quarterly "Social Inequalities and Economic Growth", Vol. 58 (2/2019), University of Rzeszow, pp. 105-116, Rzeszow.
3. Adamczewski, P. (2018) 'Intelligent Organizations in Digital Age - Case Study of SMEs in Poland', [in]: MEST Journal, Vol. 6, No. 2, pp. 1-11, Toronto.
4. Anderson, C. (2015) 'Creating a Data-Driven Organization', O'Reilly Media, Sebastopol.
5. Betz, C.T. (2018) 'Managing Digital. Concepts and Practices', The Open Group Press, San Francisco.
6. Cao L. (2017) 'Data science: a comprehensive overview', „ACM Computing Surveys", Vol. 50(3), pp. 43-78.
7. 'Future in the era of digital change. Digital transformation', Infuture.institute, Gdansk 2019.
8. Gartner (2021) 'Top 10 Strategic Technology Trends for 2021', New York.
9. Grösser, S.N., Zeier, R. (2012) 'Systematic Management for Intelligent Organizations', Springer-Verlag, Berlin Heidelberg.
10. Lechman, E. (2018) 'The Diffusion of ICT', Routledge – Taylor & Francis Group, London – New York.
11. Olszak, C.M., Pełech-Pilichowski, T., Mach-Król M. (Eds.) (2017) 'Advances in Business ICT: New Ideas from Ongoing Research'. Studies in Computational Intelligence, Volume 658, Springer, Berlin-Heidelberg.
12. Riche, N.H., Hurter, Ch. (2018) 'Data-Driven Storytelling', Taylor & Francis Group, Raton.
13. Sarker H.I., Hoque M.M., Uddin M.K., Alsanoosy T. (2021) 'Mobile Data Science and Intelligent Apps: Concepts, AI-Based Modeling and Research Directions', „Mobile Networks and Applications", Vol. 26, pp. 285–303.
14. Schwaninger, M. (2010) 'Intelligent Organizations. Powerful Models for Systematic Management', Springer-Verlag, Berlin Heidelberg.
15. Schwab, K. (2016) 'The Fourth Industrial Revolution', World Economic Forum, Cologny.
16. 'Smart Industry Poland 2020' (2020), Siemens, Warszawa.
17. Tidd J. (Ed.) (2019) 'Digital Disruptive Innovation', Series of Technology Management – Vol. 36, World Scientific Publishing Ltd., Singapore.LI, Chan, K.K. RAMAN, Lili SUN a Da WU, The SOX 404 internal control audit: Key regulatory events [online]. [cit. 2021-09-19]. DOI: 10.1016/j.racreg.2015.09.006. ISBN 1052-0457. Source: http://linkinghub.elsevier.com/retrieve/pii/S1052045715000351
18. Pereira, Teresa & Santos, Henrique. (2014). Challenges in Information Security Protection. URL: https://www.researchgate.net/publication/264116803_Challenges_in_Information_Security_Protection
19. Luke Irvin (2018) The 5 biggest information security concerns facing organisations, URL: https://www.itgovernance.co.uk/blog/the-5-biggest-information-security-concerns-facing-organisations
20. Brianna Flavin (2019) 9 Cyber Security Problems Nearly Every Organization Struggles With. URL: https://www.rasmussen.edu/degrees/technology/blog/cyber-security-problems/

21. Three Cyber Security Issues Organizations Face. URL: https://online.maryville.edu/blog/three-cyber-security-issues-organizations-face/
22. Kalie Gyarmathy (2019). Top Cybersecurity Problems and Solutions Companies Face. URL: https://www.vxchnge.com/blog/cybersecurity-problems-and-solutions

Design of Web Applications with Support for Color-blind Users

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Abstract. This article analyzes color blindness as an issue that may affect the usability of some web applications that use inappropriate color combinations or low contrast. The article provides recommendations for designing web pages friendly for color-blind users. Some tools and simulators for developing websites with support for color-blind users are mentioned.

Keywords: Color blindness, WCAG, Blindness testing tools and simulators, Web design.

1 Introduction

Color blindness is a highly prevalent vision impairment that inhibits people's ability to understand colors. Color blindness can be complete or partial. With partial color blindness, people with disabilities perceive colors differently than most people or do not distinguish certain colors. Color blindness cannot be treated, it can only be corrected by wearing special glasses or contact lenses (National Eye Institute). The Ishihara test is used to determine the form and degree of color blindness. The test is performed on paper because the computer screen has certain limitations due to the RGB color model used. Ishihara's test for detection red-green color blindness (only) is available at (Ishihara).

Fig. 1: Normal color vision, Protanopia, Deuteranopia, Tritanopia, Source: Wikipedia, public domain

Types of color blindness:

- Red-green color blindness
- Deuteranomaly - the most common type, it makes green look more red.
- Protanomaly - makes red look greener and less bright.
- Protanopia (does not perceive red color) and deuteranopia (does not perceive green color), both make you unable to tell the difference between red and green at all.

- Blue-yellow color blindness
- Tritanomaly makes it hard to tell the difference between blue and green, and between yellow and red.
- Tritanopia (does not perceive blue color) makes you unable to tell the difference between blue and green, purple and red, and yellow and pink. It also makes colors look less bright.

Table 1 Distribution of various forms of color blindness in the population, Source: (Color Essential)

Type	Denomination	Prevalence	
		Men	Women
Monochromacy	Achromatopsia	0.00003%	
Dichromacy	Protanopia	1.01%	0.02%
	Deuteranopia	1.27%	0.01%
	Tritanopia	0.0001%	
Anomalous Trichromacy	Protanomaly	1.08%	0.03%
	Deuteranomaly	4.63%	0.36%
	Tritanomaly	0.0002%	

Adding up all the numbers from table 2 results in total 8 % of men and 0.5 % of women who are suffering from some type of color vision deficiency. Complete color blindness (monochromacy) is very rare.

2 Recommendations for Websites Design

Color blind people face various difficulties interacting with web systems. The main colors of confusion are the same for red-blind and green-blind: red, orange, yellow, green and brown. Red-blind people perceive the color red much darker. To set up proper color combination in web application, it is necessary to focus on red-green and blue-yellow color vision deficiency. The difference with blue-yellow color blindness is very small and it is not necessary to solve it separately.

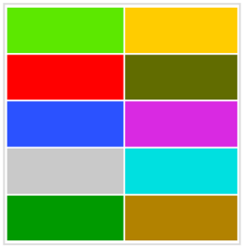

Fig. 2: Color pairs of confusion that red-blind people cannot distinguish, Source: (Color Essential)

The W3C has published Web Content Accessibility Guidelines (WCAG), the current version is 2.2. The WCAG document also defines recommendations for the use of colors, this topic is covered in Chapter 1.4.1 ‘Use of Color’. WCAG defines the different levels of contrast ratios depending on the level of success criteria (Level AA requires a contrast ratio

at least 4.5:1 for normal text and 3:1 for large test, Level AAA requires a contrast ratio 7:1 for normal text and 4.5:1 for large text).

Strantz [5] solves best practices to create visually accessible data visualizations - design of data visualization that should follow web standards to ensure that they are accessible to audiences with diverse needs. Design the visual for accessibility by using whitespace, creating contrast, maintaining size/scale, and labeling the visual clearly.

Vitols [6] analyze problems of people with disabilities who use Web information systems. In this contribution, main categories of needs are brought forward, analyzed and basic solutions for Web developers are discussed.

We can recommend the following for the development of color-blind people friendly websites:

1. Avoid some combination of colors – see Figure 2
2. Keep your color palette limited to 2 or 3 colors
3. Use high contrast – see example in Figure 3
4. Use thicker lines
5. Use both color and symbols (WCAG and Section 508 recommendations - web pages shall be designed so that all information conveyed with color is also available without color – see Figure 4)
6. Modifying brightness, saturation and hue of colors – similar of altering contrast
7. Links on a web page should be underlined or represent by icons, not only by different colors.

Fig. 3: An example of good and bad contrast on the web, Source: https://gomedia.com/tutorials/rule-three-contrast-contrast-contrast

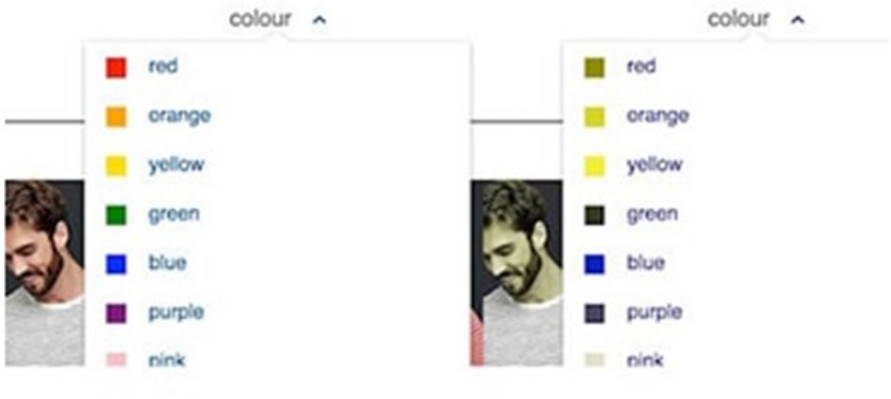

Fig. 4: An example of good and bad contrast on the web,
Source: https://gomedia.com/tutorials/rule-three-contrast-contrast-contrast

In Figure 4 we can see an example of a website according to WCAG recommendations - colors are also represented as a text. On the right, a demonstration of how people with color blindness see the web.

3 Website Blindness Testing Tools and Simulators

An overview of the tools that can be used to develop color-blind web applications is given in Table 2.

Table 2 Distribution of various forms of color blindness in the population,
Source: (Color Essential)

Tool	Source	Note
Color Oracle	http://colororacle.org/	Windows, MAC, Linux; free tool, full screen color filter
Coblis – Color Blindness Simulator	http://www.color-blindness.com/coblis-color-blindness-simulator/	Drag and drop files for testing
TPGi Colour Contrast Analyser	https://www.tpgi.com/color-contrast-checker/	Free color contrast checker tool; Windows and MAC; test compliance with WCAG 2.1
Tanaguru Contrast Finder	https://contrast-finder.tanaguru.com/	WCAG criteria checker
Color Safe	http://colorsafe.co/	Tool for adjustment a contrast in web design
ColorBlind A11Y Assistant		Chrome extension; Note: only install ColorBlind A11Y Assistant if you trust the publisher.
Colorblind Web Page Filter	https://www.toptal.com/designers/colorfilter	

Such simulators and tools can help designers make informed design decisions and make web UX pleasurable to use for people suffering from the condition.

4 Conclusion

Color vision deficiency users may experience limitations and barriers in exploring web pages, even for simple task. This paper attempts to help web developers create web applications that reflect the specific needs of people with color vision deficiency.

References

1. Color Blindness Essential, [Online], Available: https://www.color-blindness.com/color-blind-essentials/ [12-Sep-2021].
2. Ishihara test, [Online], Available: https://www.colorlitelens.com/ishihara-test [25-Oct-2021].
3. National Eye Institute – Color Blindness, [Online], Available: https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/color-blindness [12-Sep-2021].
4. Section 508 of the Rehabilitation Act, Guidance to Federal agency staff who play a role in IT accessibility, 2017, [Online], Available: https://www.section508.gov/ [27-Sep-2021].

Modeling of customer behavior in e-commerce using Google Analytics

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Abstract. Google Analytics is the most famous tool used by millions of e-commerce websites owners to assess the effectiveness of their business and efforts. This paper deals with modeling of customer behavior in e-commerce websites using Google Analytics. Google Analytics tool is very useful for the following information about customer behavior in e-commerce: Flow Visualization, Goal Flow, Traffic Sources etc. We will introduce especially issue of acquisition - how visitors arrive at the website, behavior - how visitors interacted with the website and finally will be mentioned also the issue of conversions - how visitors completed conversions on the website. The case study, included in this paper, is based on real datasets about customer behavior in e-commerce website which is specialized in business with travel luggage.

Keywords: e-commerce, Google Analytics, Customer behavior, Modeling, conversion rate.

1 Introduction

The main purpose of this paper is to analyze customer behavior on a selected e-commerce website. We want to quantify how many users have ended in some phases of activity at e-commerce website and how much users went on to complete the purchase. Very important for us is also to find out how users have been entered selected e-commerce website because it is very important for more effective online advertising.

The penetration of information and communication technologies (ICT) into the society's life has opened up new opportunities for entrepreneurial activities. ICT has become an indispensable support for communication, production activities, business, management, and so on.

Definition of e-business according to ISO / EIC, resp. CSI (Czech Standards Institute) says that e-business means a series of processes that have a clearly understandable purpose, involving more than one organization, carried out through the exchange of information and directed towards mutually agreed goals that take place over a given period of time. Similarly, e-business is defined by other sources, such as [1], [11] and others. Electronic business is the hierarchically the highest level for ICT-based business activities. If we are focusing on purely sales/shopping activities, we are talking about e-commerce, where e-shops are represented by specific web applications as one of the key communication interfaces.

E-commerce has become a standard and it is a very convenient alternative for implementing sales/shopping activities between different types of entities. With

the development and penetration of mobile communication devices, the concepts of m-business, m-commerce, and m-shops have emerged. In some articles and professional publications, we can meet these concepts but it is only in cases of direct focus on mobile communication devices. In general, when we talk about e-business and e-commerce, we also automatically take into account mobile communication devices. E-commerce affects areas ranging from distribution, purchasing, sales, marketing to product servicing. Definition of e-commerce according to ISO / EIC, resp. CSI characterizes

E-commerce as a series of processes related to the course of business transactions, involving two or more participants with a common goal of closing a deal, made by electronic means and running for a certain time. In the same way, Electronic commerce is defined in the foreign literature as in [14], [15], [9] and others.

Online shopping is a global and rapidly growing phenomenon. Almost 7.5 billion people live in the world, of which 3.5 billion people use the Internet and over 1.5 billion people make purchases online. According to server eMarketer (www.emarketer.com), retail global online sales were approaching $ 2.4 trillion in 2017, doubling to $ 4.9 trillion by 2021. More detailed current and anticipated development of turnovers from world online sales between 2017 and 2023 are presented in Figure 1.

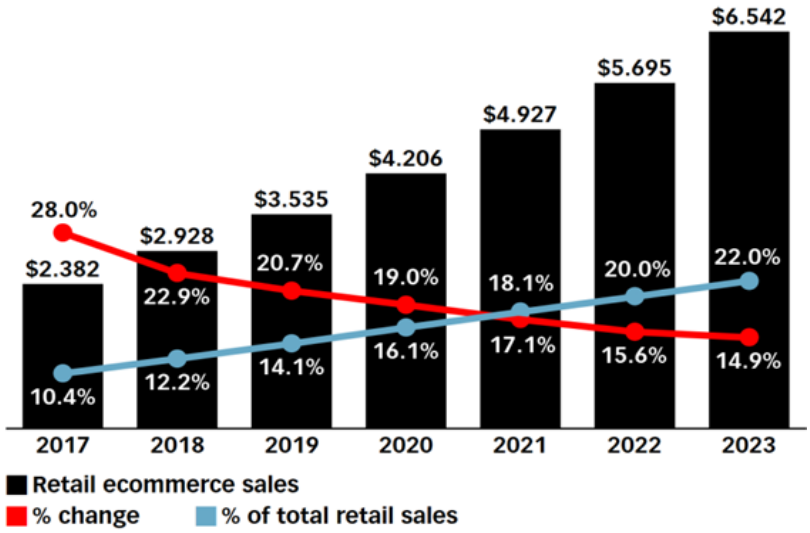

Fig. 1: Global online sales (trillion $), Source: [4].

2 Research Methodology and Related Work

We would like to introduce at first research methodology and same related work in a theoretical part of the paper. The practical part will be focused on a case study which is based on real datasets about customer behavior in e-commerce website which is specialized in business with travel luggage. We will use some Google Analytics tools such as Flow Visualization, Goal Flow and Traffic Sources for analyzing how visitors arrive at the website, how visitors interacted with the website and finally how visitors completed conversions on the website.

Our paper is based on Google Analytics methodology. We can find many manuals and practical information when we entered Google Analytics websites that are available from the following link: https://www.google.com/analytics/.

Clifton [2] is describing how Google Analytics works. Google Analytics is a page-tag solution that employs first-party cookies. By this method, all data collection, processing, maintenance, and program upgrades are managed by Google as a hosted service (SaaS - Software as a Service).

Ledford [10] are characterized Google Analytics as a historical analytics program, which means statistics are not tracked in real time. The statistical data that appears in your analytics reports will be one or two days behind. It is not a perfect situation, but despite the delay, the depth of information provided is both accurate and useful.

Google Analytics is considered as a best free web analytics tool that has many benefits and advantages but there is nothing absolutely perfect in the ICT world because all IT systems and tools have some limitations or bugs. Farney [5] are discussing some limitations of Google Analytics. First, Google Analytics is designed to be a hosted service so it means that data from your website visitors will be captured and retain on a Google server, not your own. Second, Google Analytics is not designed to be an infinitive repository for a website´s data. According to web analytics expert Brian Clifton, it is Google Analytics policy for its free version to retain data for 25 months. Despite some limitations and imperfections, Google Analytics is still an excellent web analytics that provides very useful analytics that can be used to improve a website.

Cutroni [3] deals with an understanding of visitor behavior. Google Analytics servers have special storage for raw data about visitor behavior. These log files contain numerous attributes of the pageview sent to Google such as for example the following:

- When the data was collected (timestamp - data and time),
- Where the visitor came from (referring website, search engine, etc.),
- How many times the visitor has been to the site (number of visits),
- Where the visitor is located (geographic location),
- Who the visitor is (IP address).

Sanders [13] has written the book called 42 Rules for Applying Google Analytics which is very useful for practical and very effective work with Google Analytics. This book is describing how is visitor's journey through the websites then applying that measurement, collection, and analysis of data for the main purpose of adequately optimizing and improving website performance. Very important part is also learning where your visitors come from and how they interact with the website.

We can find many scientific papers about using Google Analytics to Evaluate the Usability of E-Commerce Sites or to analyze the visitor behavior.

For example, Hasan et al have identified specific web metrics that can provide, quick, easy, and cheap, indications of general potential usability problem areas on e-commerce websites. Results showed that the heuristic evaluators were able to identify detailed specific usability problems. Hernández [8] deal with the analysis of Users' Behavior in Structured e-Commerce Websites. They are applying Model Checking to Event Log Analysis and are using this model to illustrate the most relevant access patterns to main sections and their importance within the buying process. Pakkala [12] have written a scientific paper about using Google Analytics to measure visitor statistics in the case of food composition websites. Their conclusions are as follows: basic web analytics can be carried out with low-cost

alternatives, web analytics should not be claimed to be difficult or expensive to exploit, Google Analytics gives useful information in return for rather a small effort and cost.

3 Case Study: Google analytics results from e-shop dataset analysis

The e-shop www.equipshop.cz was created at the beginning of July 2017. The idea of doing business was born a lot earlier. In the second bachelor study in 2013, like every student, I needed money for traveling and hobbies. We went through a lot of brigades until I came to the most effective way of making my own business. I have used my parents' contacts and addressed potential companies with whom I could cooperate when I managed to find suppliers. The high school colleague studied IT, and in the framework of practicing, he created a very simple internet shop. The first order is recorded on 10.2.2014. From this day until now, we have begun to work hard on improvements, two times changed from the basics of web page programming and design. 25.3.2014 was launched Sklik and Adwords a few days later, the goods appeared on the Heureka grader. We tried to automate the business as much as possible and to outsource as much as possible. Nowadays, this business lives with its life, there is an average of 300 orders a year with a turnover of around CZK 750,000. We have managed to automate the activities around us to the extent that we are dealing with business only today rather than its implementation. It has its advantages and disadvantages.

This business has grown a bit in my heart for years, so I've been looking for other opportunities to develop. I attended the fairs, searched the internet, and searched the market for more. At the beginning of 2017, I was approached by a friend who needed to test the sales platform if I had any interesting products. I did not want to interfere with the current excursion, so I took advantage of the contacts, and after a few meetings, hundreds of kilometers and tens of hours of PC analyzing the market, he discovered a seemingly interesting opportunity under the name of travel trunks. With very low start-up capital, I bought a few dozen suitcases, and in early July 2017, the first customers could buy travel trunks with us. I took advantage of the experience and started to work at the new store. After half a year we have trunks sold for CZK 150,000, yes, it's not much, but it's enough to cover operating costs. There is a long way to make the trade known and globally successful.

In the next section, we want to focus on very strong and in today's online trading undoubtedly the most important tools: Google Analytics, Sklik, and Heureka. The Analytics tool offers a tremendous amount of information. We are currently using it mainly to analyze shoppers, their numbers, behavior, and conversion rates. In Figure 2, we see a history of page views starting from the end of January 2018. So, in 7 months, 4712 unique pages were displayed. We total 7400 pageviews. Immediate exit rate is average and means only one-page visit. These visits are often through the Heurice's destination links when a person finds a travel suitcase to crash a store, or to swallow photos and leave. Generally, statistics show that 54.45% of visitors visit only one particular page, averaging 54 seconds and leaving. The remaining 45.55% will go to other sites.

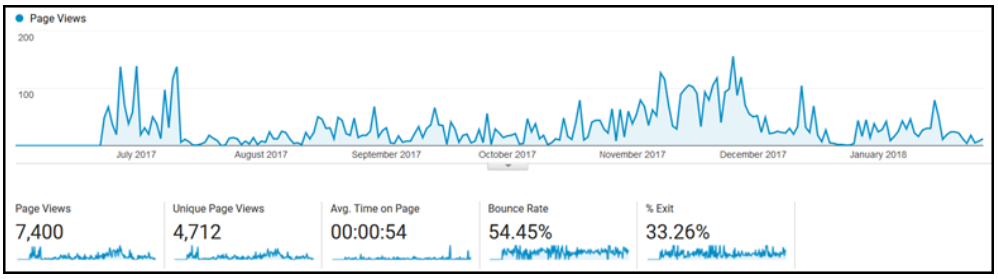

Fig. 2: Purchasing decision process, Source: Own processing in Google Analytics, 2018.

	Page	Page Views	% Page Views
1.	/cs/cestovni-kufry	1,493	20.18%
2.	/	634	8.57%
3.	/cs/skorepinove-kufry	519	7.01%
4.	/cs/textilni-kufry	494	6.68%
5.	/cs/kufry	386	5.22%
6.	/?search=travelite	249	3.36%
7.	/cs/palubni-zavazadla	193	2.61%
8.	/cs/batohy	169	2.28%
9.	/cs/kontakt	167	2.26%
10.	/cs/kosik	160	2.16%

Fig. 3: Website pageviews, Source: Own processing in Google Analytics, 2018.

From the table in Figure 2, we can see which specific pages users have visited. Of the 7,400 pageviews, the page/en/travel suitcases were 1493 times, it is 20.18% of all the pages displayed, and second is the 8.57% home page. If we use Pareto's analysis, the table shows that we have to focus on the first five pages with an emphasis on the first position. These sites should be as sophisticated and as sophisticated as possible.

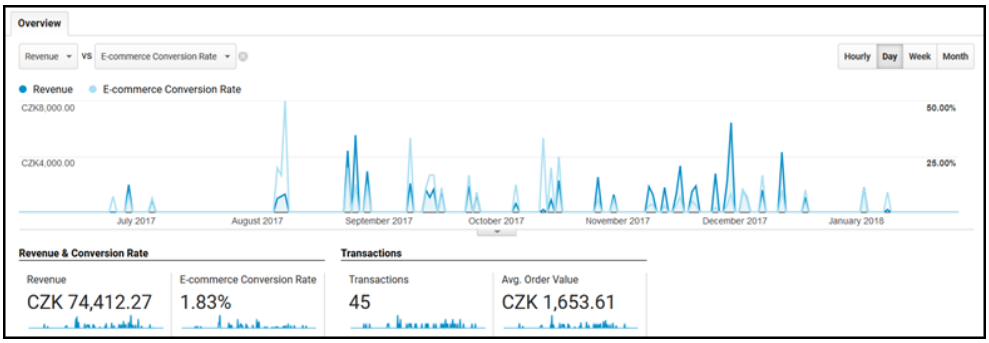

Fig. 4: Conversions and purchases,
Source: Own processing in Google Analytics, 2018.cs, 2018.

Of course, we do not optimize the store page in such a way that users only view the merchandise but create the most conversions - purchases. From figure 4 we can see that

the conversion rate of trade is 1.83%. From the statistics, the conversion is around 2-2.5%, so in our case, the conversion rate is slightly below the average. Here, we see the average value of the order, which can be used in marketing calculations. If we have analyzed and optimized sites, it is very important in the next steps to read how our customers came to the site and compare the data with the conversions that were made. We will read this information from the following picture:

Default Channel Grouping	Acquisition			Behaviour			Conversions E-commerce		
	Users ↓	New Users	Sessions	Bounce Rate	Pages/Session	Avg. Session Duration	E-commerce Conversion Rate	Transactions	Revenue
	2,040 % of Total: 100.00% (2,040)	2,036 % of Total: 100.00% (2,036)	2,461 % of Total: 100.00% (2,461)	54.45% Avg for View: 54.45% (0.00%)	3.01 Avg for View: 3.01 (0.00%)	00:01:49 Avg for View: 00:01:49 (0.00%)	1.83% Avg for View: 1.83% (0.00%)	45 % of Total: 100.00% (45)	CZK 74,412.27 % of Total: 100.00% (CZK 74,412.27)
1. Organic Search	851 (40.93%)	835 (41.01%)	930 (37.79%)	58.60%	2.53	00:01:12	0.43%	4 (8.89%)	CZK 10,032.00 (13.48%)
2. Direct	572 (27.51%)	570 (28.00%)	699 (28.40%)	54.08%	3.06	00:02:18	1.00%	7 (15.56%)	CZK 6,215.47 (8.35%)
3. Referral	507 (24.39%)	491 (24.12%)	657 (26.70%)	50.23%	3.49	00:02:11	4.57%	30 (66.67%)	CZK 49,944.80 (67.12%)
4. Social	117 (5.63%)	113 (5.55%)	131 (5.32%)	54.20%	3.24	00:01:30	2.29%	3 (6.67%)	CZK 5,430.00 (7.30%)
5. Paid Search	32 (1.54%)	27 (1.33%)	44 (1.79%)	36.36%	4.32	00:02:35	2.27%	1 (2.22%)	CZK 2,790.00 (3.75%)

Fig. 5: Visitors statistics, Source: Own processing in Google Analytics, 2018.

From the table above, we see that 7,400 pageviews created 2461 users. From the table, we see the results of SEO, where it conducts an organic search, that is, search on Google, the list and other search engines and direct, ie direct inputs using links to other sites. Referrals are direct links to products, here we can say that they are the results of Heureka, zboží.cz and other graders of goods. Social shows us that there is some marketing on social networks. And lastly, paid inputs using Sklik and Google Adwords. If we notice the penultimate column, transactions, we will simply find out which resource is generating the largest conversion. In our case, it will be a grader with an average conversion rate of 4.57%. In the next step, we can analyze these resources in more detail:

Source/Medium	Acquisition			Behaviour			Conversions E-commerce		
	Users ↓	New Users	Sessions	Bounce Rate	Pages/Session	Avg. Session Duration	E-commerce Conversion Rate	Transactions	Revenue
	2,040 % of Total: 100.00% (2,040)	2,036 % of Total: 100.00% (2,036)	2,461 % of Total: 100.00% (2,461)	54.45% Avg for View: 54.45% (0.00%)	3.01 Avg for View: 3.01 (0.00%)	00:01:49 Avg for View: 00:01:49 (0.00%)	1.83% Avg for View: 1.83% (0.00%)	45 % of Total: 100.00% (45)	CZK 74,412.27 % of Total: 100.00% (CZK 74,412.27)
1. (direct) / (none)	572 (27.15%)	570 (28.00%)	699 (28.40%)	54.08%	3.06	00:02:18	1.00%	7 (15.56%)	CZK 6,215.47 (8.35%)
2. google / organic	531 (25.20%)	519 (25.49%)	579 (23.53%)	59.41%	2.57	00:01:16	0.35%	2 (4.44%)	CZK 4,084.00 (5.49%)
3. seznam / organic	306 (14.52%)	299 (14.69%)	332 (13.49%)	56.93%	2.48	00:01:05	0.30%	1 (2.22%)	CZK 1,599.00 (2.15%)
4. cestovni-zavazadla.heureka.cz / referral	137 (6.50%)	128 (6.29%)	179 (7.27%)	54.19%	3.53	00:02:21	8.94%	16 (35.56%)	CZK 28,935.20 (38.88%)
5. zbozi.cz / referral	126 (5.98%)	121 (5.94%)	169 (6.87%)	50.89%	3.21	00:02:53	4.14%	7 (15.56%)	CZK 8,705.25 (11.70%)
6. emimino.cz / referral	78 (3.70%)	76 (3.73%)	87 (3.54%)	20.69%	4.44	00:01:43	0.00%	0 (0.00%)	CZK 0.00 (0.00%)
7. heureka.cz / referral	45 (2.14%)	39 (1.92%)	47 (1.91%)	72.34%	2.43	00:01:07	4.26%	2 (4.44%)	CZK 2,990.35 (4.02%)
8. facebook.com / referral	41 (1.95%)	39 (1.92%)	45 (1.83%)	53.33%	3.44	00:02:31	0.00%	0 (0.00%)	CZK 0.00 (0.00%)
9. m.facebook.com / referral	40 (1.90%)	39 (1.92%)	44 (1.79%)	50.00%	3.48	00:01:07	4.55%	2 (4.44%)	CZK 3,640.00 (4.89%)
10. seznam / cpc	32 (1.52%)	27 (1.33%)	44 (1.79%)	36.36%	4.32	00:02:35	2.27%	1 (2.22%)	CZK 2,790.00 (3.75%)

Fig. 6: Visitors statistics, Source: Own processing in Google Analytics, 2018.

Google Analytics allows us to make most of our information more specific as we see in Figure 7. The analytics tool provides us with a lot of information, but in this work, I will bring you another interesting indicator, namely demographic data. Figure shows that 64.5% of visitors are women aged 25-44.

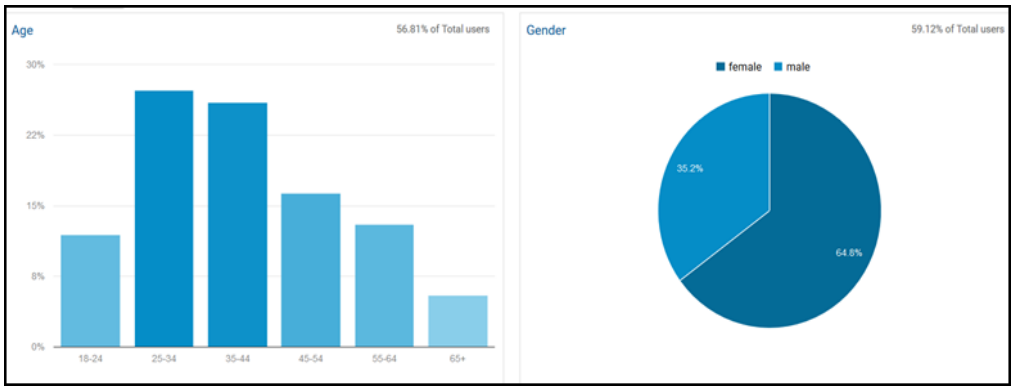

Fig. 7: Demographic statistics, Source: Own processing in Google Analytics, 2018.

This article only describes basic Google Analytics tools to help us better understand our customers. Based on the information you read, you can better optimize your website to increase conversion. Every successful website uses tools to analyze customer behavior on the web. It's one of the most common ways we can learn more about them. Having the right content on the right pages will ensure the success of the site. Without the necessary information to customers, they do not look what they expect at the right moment. Information, despite being very important, is not a guarantee of success, it only reveals the places we should take care of. How do we handle that information, it's just about us. Google Analytics provides a great deal of information and is the irreplaceable companion in the right hands when doing business online.

4 Findings and Discussion

We have presented an overview of the analysis of a real dataset from the e-shop. There were found some results such as Purchasing decision process, website page views, conversions and purchases, visitor statistics and finally demographic statistic. We can discuss this topic more with analyzing data from another e-shop in the future research or we can analyze the dataset from the same e-shop in the future and compare it with the previous historical dataset.

5 Conclusions

Google Analytics is a very useful tool for discovering customer behavior in e-commerce systems. We can use Flow Visualization, Goal Flow and Traffic Sources for analyzing how visitors arrive at the website, how visitors interacted with the website and finally how visitors completed conversions on the website.

Acknowledgement

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References

1. Chaffey, D., (2014). Digital Business & E-Commerce Management. 6th ed. Strategy Implementation & Practice. Trans-Atlantic Publications.
2. Clifton, B., (2012). Advanced Web Metrics with Google Analytics. John Wiley & Sons.
3. 7Cutroni, J., (2010). Google Analytics: Understanding Visitor Behavior. O'Reilly Media.
4. Emarketer, (2019). Global Ecommerce 2019, [Online], Available: https://www.emarketer.com/content/global-ecommerce-2019 [10 October 2021].
5. Farney. T. and N. McHale, (2013). Maximizing Google Analytics: Six High-Impact Practices. ALA TechSource
6. Google (2018). Google Analytics. https://www.google.com/analytics/
7. Hasan L., Morris A., Probets S. (2009) Using Google Analytics to Evaluate the Usability of E-Commerce Sites. In: Kurosu M. (eds.) Human Centered Design. HCD 2009. Lecture Notes in Computer Science, vol 5619. Springer.
8. Hernández, S., Álvarez, P., Fabra J., Ezpeleta, J. (2017.) Analysis of Users' Behavior in Structured e-Commerce Websites. IEEE Xplore Digital Library, vol. 5, 2017, p. 11941-11958.
9. Khorsow-Pour, M., (2006). Cases on Electronic Commerce Technologies and Applications. Idea Group Publishing.
10. Ledford, J.R., Teixeira, J., Tyler M. E., (2011). Google Analytics. John Wiley & Sons.
11. Meier, A. and H. Stormer, (2009). EBusiness & ECommerce: Managing the Digital Value Chain. Springer.
12. Pakkala, H., Presser, K., Christensen, T. (2012) Using Google Analytics to measure visitor statistics: The case of food composition websites. International Journal of Information Management, vol. 32, no. 6, p. 504-512.
13. Sanders. R. (2012). 42 Rules for Applying Google Analytics. Super Star Press
14. Schneider, G., (2016). Electronic Commerce. South-Western.
15. Turban, E., (2017). Electronic Commerce 2018: A Managerial and Social Networks Perspective. Springer; 9th ed. 2018 edition.

The Impact of Information Technology on the Carbon Footprint

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Abstract. The growing boom in digitization and the development of new technologies around the world are contributing negatively to the creation of a large amount of carbon footprint, and thus to the deterioration of the quality of the environment. It is very important to deal with the production, consumption and disposal of information technology in order to minimize the creation of a carbon footprint. Therefore, it is necessary to achieve that the company produces as little carbon dioxide as possible in the near future. This situation can only be achieved through a positive synergy effect in the change of human needs and values, the transformation of the economy, technology, consumption and production, especially in energy and transport, and savings. The article will deal with the effects of information technology on the carbon footprint, which could contribute to reducing carbon dioxide production in society.

Keywords: Carbon footprint, Information technology, Carbon dioxide, Emission, Environment

1 Introduction

Carbon dioxide, also called a greenhouse gas, is part of the Earth's atmosphere. It is one of the other gases, they make up 1% in the atmosphere, carbon dioxide alone is 0.035% in the atmosphere. [5].

Almost every activity, from food to transport, releases greenhouse gases directly or indirectly. Greenhouse gases are not only produced by carbon dioxide (CO2), but also by methane (CH4) and nitrous oxide (N2O).

Several processes arise:

- by burning fossil fuels and biomass,
- anaerobic decomposition of organic substances,
- waste storage,
- industrial production.

These activities cause the Earth's greenhouse effect. The accumulation of carbon dioxide is currently the highest in the previous 650000 years, which is why this issue is becoming a priority for the human population in the field of climate protection. Therefore, in recent years, companies have increasingly taken measures to reduce their carbon footprint to minimize the impact on the environment.

The article generally describes the issue of carbon footprint and emissions. Emissions are divided into direct and indirect, their difference will also be clarified. The next chapter, which forms a substantial part of the paper, deals with the effects of information technology on the carbon footprint. The conclusion follows where the article is summarized.

2 Carbon footprint

The rapid spread of greenhouse gas concentrations in the Earth's atmosphere are a major cause of climate change. The most important greenhouse gas is carbon dioxide (CO2) and its production is called the carbon footprint.

The carbon footprint is a measure of the impact of human activity on the environment and especially on climate change. The carbon footprint is (similarly to the ecological footprint) an indirect indicator of energy, product and service consumption. It measures the amount of greenhouse gases that correspond to a particular activity or product. The carbon footprint can be determined at various levels - national, municipal, individual, or company and product. Simply put, a carbon footprint is the amount of carbon dioxide and other greenhouse gases released during the life cycle of a product or service, household operation, transport, etc. [1].

Basic carbon footprint division:

- *Primary (direct) footprint* - The amount of greenhouse gas emissions released immediately from the activity, such as electricity generation, heating, fuel combustion or landfilling. This carbon footprint is easier to determine and can be better controlled or reduced.
- *Secondary (indirect) footprint* - The amount of greenhouse gas emissions released during the entire life cycle of products, from their production to eventual disposal. Examples are emissions associated with the construction of a house and the production of building materials or the production of a car. Product Life Cycle Analysis (LCA) data are necessary to determine the indirect trace. It is very difficult to determine them at the macro level, such as the city, the use is rather at the level of companies or households. [1]

The protocol called GHG protocol (Green House Gas protocol) introduced a very practical division of emissions into three classes. This division has become a widely used standard.

- *Scope 1* (direct emissions) - activities that fall under the control of the company and are controlled by it, in which emissions are released directly into the air. These are direct emissions. They include, for example, emissions from boilers or generators burning fossil fuels in the company, emissions from mobile sources (e.g. cars) owned by the company or emissions from industrial processes, emissions from waste treatment or wastewater treatment in facilities operated by the company.
- *Scope 2* (indirect energy emissions) - emissions associated with the consumption of purchased energy (electricity, heat, steam or cooling), which do not arise directly in the company, but are the result of the company's activities. These are indirect emissions from sources that the company does not directly control, yet it has a major impact on their size. If the company itself produces electricity / heat and sells it to other customers or if it sells the purchased electricity / heat to other customers (e.g. tenants) and the amount of this electricity is measured, it is deducted from the total Scope 2 emissions.
- *Scope 3* (other indirect emissions) - emissions that result from the company's activities and that arise from sources outside the control or ownership of the company, but are not

classified as Scope 2 (eg business trips by air, landfilling of waste, purchase and transport of material by a third side, etc.). It follows from the definition that this is the broadest and logically least precisely defined category. While Scope 1 and Scope 2 emissions are well comparable between companies, Scope 3 emissions are comparable only to a limited extent. Therefore, Scope 1 and Scope 2 emissions reporting is mandatory in the GHG Protocol and the CDP database, while Scope 3 is only recommended. In recent years, however, Scope 3 has become increasingly important, with companies reporting at least the most important items in Scope 3 by default. They can demonstrate innovative emission reduction management. [9].

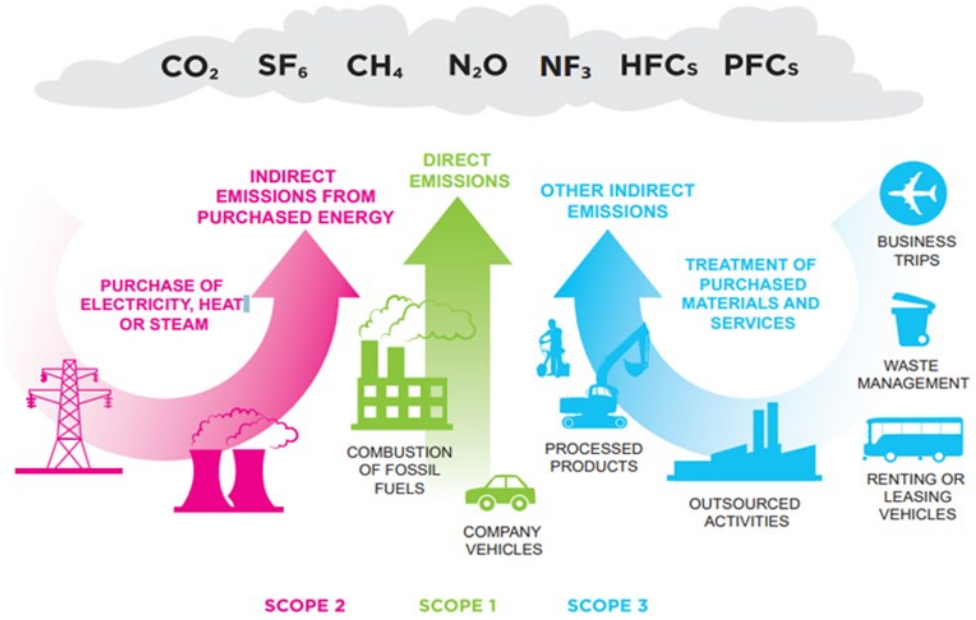

Fig. 1: Illustration of greenhouse gas production, Source: savemoneycutcarbon.com, 2020.

3 Information technology – the influence of the carbon footprint

Carbon emissions associated with the production, use and disposal of information and communication technology (ICT) equipment are a topic of growing societal interest. The carbon footprint in ICT includes mobile networks, data centers, corporate networks, but also all user devices such as telephones, computers, IoT technologies and other tools. (zive.aktuality.sk, 2020)

According to a new study conducted by researchers from the University of Lancaster and the consulting company Small World Consulting Ltd., computer technology generates much more greenhouse gas emissions than previously calculated. The area of interest of the consulting company is sustainability. Previous calculations showed values of greenhouse gas emissions of information technologies in the range of 1.8-2.8%. However, researchers claim that the values of this sector do not correspond to the real impact on the climate. The mentioned document states that the real share of information technologies in global greenhouse gas emissions is in the range of 2.1-3.9%. Older calculations did not take into account the entire life cycle and supply chain of computer

manufacturers and infrastructure, such as energy spent on the production of products and equipment, disposal of equipment, etc. The study also points to a further significant increase in greenhouse gas emissions. New trends in the ICT sector, such as big data, the Internet of Things, cryptocurrencies or artificial intelligence, pose a risk of rising emissions. [2].

Computing technologies are extremely effective in saving labor and increasing the performance of a variety of human activities. Is it indisputable that ICTs increase efficiency in many other sectors, but will lead to savings in net emissions? According to new research, from a historical point of view, it is exactly the opposite. At a time when information technology was becoming more efficient, its carbon footprint was growing relentlessly. So is it possible for the computing sector to become cleaner of greenhouse gas emissions? According to research, this is feasible, but an almost complete transformation of the sector will be needed. [2].

According to them, information, communication and computer technologies will grow so much in the coming years that it will be necessary to consider more what use is key. Only in this way will it be possible to prevent a disproportionate demand for data. At the same time, it is necessary to clearly plan the savings that could be used in both computer technology and related fields - even now, because planning in them is very long-term. [2].

4 Conclusions

The issue of environmental pollution has become increasingly popular in recent years. Due to the creation of a large amount of the greenhouse effect and the associated global warming of the Earth, great emphasis is placed on climate protection. This side effect is created by human activity, it represents. industrial production, combustion of fossil fuels, agriculture, waste storage. At the same time, e.g. waste sorting significantly helps to reduce the impact of human activity on the environment. [4].

The year 2015 was a breakthrough for this area. The UN summit on climate protection took place in Paris, at which the countries of the world undertook to reduce their carbon footprint. The carbon footprint is an indicator of the impact of human activity, presenting the total amount of greenhouse gases generated. At the mentioned summit, the limit of maximum warming was discussed and set - when the average temperature increases, it will not exceed more than 2 ° C compared to the state in comparison with the industrial period.

This article provides information on the issue of man-made air pollution and the associated threat of global warming. The main essence of the article was devoted to the methodology of the carbon footprint, specifically the effects of information technology on the carbon footprint. The paper reported on how information and communication technologies burden the environment with emissions associated with the production, use and disposal of equipment in this area.

References

1. Ci2.co.cz (2016) Co je uhlíková stopa, [Online], Available: https://ci2.co.cz/cs/co-je-uhlikova-stopa [22 Oct 2021].

2. ČT24 (2021) Výpočetní technika má vyšší emise skleníkových plynů, než se očekávalo, [Online], Available: https://ct24.ceskatelevize.cz/veda/3368992-vypocetni-technika-ma-vyssi-emise-sklenikovych-plynu-nez-se-ocekavalo [22 Oct 2021].
3. Enerfis.cz (2020) Uhlíková stopa, [Online], Available: https://www.enerfis.cz/sluzby/uhlikova-stopa/certifikace-uhlikove-stopy [22 Oct 2021].
4. Kozel, R., Sikyr, P. and Barinka, K. (2017) Online education in sorting waste, [Online], Available: https://www.webofscience.com/wos/woscc/full-record/WOS:000461539600032 [22 Oct 2021].
5. Planety.astro.cz (2010) Atmosféra země, [Online], Available: http://planety.astro.cz/zeme/1943-atmosfera-zeme [22 Oct 2021].
6. Pospíšil, R. (2021) Uhlíkovou stopu může významně snížit chytré řízení budov, říká Tomáš Chadim z Domat Control System, [Online], Available: https://www.e15.cz/byznys/e15-a-byznys/uhlikovou-stopu-muze-vyznamne-snizit-chytre-rizeni-budov-rika-tomas-chadim-z-domat-control-system-1383604 [22 Oct 2021].
7. Somrová, B. (2020) Toužíte po ekologickém telefonu? Tak tady je!, [Online], Available: https://www.energyglobe.cz/temata-a-novinky/touzite-po-ekologickem-telefonu-tak-tady-je [22 Oct 2021].
8. Tomek, M. (2018) Honba za velkými displeji zvyšuje uhlíkovou stopu. A přírodu stále více zatěžuje i internet, [Online], Available: https://plus.rozhlas.cz/honba-za-velkymi-displeji-zvysuje-uhlikovou-stopu-a-prirodu-stale-vice-zatezuje-7162304 [22 Oct 2021].
9. Třebický, V. (2016) Metodika stanovení uhlíkové stopy podniku, [Online], Available: https://ci2.co.cz/sites/default/files/souboryredakce/metodika_final_vystup.pdf [22 Oct 2021].
10. Zive.aktuality.sk (2020) Informační technologie ovlivňují klima méně, než si myslíme, [Online], Available: https://zive.aktuality.sk/clanok/145612/informacni-technologie-ovlivnuji-klima-mene-nez-si-myslime/ [22 Oct 2021].

Presentation of Information and Results of Econometric Models Using Information Technology

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Abstract. We consider econometrics as a scientific discipline that applies the tools of statistics and mathematics in the field of economics and uses computer science. The main reasons for the emergence of econometrics were the great economic crisis, criticism of economic research, the use of mathematics and statistics in economics. Thanks to the use of informatics, we can present the achieved results as well as information about econometric models. The achieved results in the form of tables and graphs are displayed with specialized software programs. Some of the most-widely used software packages include Microsoft Excel, Stata, R, SAS, and SPSS. These software programs will be compared in terms of the price of software packages, their features, and the classification of the area of application that describes a particular program. Based on the results, we determine which software is most suitable for certain areas of research.

Keywords: Econometric modeling, Econometric software, Analysis, Prices

1 Introduction

Econometrics is an intersection of three 3 disciplines, namely economics, mathematics, and informatics. To display the results of economics and mathematics, we use informatics through software products that can deal with the analysis of financial data and subsequent econometric modeling. For this article, 5 software from various companies were selected, namely Microsoft Excel, Stata, R, SAS, and SPSS.

The essence of this analysis will be to describe the functions of the software, whether it is a paid or freely available program and for which scientific field it is best used. The source of data for financial econometrics is professional financial agencies (Bloomberg, Center for Research in Security Prices), multinational financial institutions (IMF International Monetary Fund, World Bank WB), statistical offices, central banks, financial databases, but also insurance companies and pension funds [3].

2 Software for econometric modeling- features, prices, and classification

This chapter deals with the analysis of econometric modeling programs with a focus on the description, prices, and classification of the program. Microsoft Excel, Stata, R, SAS, and SPSS were selected for this article.

2.1 Microsoft EXEL

Microsoft Excel is the most widespread and the most used spreadsheet in its class. It is used to create tables and graphs, analyze data, and create lists (databases). In the picture we see the Excel environment, where the most important part is the top panel, which consists of various menu sections (File, insert, home, page layout, formulas, data, review, and developer). Excel is mainly used in econometrics for linear regression.

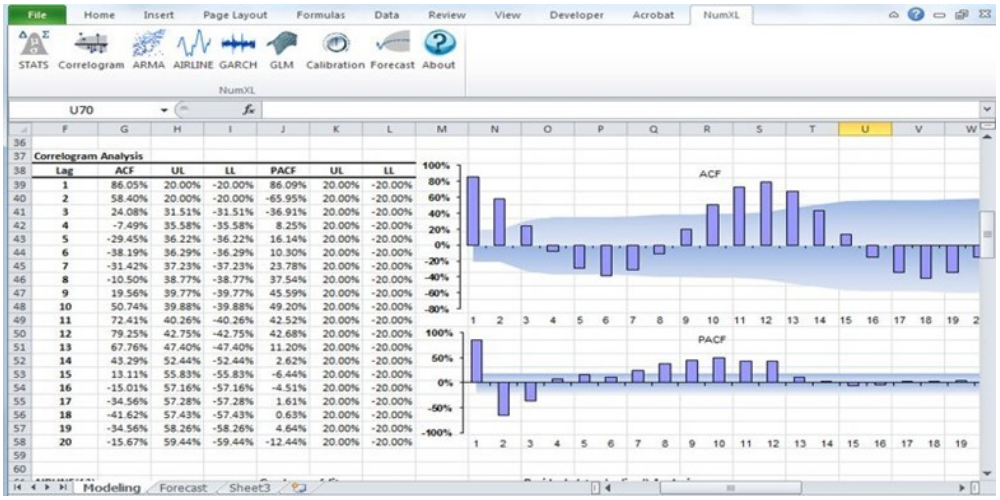

Fig. 1: Microsoft excel window, Source: [6].

Excel must be installed on a device, but it can also be used online using Microsoft 365, divided for home (personal, family) and for business. Microsoft 365 Personal costs 99.99 $ / year (1TB storage) and Microsoft 365 Personal makes $ 69.99 / year, which also has premium security features in the mobile app. Microsoft 365 Business has 4 paid variants, namely Basic ($ 5.00 user / month), Standard (12.50 $ user / month), Premium (20.00 $ user / month) and Apps for business (8.25 $ user / month). The Standard version has extra features: Desktop versions of Office apps with premium features, easily host webinars, attendee registration and reporting tools, manage customer appointments. In the Premium version, we also find advanced security, access, and data control and cyberthreat protection. Microsoft allows students to use office software for free during their studies [6].

2.2 Stata

Stata is a complete, integrated software package that provides all your data science needs-data manipulation, visualization, statistics, and automated reporting. The main part of the program is the top panel (file, edit, data, graphics, statistics, user, and window). The state has the following functions: Master your data, broad suite of statistical features, publication-quality, graphics, automated reporting, truly reproducible research, has with Python integration and real documentation. Used for linear models, forecasting, structural equation modeling. Stata is intended for all scientific disciplines.

Stata has 4 versions of the program (business, government, nonprofit, educational, or student use). Stata Business and Stata Government/nonprofit single-user costs from 765 $ USD per year to 995 $ USD per year. Educational users have two pricing options for single-user licenses- Stata Prof+ Plan pricing for participating universities and discounted educational pricing. The license for the Stata Student single-user ranges from $ 94 USD per year to $ 375 USD per year [8].

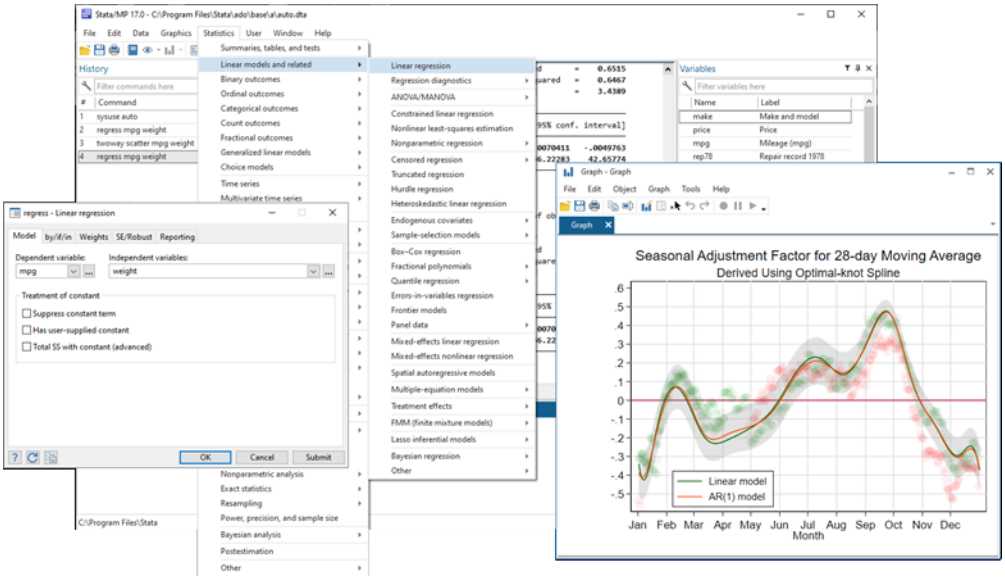

Fig. 2: Stata window, Source: [8].

2.3 R

R project is a software environment where statistical computing and graphics are done. To make R easier to use, you can download RStudio. R is an open source and free econometrics tool and statistical analysis software. It is ductile software, and you can do a wide range of work through this software. R is a mobilized software that provides the facilities of data manipulation, mathematical calculation, and graphical display. The program menu consists of several parts (file, edit, code, view, plots, session, project, builds and tools). R provides a wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, and clustering) and graphical techniques, and is highly extensible. The S language is often the vehicle of choice for research in statistical methodology, and R provides an Open-Source route to participation in that activity [7].

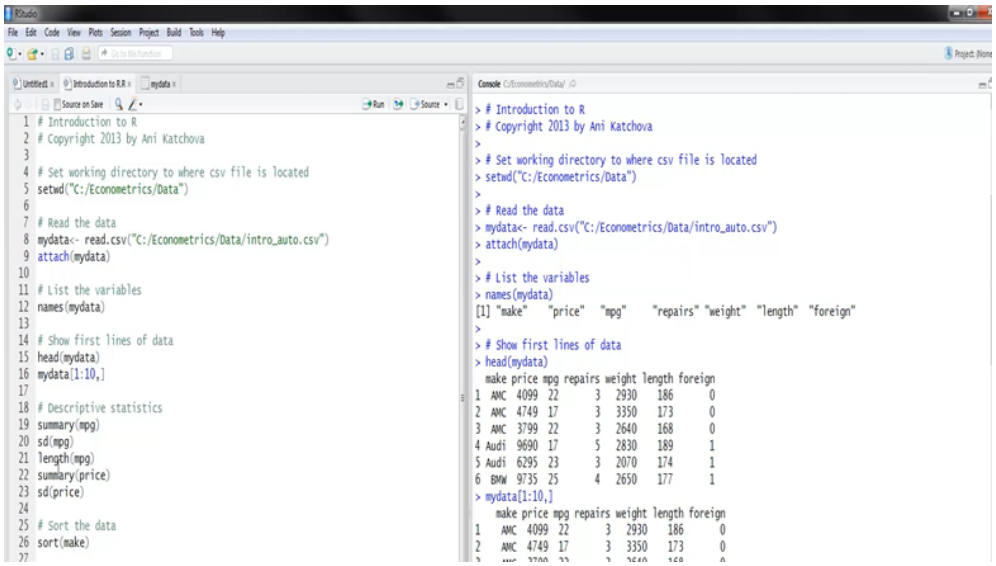

Fig. 3: R window, Source: [7].

2.4 SAS

SAS transforms a world of data into a world of intelligence. The program menu consists of several parts (file, edit, view, tasks, program, and tools). SAS was used originally for statistics application in agriculture projects. But now it's used in various industries from media to retail, education, and finance. In simple words, SAS Programming allows you to process a large chunk of raw data to manageable small sets of data, leading to results which help in decision making.

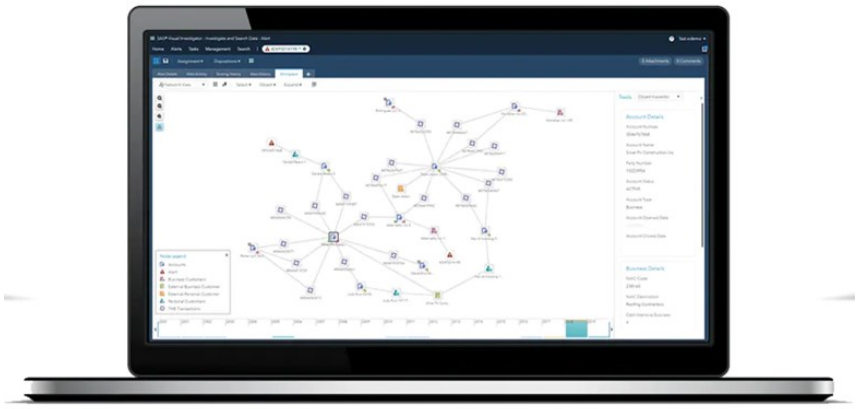

Fig. 4: SAS window, Source: [9].

SAS is free to download and provides free webinars, tutorials, and E-learning. The company has an offer for students and teachers such as SAS®OnDemand for Academics (student, learner, and educator) and SAS® Viya® for Learners (educator) [9].

2.5 SPSS

IBM SPSS Statistics software is a vast library of machine learning algorithms. It reduces pressure and risk factors. This data analysis software is user-friendly and has a modern interface with high statistics analytical capability. IBM SPSS Statistics software will also be helpful for all types of users. The menu consists of parts (file, edit, view, data, transform, insert, format, analysis, direct marketing, graphs, utilities, and window).

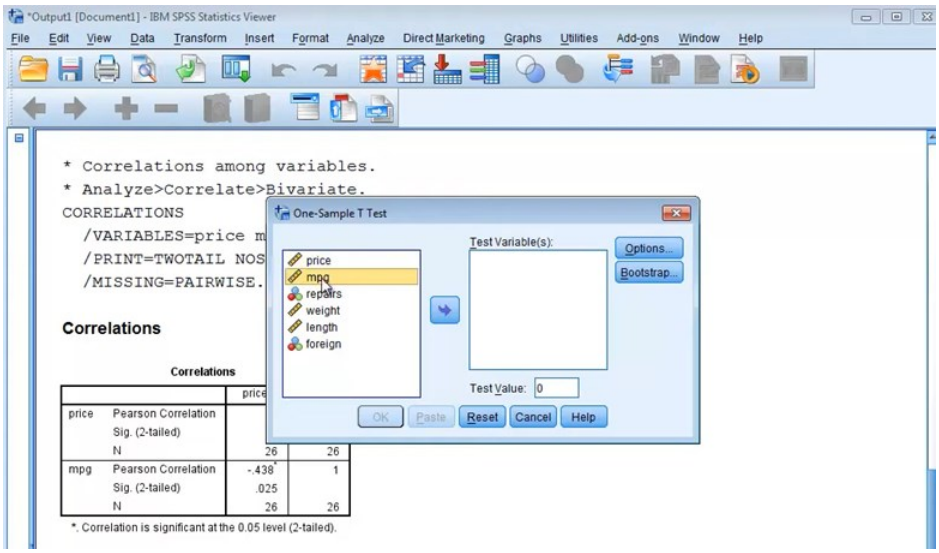

Fig. 5: SPSS window, Source: [5].

IBM has 2 program offers: free trial and subscription. All trial registrants are restricted to one free trial per computer per year. Take advantage of flexible payment plans, monthly or annually. Extend the Base Edition with 3 optional add-ons. Not intended for individual student/faculty use. Starting at 95.53 € per authorized user per month. Universities with an economic focus have a free license for their students [5].

3 Conclusions

This article presents a selection of software that is used for econometric modeling. 5 software programs from different companies (Microsoft Excel, Stata, R, SAS, and SPSS) were selected. The environment and price offer of the programs were described.

Paid programs include Microsoft Excel, Stata, and SPSS. R and SAS programs are free downloadable software. All paid software offers free licenses for students and teachers.

I recommend the Stata software, a program that can be used for all disciplines. The software for the best and most efficient use for econometric modeling is SPSS from IBM. The program selection can be selected using the evaluation set method. [1].

References

1. Kozel, R., Mikoláš M., Vilamová Š. and Očko P. (2017). New methods of designing the balanced scorecard method for management in industrial companies, [Online], Available: [24 Oct 2021].
2. Book:
3. Cipra T. (2009) Finanční ekonometrie ,2nd ed., Praha: Ekopress, 2013.
4. World Wide Web page
5. Ibm.com (2021) IBM -Country – Czech Republic [Online], Available: https://www.ibm.com/analytics/spss-statistics-software [24 Aug 2021].
6. Microsoft.com (2021) Microsoft: Clouds, Computers, Apps and Gaming [Online], Available: https://www.microsoft.com/en-us/ [24 Aug 2021].
7. R-project.org (2021) R: What is R? [Online], Available: https://www.r-project.org/about.html [24 Aug 2021].
8. Stata.com (2021) Stata: Software for Statistics and Data science, [Online], Available: https://www.stata.com/why-use-stata/#close [24 Aug 2021].
9. Sas.com (2021) SAS: Analytics, Artificial Intelligence and Data Management [Online], Available: https://www.sas.com/cs_cz/home.html?gclid=EAIaIQobChMIo9DsvKqw8wIVxO7tCh0cAwJ9EAAYASAAEgKnXfD_BwE [24 Aug 2021]

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INFORMATION MANAGENENT AND INNOVATION

Simulation software - multicriterial evaluation

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Abstract. Today, simulation tools are becoming a widely used part of management information support. Their use can give businesses and companies a competitive advantage. The paper suggests criteria for evaluation and their choosing and compares them for creating dynamic models using two selected methods of multi-criteria decision making. SW tools are compared in the evaluation using seven criteria, which were selected for modelling and simulation in different areas and are important for SME company employees. The aim of this paper is to compare the specific software available that supports the creation of simulation models using selected methods of multi-criteria evaluation. The Saaty method was used to determine the weight of the criteria and the AHP method and the TOPSIS method were used to evaluate the variants.
The results of the application of both methods in the comparison of variants showed that the most suitable software tool for creating applications that facilitate decision-making is Vensim, the second and third positions were occupied by MATLAB and Witness. Rank 2 and 3rd positions differed in the application of the given methods.

Keywords: AHP, criteria, Saaty method, TOPSIS

1. Introduction to the simulation

The growing popularity of simulation models leads to increased demand for simulation tools. Therefore, the choice of the appropriate software tool plays a key role for SME companies. The selection of an inadequate software package can result in significant financial losses and in the disruption of simulation projects. [Hlupic, 1997] In recent years, the selection of the most suitable simulation software to correctly face industrial problems has become vital for companies. Especially SMEs may not have the appropriate tools. (Fumalgali, et al., 2019)

At present, simulation software is being developed and continually innovated within software engineering, which increases the accuracy and reliability of numerical calculations. Bader et al. (2011) said the development of simulation software focused on efficiency and scalability issues with ever-evolving hardware. This paper suggests the criteria for choosing the appropriate software by using the AHP method which includes the 2 hierarchical structures and compares them with the TOPSIS method.

2. Methods for the evaluation

The Saaty method, which is part of the AHP method and can also be part of the TOPSIS method, was chosen to calculate the weights of the criteria.

Analytical Hierarchical Process is based on the evaluation of each group of criteria and subcriteria. By using this method, the global significance for the criteria and local significance for the sub-criteria is calculated. The evaluation of the criteria and sub-criteria represents the following matrix:

	c_1	c_2	c_3	c_n
c_1	1	s_{12}	s_{13}	s_{1n}
c_2	$1/s_{12}$	1	s_{22}	s_{2n}
c_3	$1/s_{13}$	$1/s_{23}$	1	s_{3n}
c_n	$1/s_{1n}$	$1/s_{2n}$	$1/s_{3n}$	1

where $S = \{s_{ij}\}$, where $i, j = 1, 2, \ldots, n$. (1)

$$s_{ij} \approx \frac{w_i}{w_j}, \quad (2)$$

The sum of local significances is equal to 1 (100%). The sum of global significances must also be equal to 1 (100%). When calculating significances, the Saaty matrix of mutual comparison of all criteria to each other is used (Saaty, 1980). The resulting significance is equal to the geometric mean of the product of the individual paired comparisons. Saaty uses the 9-escalate scale of the criteria evaluation (Saaty, 1980) (see Table 1).

Value	Criteria Evaluation
1	equal importance among elements i and j
3	moderate importance of i element before j element
5	strong importance of i element before j element
7	very strong importance of i element before j element
9	the extreme importance element i before j

Table 1 Saaty´scriteria evaluation

The Saaty matrix has two main attributes, reciprocity and consistency. The condition of reciprocity is considered as

$$s_{ij} = \frac{1}{s_{ji}} \quad (3)$$

Consistency is evaluated by the ratio of consistency (CR). The consistency value must be CR < 0.1, where

$$CR = \frac{CI}{RI} \quad (4)$$

where RI is the random index.

When

$$CI = \frac{\lambda_{max} - n}{n-1} \approx \frac{w_i}{w_j}\ , \tag{5}$$

where λ_{max} is the own number and n is number of criteria.

We determine the weight of each criterion according to the geometric mean

$$w_i = \frac{\left(\prod_{j=1}^{n} s_{ij}\right)^{1/n}}{\sum_{j=1}^{n}\left(s_{ij}\right)^{1/n}} \tag{6}$$

The final option rating is then expressed in the following relationship.

$$U_i = \sum_{j=1}^{k} u_{ij} \times w_j \tag{7}$$

Where Ui represents the general significance of variant I with respect to the objective of the decision-making process, uij expressed the significance of the variants for the individual criteria and wj expresses the significance j of that criterion (Bazsová, 2015).

3. Results and discussion

The input data are shown in Table 2. They were collected from the websites Seven criteria were set, which were subsequently assessed.

Criteria	Variants					
	MATLAB	Powersim Studio	Vensim	Witness	AnyLogic	FlexSim
Price	2 000 €	3 000 €	50 €	2 085 €	13 950 €	16 500 €
Ease of use	4,0 (z 5)	4,3	3,7	3,9	3,9	4,1
Customer support	4,2 (z 5)	3,3	3,6	4,4	4,2	4,6
Tutorials	3	1 (min)	3	5 (max)	4	4
3D projection	yes	no	no	yes	yes	yes
Dynamics modelling	no	yes	yes	yes	yes	yes
Areas of use	big	small	middle	middle	middle	middle

Table 2 Basic information about the software products. (Own processing)

For the preparation of the evaluation by using the AHP method, it is necessary to create the tree of criteria. It has chosen 3 global criteria: price and use of SW, function, and user complexity. After that has chosen the second level, partial criteria, price, using of the software, dynamics modelling, 3D projection, ease of use, tutorials, customer support.

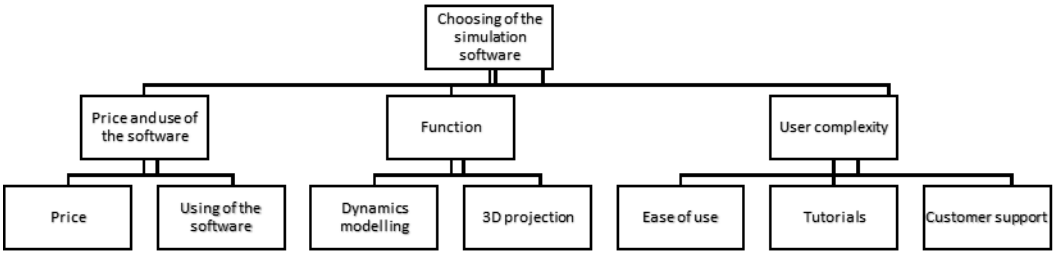

Figure 1 Tree of the criteria according for AHP evaluation.

The mutual comparison of the importance of the seven proposed criteria can be compared using a scale, which in this case was 9 degrees. Table 3 shows the mutual evaluation of the importance of the proposed criteria using the Saaty matrix. The results in Table 2 show that the most important for the user is the price (0.417), second is the dynamics modelling (0.200), and the least important is the customer support (0.021).

Criteria	Price	Using of the SW	Dynamics modelling	3D projection	Ease of use	Tutorials	Customer support	Geomean	Weight
Price	1	5.00	4.00	7.00	5.00	7.00	9.00	4.608	0.417
Field of application	0.20	1	0.33	5.00	0.50	5.00	9.00	1.334	0.121
Dynamics modelling	0.25	3.00	1	7.00	2.00	5.00	5.00	2.216	0.200
3D projection	0.14	0.20	0.14	1	0.20	0.33	3.00	0.361	0.033
Easy of use	0.20	5.00	0.33	5.00	1	5.00	7.00	1.788	0.162
tutorials	0.14	0.20	0.20	3.00	0.20	1	3.00	0.519	0.047
Customer support	0.11	0.11	0.20	0.33	0.14	0.33	1	0.234	0.021

Table 3 Saaty´ matrix. (Own calculation)

The results using the Saatys matrix for preparing criteria applying the TOPSIS method showed that the most important is the price of the criteria (0.833)

Criteria	Geomean	Weight
Price and field of application	2.466212	0.6370
Function	0.40548	0.1047
User Complexity	1	0.2583

Price	2.236067977	0.8333
Field of application	0.447213595	0.1667
Dynamics modelling	0.447213595	0.1667
3D projection	2.236067977	0.8333
Ease of Use	2.466212	0.6370
Tutorials	1	0.2583

Table 4 Results of the Saaty matrix for evaluation by the TOPSIS method. (Own processing)

The results of the global weights by applying the AHP method are shown in Figure 2. The global weight 0.637 achieved price and use of the software, in the second place, is User complexity (0.258) and Function has the least global weight 0.105.

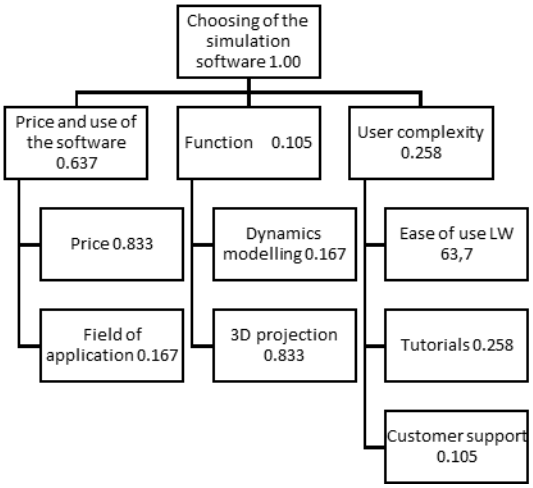

Figure 2 Results of the local and global weights by using the AHP method. (Own processing)

The evaluation of the simulation software according to the seven criteria assessed shows Table 5. Results in the first row are negative because they should be converted because of the direction of the whole criteria.

Normalization by weights					
V1	**V2**	**V3**	**V4**	**V5**	**V6**
-0.0222	-0.0333	-0.0006	-0.0231	-0.1547	-0.1829
0.0377	0.0075	0.0188	0.0188	0.0188	0.0188

0.0182	0.0364	0.0364	0.0364	0.0364	0.0364
0.0065	0.0033	0.0033	0.0065	0.0065	0.0065
0.0271	0.0291	0.0250	0.0264	0.0264	0.0277
0.0070	0.0023	0.0070	0.0117	0.0094	0.0094
0.0037	0.0029	0.0031	0.0038	0.0037	0.0040

Table 5 Results of the TOPSIS method

The results in Table 6 show the searched minimum as the base variant and the searched maximum as the ideal variant for a given criterion.

Base variant	**Ideal variant**
0.1829	-0.0006
0.0075	0.0377
0.0182	0.0364
0.0033	0.0065
0.0250	0.0291
0.0023	0.0117
0.0029	0.0040

Table 6 Base and ideal variant according to the TOPSIS method (own processing)

Table 7 shows the evaluation of the distance according to each criterion. Distances are very low.

V1	V2	V3	V4	V5	V6
0.02584	0.022399	0.033258	0.025538	0.000799	0
0.000909	0	0.000128	0.000128	0.000128	0.000128
0	0.000332	0.000332	0.000332	0.000332	0.000332
1.06E-05	0	0	1.06E-05	1.06E-05	1.06E-05
4.12E-06	1.65E-05	0	1.83E-06	1.83E-06	7.32E-06
2.2E-05	0	2.2E-05	8.79E-05	4.95E-05	4.95E-05
6.16E-07	0	6.84E-08	9.2E-07	6.16E-07	1.29E-06

Table 7 Distance from basal and ideal variants by using TOPSIS method. (Own processing)

Table 8 shows the distance from the base and ideal variants with the inclusion of the weights of the criteria. As you can see in Table 8, the base variants have been evaluated mainly according to criteria 3.

V1	V2	V3	V4	V5	V6	V1	V2	V3	V4	V5	V6
0.02584	0.022399	0.033258	0.025538	0.000799	0	0.000467	0.00107	0	0.000509	0.023746	0.033258
0.000909	0	0.000128	0.000128	0.000128	0.000128	0	0.000909	0.000355	0.000355	0.000355	0.000355
0	0.000332	0.000332	0.000332	0.000332	0.000332	0.000332	0	0	0	0	0
1.06E-05	0	0	1.06E-05	1.06E-05	1.06E-05	0	1.06E-05	1.06E-05	0	0	0
4.12E-06	1.65E-05	0	1.83E-06	1.83E-06	7.32E-06	4.12E-06	0	1.65E-05	7.32E-06	7.32E-06	1.83E-06
2.2E-05	0	2.2E-05	8.79E-05	4.95E-05	4.95E-05	2.2E-05	8.79E-05	2.2E-05	0	5.5E-06	5.5E-06
6.16E-07	0	6.84E-08	9.2E-07	6.16E-07	1.29E-06	1.22E-07	1.29E-06	7.6E-07	3.04E-08	1.22E-07	0

Table 8 Distance from base and ideal variants by using TOPSIS method. (Own processing)

Table 9 shows the values and order of the variants using the base and ideal level. The first order achieved variant V3 (Vensim SW).

Base variants	v-	0.164	0.151	0.184	0.162	0.036	0.023
Ideal variants	v+	0.029	0.046	0.020	0.030	0.155	0.183
	zi	0.851	0.768	0.901	0.846	0.190	0.111
	Order	**2**	**4**	**1**	**3**	**5**	**6**

Table 9 Base and ideal variants assessment. (Own processing)

Table 10 shows the calculation of the global weights and the assessment according to the criteria. The highest value has been achieved at criteria C1 as expected.

	V1	V2	V3	V4	V5	V6	Global Weights
C1	0.02	0.02	0.93	0.02	0.00	0.00	53.08%
C2	0.31	0.06	0.16	0.16	0.16	0.16	10.62%
C3	0.09	0.18	0.18	0.18	0.18	0.18	1.75%
C4	0.20	0.10	0.10	0.20	0.20	0.20	8.73%
C5	0.17	0.18	0.15	0.16	0.16	0.17	16.45%
C6	0.15	0.05	0.15	0.25	0.20	0.20	6.67%
C7	0.17	0.14	0.15	0.18	0.17	0.19	2.71%

Table 10 Variants Assessment by using AHP method. (Own processing)

Table 11 shows the weighted evaluation of the variants. Variant 3 (Vensim SW) shows the highest value of the evaluation according to the seven criteria (0.536), the second position occupied variant V1 (Matlab SW, 0.107) and third position achieved variant V4 (Witness SW, 0.098)

	V1	V2	V3	V4	V5	V6
C1	0.012	0.008	0.495	0.012	0.002	0.002
C2	0.033	0.007	0.017	0.017	0.017	0.017
C3	0.002	0.003	0.003	0.003	0.003	0.003
C4	0.017	0.009	0.009	0.017	0.017	0.017
C5	0.028	0.030	0.025	0.027	0.027	0.028
C6	0.010	0.003	0.010	0.017	0.013	0.013
C7	0.005	0.004	0.004	0.005	0.005	0.005
Total	0.107	0.063	0.563	0.098	0.084	0.085
Order	2	6	1	3	5	4

Table 11 Evaluation and order of the variants by using AHP method. (Own processing)

Except for the first criteria (price), all the rest criteria were maximized. We have to make normalization and convert the first criterion on the maximizing.

	Order according to the TOPSIS	Order according to the AHP
1	Vensim	Vensim
2	Witness	Matlab
3	Matlab	Witness
4	Powersim Studio	FlexSim
5	AnyloGic	AnyloGic
6	FlexSim	Powersim Studio

Table 12 Order of simulation software when applying TOPSIS and AHP method. (Own processing)

As we can see in Table 12, the first position has not changed in both evaluations. The order of the second and third positions has changed using various evaluations. Powersim studio achieved the fourth position, while by AHP evaluation it was the last.

When applying the AHP method, it enables us to create the criteria and sub-criteria which were described by using Decision 3. The TOPSIS method does not recognize the structure of the criteria, it places the criteria on one basic level and compares them with each other. It is hardly to say what is better, if the comparison with the structure, resp. three or the comparison on one basic level. The results of both methods have evaluated Vensim SW as the best appropriate software for the work with dynamic models. As an alternative was offered the Witness or Matlab (2nd and 3rd place).

4. Conclusion

Decision making is possible to implement practically in all areas of life. This evaluation and subsequent comparison were used by choosing the simulation software. The simulation software was based on the seven criteria evaluated. Six representative simulation software were selected. Two methods, TOPSIS and AHP, were used for the evaluation of the variants. The AHP method enables us to create the criteria and subcriteria which was described by using Decision 3. The TOPSIS method does not recognize the structure of the criteria; it places the criteria on one basic level and compares them with each other. It is hardly to say what is better if the comparison with the structure, resp. three or a comparison on one basic level. The results of both methods have evaluated Vensim SW as the best appropriate software for the work with dynamic models. As an alternative, the Witness or Matlab (2nd and 3rd place).

Acknowledgements

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References

1. Bader, M., et al (2011) ‘Simulation software for supercomputers‘. *Journal of computational science*, vol. 2 no. 2, pp. 93-94.
2. Bazsová, B. (2016) ‘Proposal and Evaluation of the Competency Model of the Academic Employee‘. *Proceedings of the International Scientific Conference Quantitative Methods in Economics, Vrátna, Slovakia, pp. 25-32*.
3. Ramík, J. and Perzina, R. (2008) *Moderní metody hodnocení a rozhodování*, *Karviná: Slezská univerzita v Opavě.*
4. Bazsová, B. and Štěpán, M. (2020) ‘Use of the TOPSIS method in ICT purchasing decisions‘.*Proceedings of the 23nd International Conference on Information Technology for Practice , Ostrava, Czech Republic*, pp. 53-62.
5. Capterra (2021) *Simulation Software*, [Online], available: https://www.capterra.com/simulation-software/ [24 September, 2021].
6. Fumagali et al (2019) ‘Framework for simulation software selection‘. *Journal of simulation*, vol. 13, no. 4, pp. 286-303.
7. Hlupic, V. (1997) ‘Simulation software selection using SimSelect‘. *Simulation*, 69(4), pp. 231-239.
8. Saaty, T. L. (1980) *The analytic hierarchy process: planning, priority setting, resource allocation*. London: Mc Graw-Hill International Book Co.

Cloud storage selection model

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Abstract. Using cloud storage is a very interesting opportunity for companies that want to simplify their computer infrastructure. The essence of cloud computing is that the applications that company employees need for their work are located on the Internet. The aim of the paper is to analyze, evaluate, and select a suitable cloud storage for the company X, from the range of storage offered by providers on the market in the Czech Republic. Cloud storage is selected using multi-criteria evaluation, specifically the AHP method. The results showed that the most suitable form of cloud storage is Mega. The evaluation was based on 3 groups of criteria, economic, technical, and data protection.

Keywords: Analytical hierarchical process (AHP), cloud, criteria, evaluation, variants

1. Introduction

The cloud is also becoming more and more popular with companies that work with applications and functions on their end stations on a daily basis. Cloud leads to cost savings associated with the operation of IT and computer network in the company, but also network administrators. The most common form of cloud computing is a remote data center that provides the application and continuously updates and controls it. The company hosting the applications does not have to worry about updating applications, purchasing and managing them, as well as archiving, resp. Data Backup. The advantage of cloud computing is that it is not necessary to have installation disks in the company and install the necessary application for each computer station, but it is possible to rent this service from a company that runs this application on its server, performs its regular update and maintenance, and bears costs associated with the maintenance and insurance of this server. According to Lacko (2012), cloud computing means the use of computing technologies outside the home or corporate network.

Cloud systems are tools and software for cloud computing that are deployed on the Internet or in a cloud computer network. Users can use them at any time. Looking at history, Eric Schmidt, the CEO of Google, first used the term in 2006. Since then, the SaaS infrastructure (Software as a Service applications and from Google applications or S3 / EC2 services offered by Amazon) has been commonly offered. Pochyla, 2011)

According to Vaquero et al. (2008), the main principle of the cloud is user friendliness, the concept of massive data scalability is important, and the cloud has been defined as virtualized hardware and software plus previous monitoring and delivery technologies.

Due to the benefits of this environment, the cloud is globally considered a standard environment for individuals and the corporate sector. Cloud reduces capital expenditures and helps companies achieve their strategic goals. Cloud provides secure, accessible, and manageable services not only for large and medium-sized companies but also for small businesses and individuals. The basic structure is shown in Figure 1. However, the cloud can also be a security threat to businesses and individuals. It may slow down computational operations. Allocating resources in the cloud is difficult because resources provide numerous measures of service quality. With a growing organization (company), the transition to the cloud becomes more complicated.

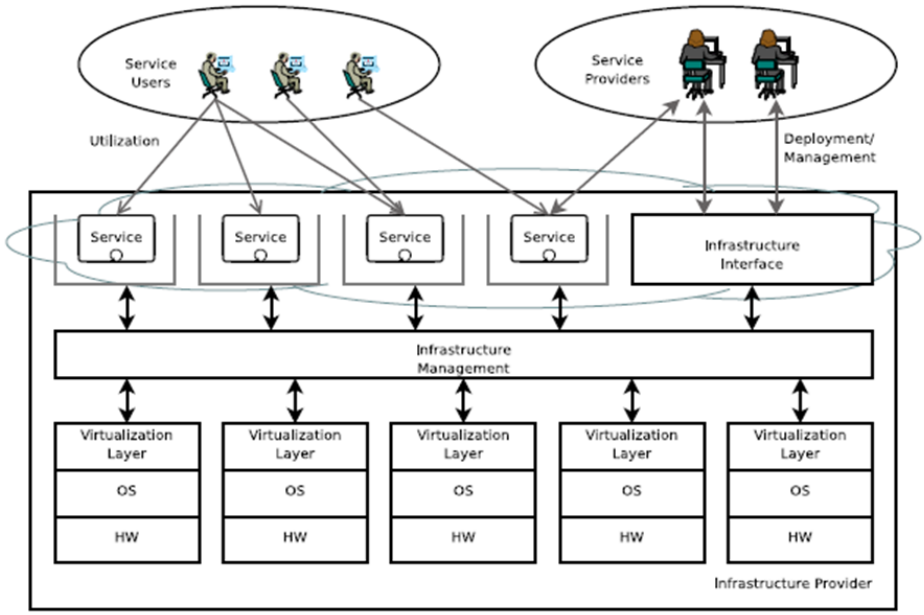

Figure 1 Fundament of the cloud, source: VAQUERO, et al., 2008

When evaluating and selecting cloud providers, customers mainly measure its availability, the diversity of services provided, the performance of the cloud, and, of course, the price for mediation. According to Vele, Velte, and Elsenpeter (2011), one of the technical requirements for the cloud is comparing especially the connection speed to the server, delay length, deployment latency, data storage deletion time, data storage read time.

We can classify two groups of criteria, economic and technical criteria. We can include other sub-criteria in these two groups, which are shown in Table 1.

Table 1 Basic group of criteria for evaluating cloud selection, own processing

Quantitative criteria	Monthly fee
Qualitative criteria	Monthly for 1 GB
	Free space
	File versioning
	File encryption
	Maximum file size
	Upload
	Download

2. Analytical hierarchical proces (AHP)

Analytical Hierarchy Process (AHP) is a method of multi-criteria evaluation. It is based on a definition of each group of criteria and sub-criteria and an assessment of their importance - global significance for the criteria and local significance for the sub-criteria. The hierarchical structure represents the system and its elements, which are grouped and each element influences other elements (Ramík and Perzina, 2008). According to Shejbal (2006) the top of the hierarchy contains one element, which is the objective of the evaluation. The AHP method is first based on the evaluation of the criteria to which the weight is assigned. The higher the weight of a given criterion, the higher the importance of this criterion. The weights of the criteria can be evaluated according to several methods. For our research, we chose the Saaty method, which is based on the selection of a scoring scale. Based on the evaluation of the criteria, the evaluation of variants follows. For this research, 6 variants were selected, which represent the possibility of storing data in a cloud environment, which is called Box, Dropbox, Google Drive, Mega, Microsoft One Drive, Yandex Disk. Table 2 describes the basic characteristics of individual cloud storages, according to which the evaluation criteria of the mentioned variants were established. As can be seen from this table, eight criteria have been defined: free space, file versioning, file encryption, monthly payment per 1 GByte, maximum file size, upload and download (see Table 2)

Table 2 Characteristics of basic input data, source: Kilián, 2020; Novák, 2021

Properties	Box	Dropbox	Google Drive	Mega	Microsoft OneDrive	Yandex Disk
Free space	10 GB	2 GB	15 GB	15 GB	5 GB	10 GB
File versioning	only with subscription	until 30 days	30 days or 100 changes	yes	yes	ne
File encryption	yes	yes	yes	yes	ne	ne
Monthly for 1 GB	2.3 CZK	0.16 CZK	0.6-0.3 CZK	0.64-0.1 CZK	1-0.05 CZK	0.27-0.07 CZK

Max file size	5 GB	unlimited	5 TB	unlimited	15 GB	10 GB
Upload	8.2 Mb/s	7.6 Mb/s	6.05 Mb/s	7.8 Mb/s	12.5 Mb/s	5.67 Mb/s
Download	31.2 Mb/s	30 Mb/s	68.4 Mb/s	27.3 Mb/s	50 Mb/s	4.55 Mb/s
Monthly fee	starter: 120 CZK full version: 360 CZK	266 CZK	60-3000 CZK according to the storage	133 CZK 266 CZK 533 CZK 799 CZK	50 CZK 189 CZK 269 CZK	10.86 CZK 36 CZK 109 CZK

The characteristics important for further evaluation, in particular the direction of the criterion and the type of data, whether quantitative or qualitative is listed in Table 3 (see Table 3).

Table 3 Characteristics of input data, own processing

Name of the criteria	Orientation	A1	A2	A3	A4	A5	A6	Units	Type of data
Free space	max	10	2	15	15	5	10	GB	quantitative
File versioning	max	With subscription	30 days	30 days	yes	yes	no		qualitative
File encription	max	yes	yes	yes	yes	no	no		qualitataive
Monthly for 1 GB	min	2.3	0.16	0.45	0.37	0.525	0.17	CZK	quantitative
Maximum file size	max	0.005	100	5	100	0.015	0.01	TB	quantitative
Upload	max	8.2	7.6	6.05	7.8	12.5	5.67	Mb/s	quantitative
Download	max	31.2	30	68.4	27.3	50	4.55	Mb/s	quantitative
Monthly fee	min	120	266	60	133	50	10.86	CZK	quantitative

At first, two groups of criteria were considered, but based on expert assessment, these two groups of criteria were subsequently reworked and three groups were created: economic criteria, data transfer criteria, and data protection and storage. (Table 4).

Table 4 Criteria tree according to the AHP method, own processing

Criteria		Sub-criteria	
C1	Economical criteria	C11	Monthly for 1 GB
		C12	Minimal monthly fee
C2	Data transfer	C21	Upload
		C22	Download
C3	Data protection and storage	C31	Free space
		C32	File encription
		C33	File versioning
		C34	Maximum file size

Table 4 classifies criteria into main criteria and sub-criteria. It is clear from Table 5 that the third group of criteria - data protection and storage - is of the most importance.

Table 5 Evaluation of criteria using the Saaty method, own processing

	Geomean	Local weights
Economical criteria	0.928	0.199
Data transfer	0.311	0.067
Data protection and storage	3.420	0.734

Table 6 evaluates the individual variants using the given criteria and determines the global weights. File encryption reached the highest global weight (44.31%), followed by file versioning (18.8%) followed by a minimum monthly subscription (15.94%).

Subsequently, the order of the clouds considered was evaluated in Table 6 is follows. Mega Cloud was ranked first, followed by Dropbox, and Yandex Disc came in third. Google Drive achieved the fourth position and Box the fifth position. Microsoft OneDrive finished in sixth place.

Table 6 Evaluation of variants using the AHP method, own processing

Sub-Cr	Global Weights	V1	V2	V3	V4	V5	V6
SubC11	**2.88%**	0.005	0.001	0.008	0.008	0.003	0.005
SubC12	**18.80%**	0.035	0.023	0.023	0.047	0.047	0.012
SubC21	**44.31%**	0.089	0.089	0.089	0.089	0.044	0.044
SubC22	**3.99%**	0.001	0.013	0.005	0.006	0.004	0.012
SubC31	**7.42%**	0.000	0.036	0.002	0.036	0.000	0.000

SubC32	**1.66%**	0.003	0.003	0.002	0.003	0.004	0.002
SubC33	**5.01%**	0.007	0.007	0.016	0.006	0.012	0.001
SubC34	**15.94%**	0.009	0.004	0.018	0.008	0.021	0.099
	Sum:	**0.149**	**0.176**	**0.162**	**0.202**	**0.135**	**0.175**

The final three evaluation by using AHP method is displayed at the Figure 2.

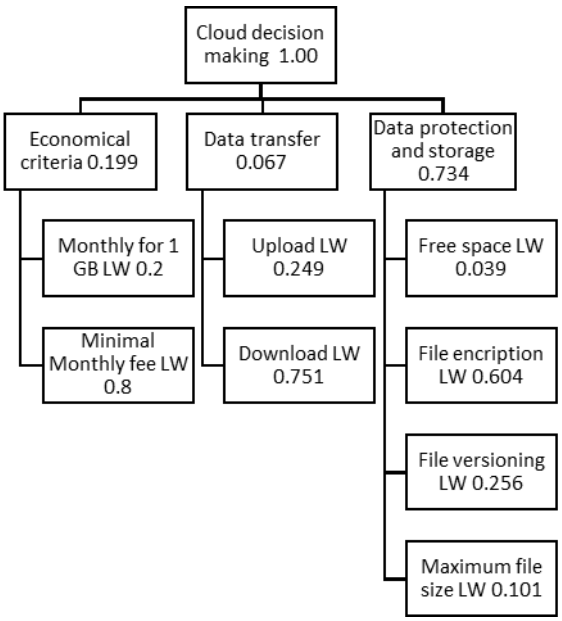

Figure 2 Decision three results by using AHP method, own processing

3. Conclusion

This survey proved the possibility of implementation of decision-making theory into decision making in the field of cloud computing. The results showed the evaluation among the six alternatives. The optimal resolution was influenced by three groups of main criteria and eight particular criteria. The best result was achieved at alternative No. 4 – Mega. The usefulness 0.202 was achieved.

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References

1. KILIÁN, Karel, 2020. Porovnání deseti cloudových disků: kam a za kolik uložit 100 GB, 1 TB a 10 TB dat? https://www.zive.cz/clanky/porovnani-deseti-cloudovych-disku-kam-a-za-kolik-ulozit-100-gb-1-tb-a-10-tb-dat/sc-3-a-205481/default.aspx#part=1
2. LACKO, Ľuboslav (2012). Osobní cloud pro domácí podnikání a malé firmy. Brno: Computer
3. NOVÁK, Petr. Cloudové úložiště 2021: Srovnání Dropbox, OneDrive a Google Drive, [Online]. Available: https://www.skrblik.cz/telefon/internet/cloudova-uloziste/ [14 Sep 2021].
4. POCHYLA, Martin (2011). Cloud computing: A Paradigm Shift for small and Medium Business. ECON ´11: journal of economics, management and business, 2011. Ostrava: Technical university, pp. 128-138.
5. RAMÍK, Jaroslav and Radomír Perzina (2008). Moderní metody hodnocení a rozhodování. Karviná: Slezská univerzita v Opavě.
6. SHEJBAL, Jaroslav. Realizace metody AHP v prostředí tabulkového kalkulátoru. Pardubice, 2006. Diplomová práce. Univerzita Pardubice. Fakulta ekonomicko-správní. Ústav systémového inženýrství a informatiky.
7. VELTE, Anthony T., Toby J. VELTE and Robert C. ELSENPETER (2011). Cloud Computing: praktický průvodce. Brno: Computer Press.
8. VAQUERO, L.M. et al (2008). A break in the clouds: towards a cloud definition, [Online], SIGCOMM Comput. Commun. Rev. 39, 50–55. Available: https://doi.org/10.1145/1496091.1496100 [12 Sep 2021].

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How self-service Business Intelligence applications increase the efficiency of production management

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Abstract. Using Self Service Business Intelligence (SSBI) applications is often chosen in business practice for fast, self-service, low-cost, variable, easy-to-replace, add-on, and reliable data solutions. When combined with online data queried from the SQL database server, SSBI reports are an effective tool for increasing efficiency of production management. This work describes examples of good practice where the processed reports increased the efficiency of work in planning and managing custom production. In particular, the use of Power Query functionalities in combination with data modeling in Power Pivot is described, the results of which are clear visualizations for daily work.

Keywords: Efficiency, Production Management, Self Service Business Intelligence, Data Modelling

1 Introduction

In any activity, the economic objective is to use all resources efficiently. Production management is primarily concerned with production management, which is concerned daily with the preparation of plans according to the requirements of the enterprise, the use of capacity in production, meeting deadlines according to plan, cooperation, quality control, etc. The structure, content and functions of production management are not universally given and are always conditioned by the typology of the enterprise. This statement is particularly true in the case of structured custom production of a wide portfolio of technologically demanding products consisting of many manufactured components and the necessary cooperation.

Records on planned and realized production are collected in enterprise information systems in different structures according to the functionality provided by the information system. These are the transactional databases of the Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES) modules. The basic integration between these information systems in the transmission of data on the started and ended work operation is the minimum prerequisite for their uniform functioning. Thus, some data is transferred between them, but this is insufficient to provide comprehensive information for production management.

Howson (2014) summarized that Business Intelligence (BI) is a broad and popular topic that refers to the knowledge, processes, technologies, applications, and practices that facilitate business decision making. To design and implement a complex sophisticated management information system using BI tools is quite challenging in terms of time, people,

knowledge, and money. Such an implementation is carried out by a professional information systems vendor, which requires intensive involvement of the most experienced people in the company. Unless all production processes in the company are perfectly and comprehensively mapped, this costly implementation is also quite risky.

In a broader sense, efficiency means the elimination of waste of scarce resources (including their non-use, if available) and their use in production in a way that is closest to the company's objective, which is usually considered to be profit generation (Keřkovský and Valsa, 2012). To manage the often time-varying production process, tools need to be used appropriately in a way that is understood and respected across production management and production workers. Self Service Business Intelligence (SSBI) tools are ideal for this purpose and their proper deployment in production management saves the company money, increases the efficiency of production management, and improves collaboration with production workers.

Microsoft Office is commonly used in enterprises, and SSBI tools such as Power Query and Power Pivot are available by default in Excel 2019.Power Pivot is an Excel add-in that is used to perform powerful data analysis and create sophisticated data models (MICROSOFT, 2021). Thus, you just need to use these tools. It is fast, inexpensive, and easy to understand for both administrators and users.

SSBI is therefore a " golden mean " between having only separate information systems without enough up-to-date information or implementing a costly management information system with BI tools. This paper describes the main elements of SSBI implementation in production management using a Czech production company as an example. Thus, the now standard computing technology is described, but what is unique is the procedure to obtain information at a good price and use it to manage production more efficiently.

2 Data flow in the production process and supporting architecture for data model processing in SSBI

Even businesses that have long produced globally competitive goods and services have great potential to make better use of data. The production process is a key part of the enterprise value chain (Tomek and Vávrová, 2014). Therefore, working with data and turning it into information for production management and profit generation is very important.

Before using the tools from the so-called "Power Soup" by Collie and Singh, (2015) in Figure 1, it is first necessary to map the data flow in transactional information systems to obtain the necessary tabular resources for data modelling.

There are available four information systems and these are ERP, MES (Production planning and Collection data in production) and attendance system. These database information systems are installed on a dedicated SQL server which manages the databases and shares the applications on the network for the clients. Only the necessary data transfer integration between ERP and MES is currently performed within the database integration in the SQL server. Such as the production order codebook and the related products and their production operations, including the workplace codebook, or the transfer of data on started and completed work operations.

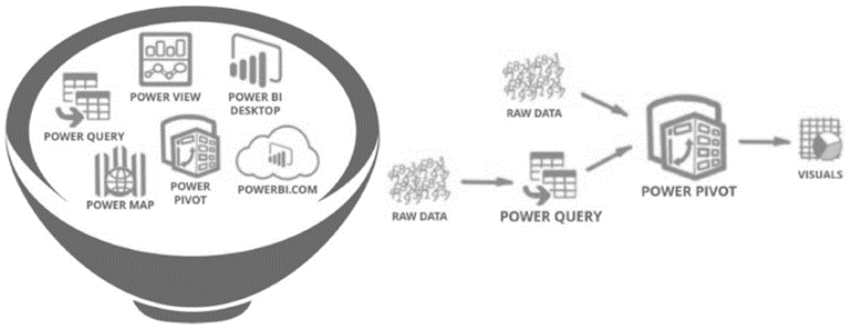

Figure 1 Power Soup“, Source: Collie and Singh, 2015.

The information systems only provide the user with partial data for one single order and then the user (production managers, foremen, planners, controllers, etc.) must "click and click" to get information for the next order. With a daily volume of several hundred production operations, it was almost impossible to manage everything clearly and predict possible problems and delays.

Before creating the data model, the links between the individual information systems were first mapped. For a simplified view, the basic data flow between them is plotted in Figure 2. It then shows how the data is processed into the data model and used in production control using Power Query and Power Pivot tools and SQL queries. These different main data processing parts are numbered in the diagram in steps 1 to 8.

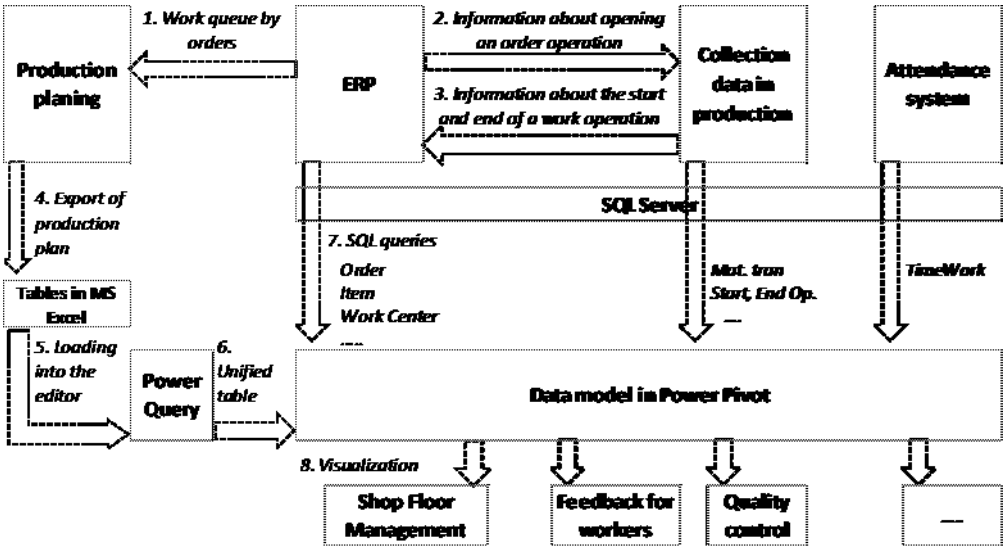

Figure 2 Data flow diagram and transformation, Source: own

1. Work queue by orders

In the ERP system, order requests and their operations are continuously opened based on orders from customers or internal orders according to inventory maintenance. The queue of these orders is transferred via a data pump to production planning, where the production planner creates weekly schedules for all workstations.

2. *Information about opening an order operation*

Automatic transfer of data of open orders and their operations to the Collection data in production system.

3. *Information about the start and end of a work operation*

Automatic transfer of data on the start and (complete) completion of the order operation back to the ERP. The completed operation is then in the ERP.

4. *Export of production plan*

The Production planning system can only export the resulting tables with individual workplace plans to the source excel spreadsheet for now. Each workplace has its own table in a separate sheet. As shown in Figure 3.

Figure 3 Sheets in excel source from Production planning, Source: own

5. *Loading to the editor*

The individual tables in the sheets are loaded into the Power Query editor into a separate additional excel file.

6. *Unified table*

The Power Query editor unifies 21 tables into one common table. The result is shown in M language in Figure 4.

7. *SQL queries*

Standard SQL queries are used to display online data quickly and reliably from information systems, such as: code lists from ERP, complete material, and time (including partial shutdowns and production overhead) transactions from Collection data in production, or a table of worker times from the Attendance system. The tables are then part of the data model.

```
let
    Zdroj = Excel.Workbook(File.Contents([redacted]
        \Plánování\PQ_PJ\PQ_PJ.xlsx"), null, true),
    Lasery_Trul_Table = Zdroj{[Item="Lasery_Trul",Kind="Table"]}[Data],
    #"Změněný typ" = Table.TransformColumnTypes(Lasery_Trul_Table,{{"Zakázka", type text},
        {"Výrobek", type text}, {"Popis výrobku", type any}, {"Množství", Int64.Type},
        {"Deadline zakázky", type text}, {"Termín start", type text}, {"Vstup do stroje",
        type datetime}, {"Výstup ze stroje", type datetime}, {"Trvání operace", type text},
        {"Plech/Stroj/Ks", type text}, {"Splnění termínu [Dny]", type text}, {"Column12",
        type any}, {"Stroj", type text}, {"Číslo operace", Int64.Type}}),
    #"Připojený dotaz" = Table.Combine({#"Změněný typ", Brouseni, Jehlenir, #"Irisky a
        Navarovaci laser", Lakovna, Lakovna_1, #"Mokre lakovani", Nytovani, Odmasteni,
        Ohranovani, #"Roboticke ohranovani", Rovnani, Sitotisk, Svarovani, #"Trumatic 7000",
        Vrtani, #"Trumpf 5000", #"Kontrola Press", Hexagon, Maskovani}),
    #"Filtrované řádky" = Table.SelectRows(#"Připojený dotaz", each true),
    #"Odebrané prázdné řádky" = Table.SelectRows(#"Filtrované řádky", each not List.IsEmpty
        (List.RemoveMatchingItems(Record.FieldValues(_), {"", null}))),
    #"Změněný typ1" = Table.TransformColumnTypes(#"Odebrané prázdné řádky",{{"Číslo operace",
         type text}})
in
    #"Změněný typ1"
```

common columns

unified tables

✓ Nebyly zjištěny žádné chyby syntaxe.

Figure 4 M-language syntax for unified tables, Source: own

Data model in Power Pivot

The collected tables are processed in the Power Pivot data model using relations into a multidimensional model containing 11 dimensions and 3 fact tables. It can be concluded that the Power Pivot interface is user-intuitive, and many useful visualizations can be obtained from it. The multidimensional model in Power Pivot is shown in Figure 5.

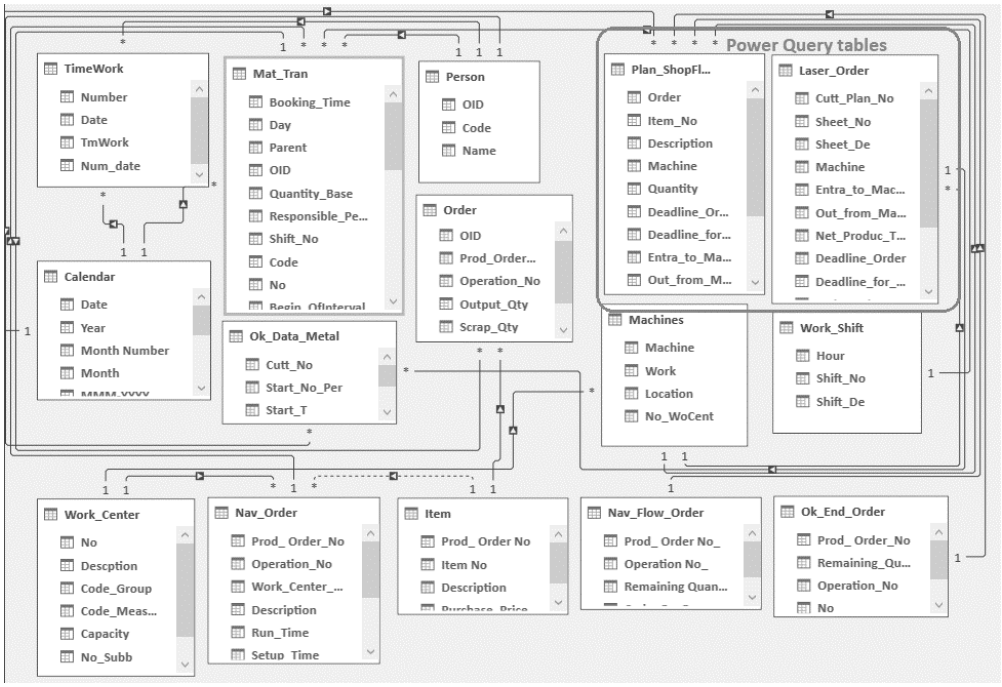

Figure 5 Multidimensional model in Power Pivot, Source: own

8. Visualization

The goal of all data processing using SSBI tools is a high-quality online visualization of all the operations performed on orders. Finished reports are used to provide information at various levels of production management such as Shop Floor Management at various levels, various Feedback for workers, Quality control, Production planning, Statistics to analyze the accuracy of technological procedures and their standardized time consumption. Applications are taken part of production controlling. Examples for Shop Floor Management and Feedback for workers are included in chapter 3.

3 Challenges for Innovation

MS Excel is used to visualize the data from the multidimensional model, which with the help of pivot tables, cross-sections, common functions, and simple DAX language calculations provides sufficient apparatus for quality reporting. Power BI or Tableau tools could also be used for high quality and probably nicer visualization, but MS Excel is still the most accessible for the user and without major investments.

For example, the shop foreman works daily with an application that provides him with all the information about the work in progress in production online. He walks the shop floor every morning with a tablet and communicates with the foremen and operators in production, who can see their work clearly. Figures 6 and 7 show selected visualizations.

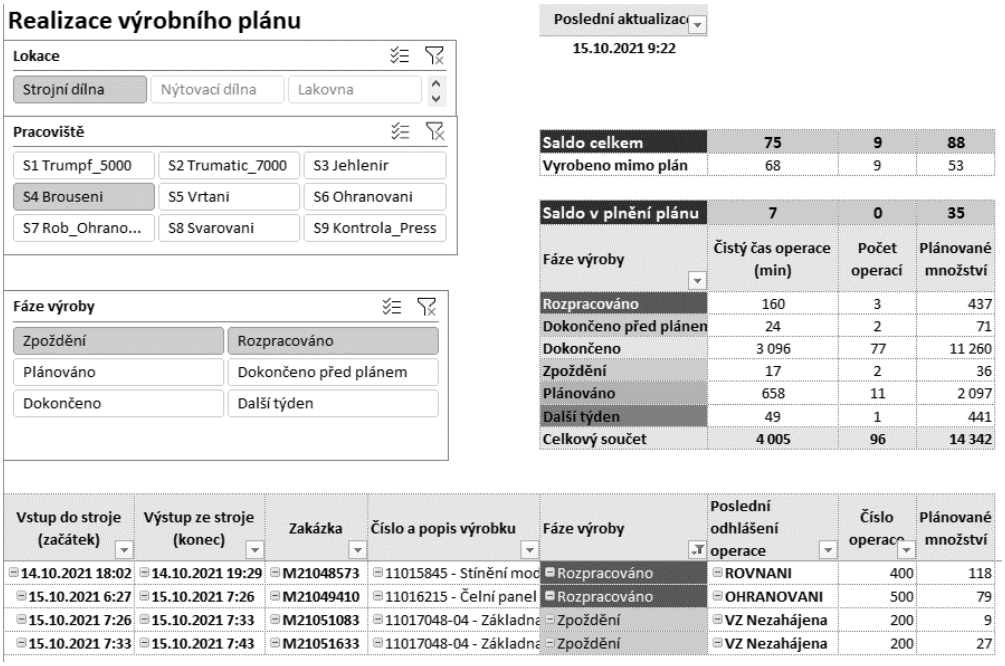

Figure 6 Realization of the production plan for Shop Floor Management, Source: own

Since the firm under study in this paper is a Czech firm, the attributes in the reported pivot tables and cross-sections are in Czech language.

It is desirable that these online reports are continuously available to all operators in production on monitors located in the production or in the corridors. This is also the philosophy of Shop Floor Management.

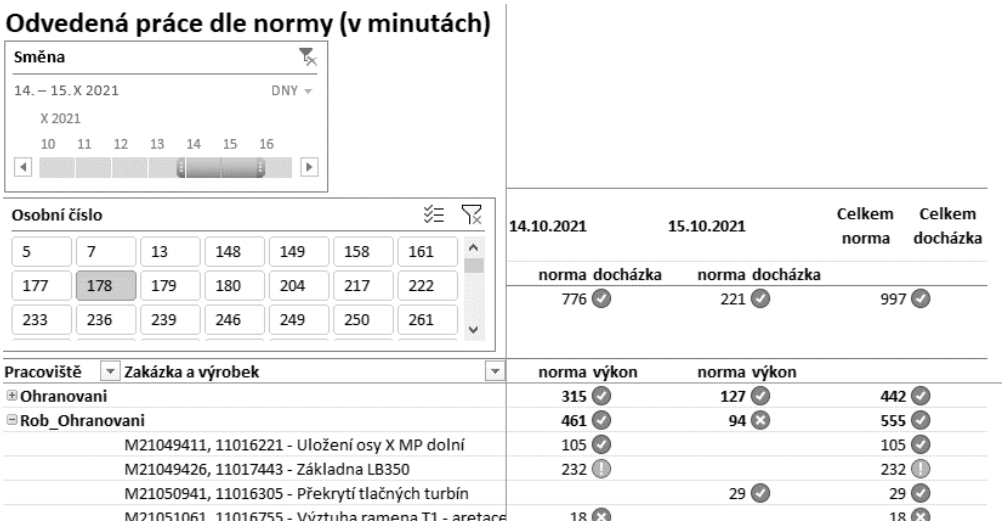

Figure 7 Work done by standard in minutes, Source: own

4 Conclusion

In conclusion, it is possible to create quality reporting for production management even without the cost and time-consuming developed management software. This is what SSBI tools provide.

Objectively, however, it is necessary to admit the shortcomings of SSBI, such as the limited capacity of MS Excel, which works significantly slower from 25MB. SSBI tools can never completely replace Business Intelligence, but it is a good compromise to get a self-service overview of data flows in the enterprise.

Recent years in the field of information technology have shown that, alongside large-scale, highly complex and powerful computing systems, there is also a tendency to seek and use relatively simpler, easily accessible, and manageable means for the work of individual users (Pour et al, 2018). The whole data processing process in SSBI can also serve as an excellent basis for a future management information system created by a professional contractor.

References

1. Collie, R. and A. Singh. (2015). *Power Pivot and Power BI: The Excel User's Guide to DAX, Power Query, Power BI & Power Pivot in Excel 2010-2016*, Merritt Island: MrExcel.com.
2. Howson, C. (2014). *Successful Business Inteligence. Unlock the Value of BI &Big Data*, New York: McGraf-Hill Education.
3. Keřkovský, M a VALSA, O. (2012). *Moderní přístupy k řízení výroby, 3. doplněné vydání*, Praha: C. H. Beck

4. MICROSOFT (2021). *Power Pivot: Powerful data analysis and data modeling in Excel*, [Online]. Available: https://support.microsoft.com/en-us/office/power-pivot-powerful-data-analysis-and-data-modeling-in-excel-a9c2c6e2-cc49-4976-a7d7-40896795d045 [22. October 2021].
5. Pour, J., Maryška, M., Stanovská, I. and Šedivá Z. (2018). *Self Service Business Inteligence. Jak si vytvořit vlastní analytické, plánovací a reportingové aplikace*, Praha: Grada.
6. Tomek, G. and V. Vávrová. (2014). *Integrované řízení výroby. Od operativního řízení výroby k dodavatelskému řetězci*, Praha: Grada.
7. Nazari-Shirkouhi, S., Keramati, A., Rezaie, K. (2015) 'Investigating the Effects of Customer Relationship Management and Supplier Relationship Management on New Product Development'. *Tehnicki Vjesnik-Technical Gazette*, 22(1), pp. 191-200.
8. Nguyen, B., Chen, J., Foroudi, P., Yu, X., Chen, CHS. Yen, D. A. (2020) 'Impact of CRM strategy on relationship commitment and new product development: mediating effects of learning from failure'. *Journal of Strategic Marketing*, forthcoming article.
9. Rizvi, M. (2017) '*Implications of Internet of Things (IoT) for CRM*', [Online], Available: https://customerthink.com/implications-of-internet-of-things-iot-for-crm/ [13 Dec 2017].
10. Rodriguez, M., Peterson, R. M., Krishnan, V. (2018) 'Impact of CRM technology on sales process behaviors: empirical results from US, Europe, and Asia'. *Journal of Business-To-Business Marketing*, 25(1), pp. 1-10.
11. Spiliopoulos, D. (2020). '*How IoT and AI can enable companies to restart their business during Covid-19*', [Online], Available: https://iottechnews.com/news/2020/jun/02/how-iot-and-ai-can-enable-companies-during-covid-19-to-restart-their-business/ [2 June 2020].
12. Serova, E. (2019) 'Artificial Intelligence for Analysis of Collaborative Consumer Networks Management'. In P. Griffiths & M. N. Kabir (Eds.), *Proceedings of the European Conference on the Impact of Artificial Intelligence and Robotics ECIAIR 2019,* pp. 304-311. Oxford, England: ECIAIR.
13. Threlfall, D. (2020) '*How to Create a Powerful Chatbot in 15 Minutes*', [Online], Available: https://mobilemonkey.com/blog/how-to-create-a-chatbot/ [2020].

Expert system for implementation of IS agile operation and maintenance

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Abstract. Implementing agile and lean practices into the operation and maintenance of an IS requires an experienced expert. Partial support of the teams without such an expert can be provided by a formal tool proposing which techniques to start with. If the rules and ways of working are automated, it is difficult or impossible to avoid them. Therefore, even implementing an automated tool will help substitute the expert in selecting suitable procedures (agile practices) based on the symptoms of the current way of working. Based on the symptoms listed for each defined principle, the tool will suggest which practices are suitable for implementation. This paper deals with the design and implementation of an expert system to support selecting appropriate practices for agile information systems operation and maintenance services. A sequential model is discussed to support the decision-making process of selecting appropriate practices for a given IT service.

Keywords: agile operation, agile maintenance, agile practices, expert system

1 Introduction

Effective work of the operation and maintenance requires certain principles and rules. The given principle is affected by the environment, systems, mood, but primarily our behaviour and taste. Concerning different conditions, environments, technologies or characteristics of the workers, it is impossible to define precisely how to fulfil any principle. The publication [1] describes the principles and practices used in the implementation of agile IS operation and maintenance and presents structures (principles and practices) to make the whole process efficient without unnecessary bureaucracy as well as to support the goals both of the project/IT service and the organisation. In this paper, we will present an automated tool to better navigate the practices and make implementing the principles into a real IT environment easier.

The presented approach to implementing agile and lean practices in publication [1] requires an experienced mentor. As a partial help to teams without this mentor, it can provide a formal tool to support the decision on which practices to start with. If we automate rules and ways of working, it is difficult or impossible to avoid them. Therefore, even implementing an automated tool will help replace the expert in selecting the appropriate agile practice(s) based on the symptoms of the current way of working. Based on the symptoms listed for each defined principle, the tool will suggest which practices are suitable for

implementation. The tool, therefore, supports the decision-making process on the relevance of practices, but the implementation itself is the task of the team. This step, therefore, only reduces the risk of selecting an inappropriate practice, but not the risk of inappropriate implementation or understanding the principle behind the practice. The tool cannot help with misunderstanding, thus support from an experienced team member or mentor is essential.

2 Formal expert system

To properly design a decision tool, we need to define the decision process, input and output data, database and rules. Simulating decision processes is characterised by the following peculiarities, discussed in reference [2]:

Decision making does not rely only on analytical information but primarily on knowledge represented by a cognitive process and an abstraction process (which is the prerogative of brain activity).

Decisions can be made by several different approaches depending on how many individuals will consider them.

It is very difficult to accurately formulate an algorithm for a decision-making process.

Much information used in decision making is of external origin with respect to the already established and known database of the decision problem.

A decision process in a broad sense can be defined as an organic unity of three phases:

- Informational (knowledge acquisition).
- Planning (consideration of alternatives).
- Selection (choosing an alternative).

While the actual decision making refers only to the last phase, the first two phases (gathering information and considering alternatives) are preparatory phases.

The most natural and operative expression of expert knowledge for humans is a natural language, in oral or written form. An example of an expression of expert knowledge in the area of methodologies for the development, operation and maintenance of IS and IT services may be the defined agile principles of operation and maintenance described in [1]. According to [3], it has been verified by practice that perhaps the most effective form of expressing human knowledge (e.g. behaviour of an object) is a rule of the IF-THEN type. It turns out that a set of such rules can describe the behaviour of an arbitrarily complex system. The basic property of verbal concepts is their conceptual indeterminacy - vagueness. If we require an expert system to operate similarly well with knowledge, and if this knowledge is formulated in terms of rules (linguistic descriptions), we necessarily face the problem of finding a suitable tool for the computational formalisation of their conceptual indeterminacy, i.e. vagueness. In practice, the most widespread way of modelling vague concepts as a formalisation of the vagueness of natural language words has become the so-called fuzzy sets. An example of vague concepts can be the symptoms of the absence of a defined principle in [1] described as follows:

"high level of bureaucracy",
"low communication between the team members",
"long period of approving anything",
"lack of time to learn and implement new things".

The authors have demonstrated the usefulness of this approach for decision support in various applications, e.g. [4, 5, 6] and many others.

3 Decision-making method

The decision to select an appropriate practice for a given IT service is based on the symptoms included in the definition of agile and lean principles of operations and maintenance in [1]. In [2], a sequential model was proposed to support the decision process of selecting appropriate practices for a given IT service. Although the decision process contains a number of uncertainties, its structure can be defined reasonably well. In particular, the elements of this decision process can be broadly classified into the following groups:

S – set of situations,

D – set of all possible solutions,

G – set of all objectives (admissible) for further operation of the system,

F – set of all levels of the given object existence,

K – set of all evaluations of the given solution,

T – time interval.

In our case of selecting appropriate agile and lean practices based on existing symptoms of the current way of working, this means the following:

S – set of all symptoms of the given principle observed in the current way of work,

D – set of all practices,

G – set containing only relevant practices of the given principle,

F – set of all levels of the existence of all practices in set D,

K – set of all evaluations of the relevant use of the given practice from set G for a given situation S,

T – time interval.

The actual decision process is represented by different mappings between these sets. In particular, these representations are:

The process of aggregating information about a given situation and evaluating it, i.e. selecting only the information that is relevant to the final decision:

$$M_1 : S \times T \times F \rightarrow S \times T \times F$$

The process of creating a set of admissible solutions, which consists of two sub-processes $M_2 = M_{22} \circ M_{21}$, where

M_{21} – formulation of control objectives based on a description of the given situation

M_{22} – formulation of admissible solutions

$$M_{21} - S \times T \times F \rightarrow G \times S \times T \times F$$

$$M_{22} - G \times S \times T \times F \rightarrow D \times S \times T \times F$$

The process of modelling the effects of admissible solutions

$$M_3 : D \times S \times T \times F \rightarrow D \times S \times T \times (S \times T)^* \times F$$

(here, in fact, each admissible solution is assigned a set of situations and their time courses, which arise on the basis of the given decision).

The process of adopting the solution, which consists of two sub-processes $M_4 = M_{42} \circ M_{41}$, where

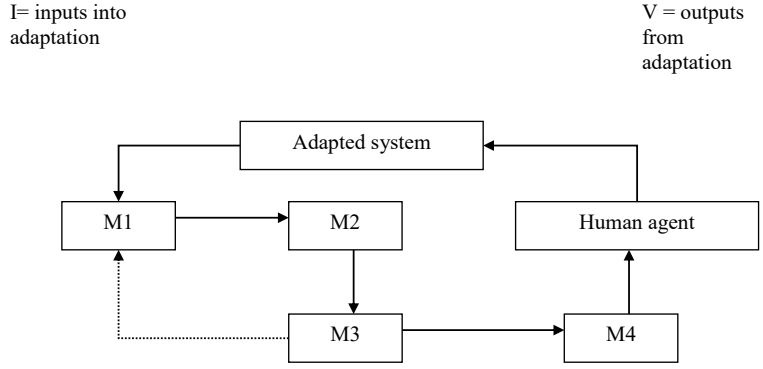
M_{41} – evaluation of the behaviour of admissible solutions effects

$$M_{41} : D \times S \times T \times (S \times T)^* \times F \rightarrow D \times K \times T \times F$$

M_{42} – selection of the best variants

$$M_{42} : D \times K \times T \times \rightarrow D \times T$$

The whole decision-making process is formed by a gradual composition of these partial processes $M = M_4 \circ M_3 \circ M_2 \circ M_1$, as depicted in the following scheme:



Let us note that the actual implementation of the individual processes M1 - M4 can be ensured by the so-called fuzzy algorithms using the results of fuzzy set theory. The individual processes M1 - M4 differ from each other by the nature of input and output variables and other relations that are realised within these processes. Each process can be characterised by the following six:

$$(T_i, T_v, X_{ch}, T_p, T_k, T_{kk})$$

where:

T_i – input type
T_v – output type
X_{ch} – output character
T_p – indefiniteness type

T_k – type of selection criterion
T_{kk} – type of individual criterion elements

4 Expert system implementation

For example, Linguistic Fuzzy Logic Controller (LFLC) 2000 can be used to implement an expert system [7, 8]. LFLC is specialised software that is based on fuzzy set theory and fuzzy logic and allows inferences to be made based on an imprecise description of a situation using linguistically formulated IF-THEN rules. The main task of this tool is to design and test a knowledge base composed of a set of IF-THEN rules. In our case, we use the tool to create a so-called aggregated knowledge base, which consists of several (at least two) knowledge bases. The final output is then an aggregation of the outputs of these knowledge bases.

An aggregated knowledge base is a set of knowledge bases that have IF-THEN rules created in such a way that the same type and number of input values of the input set can be applied to each of these knowledge bases. The output of the knowledge base is an automatically generated decision, i.e. a linguistic expression modelled by a fuzzy set or a defuzzified numerical value.

To evaluate the decision, any properly constructed knowledge base system needs the following components:

A set of input values - based on these values, the rules of the corresponding knowledge base are applied. It is possible to insert multiple sets of input values. For each of these sets, a list of fuzzy knowledge base evaluations is created in the output file.

Multiple knowledge bases (at least 2) - each of these knowledge bases contains IF-THEN rules that are related to each other. If required, it is advisable to have an IF-THEN rule for each set of input values. If no IF-THEN rule exists for a given set of input values in a knowledge base, then the output file will be populated with a value of NOT KNOWN for that knowledge base and the corresponding set of input values, indicating that no rule has been applied. Output value file - this file contains for each set of input values a ranked list of outputs after the application of knowledge base rules. Based on the outputs of the applied knowledge base rules, each of these knowledge bases takes a value from the set of M <0; 1>.

We will illustrate the application of this mechanism and the use of the tool by selecting relevant practices supporting the implementation of the second principle from the publication [1].

Principle (2): Cooperation and communication, system perspective

Objective: meeting user needs and informing IT service users; meeting the organisation's business objectives through effective IT service support; visibility of current service status; systematic overall improvement; helping the business to create value; motivated team and fun at work.

Pattern: share enterprise goals across the workforce; map those goals to IT (per project/service); define metrics that benefit the enterprise (not the process itself); optimise for the whole, not local organisational units; rotate people in development and operations and maintenance teams; regularly demonstrate new, modified functionality; seek to understand and respect people, their differences, and personal goals.

Anti-pattern: despise end users, they don't know how to program and don't understand us gurus; withhold information and don't explain management decisions, people don't need to know and don't care; design processes and measures to best suit only your organisational unit and your budget and measure against them; create separate teams for developing IT services and for their operation and maintenance; define the same development goals for all employees according to the above template.

Symptoms of the P2 principle (quoted by the symptom code):

(P2_1) functional way of working (rule-oriented) with document communication;

(P2_2) the team does not know the corporate goals and sub-optimises to achieve the goals of their unit;

(P2_3) ignorance of the end-user;

(P2_4) ignorance of the current (real) status of the delivery (project, service);

(P2_5) separate operations and maintenance teams;

(P2_6) "90% done" syndrome, where the last 10% takes as long as the first 90%;

(P2_7) IT perceived as a cost;

(P2_8) unclear (unmeasured or unquantifiable) contribution of IT to the business;

Most of the symptoms we have listed are soft indicators that are assessed and perceived subjectively. A worker who is confronted with all the problems of the current way of working will have a different view, while a manager who stands outside their impact, or who has introduced the way of working, will have a different view. As an input to decision-making, we do not provide a complete list of symptoms. We have excluded those that serve as auxiliary indicators and are perceived more as mentors or to raise questions in the minds of employees and managers.

Appropriate practices to implement this principle:

(1) Visualization

(2) Company scenarios

(3) Pair work

(4) Rotation

(5) Retrospective

(6) Fighting ambiguity

In identifying agile principles for the operation and maintenance of IT services, knowledge bases represent the principles. The input of the knowledge base is symptoms that highlight the absence of a given principle, and the output is a ranked list of appropriate practices that will help to implement the principle in practice. Since each agile principle has different lists of symptoms and practices, it is useful to create an appropriate knowledge base for each principle.

Each symptom has a defined value domain in which it can take on value according to the subjective assessment of the employees. In our case, we choose a context for all symptoms, a set of values <0; 10>, where 0 means that the symptom is not present at all and 10 means that it is completely present. However, this is not an enumerative definition, but we are again working with degrees of membership in a given fuzzy set. Thus, for the symptom "end-user ignorance", the symptom rating will mean the following:

Value 0: I have never seen the customer or the end-user. I don't know for whom the application is developed/operated and what functionality he/she uses exactly for what in his/her daily work.

Value 2.8 (small): we have seen the customer in person once at the beginning of the project and receive brief feedback from them once a year after the software is delivered.

Value 10: we know the customer or end-users personally, receive regular feedback from them, and observe them at work on a regular basis so that we have a better understanding of the problem domain and can improve the functionality provided in the form of IT services.

Since the ratings given are subjective (someone will say 1.2, someone else 7.8) and exist in the form of linguistic expressions (yes, we saw the customer at the beginning, but we have no idea exactly, its inclusion is small), we work in the knowledge base with fuzzy concepts such as small, medium, large. The employee does not know if the customer is included in the communication at level 5 or 7 but will say little, enough, medium.

Working with linguistic expressions using fuzzy means allows us to work formally with fuzzy information. Thus, we do not work with an enumeration of values 1-10, but with linguistic expressions small, medium, big, very big, etc., which are closer to human expression. We create a knowledge base by defining for different combinations of symptoms and their possible values an output value indicating the appropriateness of the practice in a given case.

As an example of knowledge base creation, consider the practice of **Visualization**. Visualisation is a very powerful technique that can often very easily and inexpensively show problems that the worker, team or manager was not aware of. Agile approaches use visualisation as a very powerful yet simple tool. An example is the *Burn down chart*, so popular in Scrum. Another effective visualisation tool is, for example, a dashboard capturing the flow of development in *Kanban*, or *Value Stream Analysis*, or *Capacity Alerts (signal wheel)*, or *Customer Blog*, where, if a major incident occurs, we document what happened, why it could not have been prevented, and most importantly, what we are doing about it now.

The knowledge base for the practice of *Visualisation* is formed by the following rules made up of fuzzy values of symptoms (P2_1 to P2_8) affecting the practice. Here are examples of the rule notation:

IF P2_1 = small AND P2_2 = small AND P2_3 = small AND P2_4 = small AND P2_5 = small AND P2_6 = small AND P2_7 = small AND P2_8 = small THEN Visualization = small

IF P2_1 = medium AND P2_2 = medium AND P2_3 = medium AND P2_4 = medium AND P2_5 = medium AND P2_6 = medium AND P2_7 = medium AND P2_8 = medium THEN Visualization = medium

IF P2_1 = big AND P2_2 = big AND P2_3 = big AND P2_4 = big AND P2_5 = big AND P2_6 = big AND P2_7 = big AND P2_8 = big THEN Visualization = big

IF P2_1 = big AND P2_2 = big small AND P2_3 = small AND P2_4 = small AND P2_5 = small AND P2_6 = small AND P2_7 = small AND P2_8 = small THEN Visualization = big

The actual decision process is represented by different representations between the following sets:

S – set of all symptoms of the given principle observed in the current way of work,
D – set of all practices,
G – set containing only relevant practices of the given principle,
F – set of all levels of the existence of all practices in set D,
K – set of all evaluations of the relevant use of the given practice from set G for a given situation S,
T – time interval.
It concerns the following mappings:

First, we need to identify the knowledge bases for the research area, i.e. our described principles 1-4 and their symptoms:

$$M_1 : S \times T \times F \to S \times T \times F$$

The process of creating the set of admissible solutions (selection of relevant practices):

$$M_{22} - G \times S \times T \times F \to D \times S \times T \times F$$

The process of modelling the effects of acceptable solutions, i.e. evaluating the appropriateness of using relevant practices. Thus, in this process, we create a list of input language variables and the range or set of values they can take:

$$M_3 : D \times S \times T \times F \to D \times S \times T \times (S \times T)^* \times F$$

where $(S \times T)^*$ defines the set of all chains over $(S \times T)$,

(in fact, each permissible solution - practice - is assigned a set of symptoms and their time courses that arise on the basis of that decision).

The process of approving the solution, which consists of two sub-processes $M_4 = M_{42} \circ M_{41}$, where

M_{41} – evaluation of the behaviour of admissible solutions effects (selection based on M3)

$$M_{41} : D \times S \times T \times (S \times T)^* \times F \to D \times K \times T \times F$$

M_{42} – selection of the best variants (final selection from set M41)

$$M_{42} : D \times K \times T \times \to D \times T$$

The output of the decision-making process using the linguistic terms small, medium, large, etc., are rated practices in the interval <0; 1> indicating the degree of appropriateness

of using the practice in a given context (symptom occurrence). P2_1 to P2_8 are symptoms that take on specific values, describing a specific situation in a project or IT service. To describe a specific situation, we use the context <0; 10> that we defined above.

Based on these concrete input values (the description of the concrete situation), rules from the knowledge base are applied, and a decision is made using an inference mechanism, which is interpreted in the following figure using degrees of membership rather than linguistic expressions. This is due to the existence of only a prototype of our tool. The output, i.e. practices, are scored (0 not applicable, 1 most applicable) for all possible combinations of symptom values: practices with a value closest to one are maximally applicable, we are to implement these.

5 Conclusion

The presented software expert system and the sequential decision-making model is a suitable automated tool to reduce the risk of selecting an inappropriate practice of agile control in IS operation and maintenance. The verification was done as a controlled interview with experts on agile methodologies. They expressed their satisfaction with the proposal of the expert system.

References

1. KLIMEŠ, C., PROCHÁZKA, J. Provozujte IT jinak. Agilní a štíhlý provoz, podpora a údržba informačních systémů a IT služeb. Praha, Grada, 2011. 288 p. ISBN 978-80-247-4137-6
2. KLIMEŠ, C. Model of adaptation under indeterminacy. Kybernetika. Vol. 47 (2011) No. 3, pp. 355 – 368. ISSN 0023-5954
3. POKORNÝ, M. Expertní systémy. Ediční středisko CIT OU. Ostravská univerzita v Ostravě, 2004.
4. WALEK, B., BARTOŠ, J. & FARANA, R. Fuzzy tool for proposal of suitable products in online store and CRM system. In: Lecture Notes in Computer Science. Volume 8669 LNCS, 2014, pp. 433-440. ISSN 0302-9743. ISBN 978-331910839-1. DOI 10.1007/978-3-319-10840-7-52
5. BARTOŠ, J., WALEK, B., SMOLKA, P., PROCHÁZKA, J., KLIMEŠ, C. Fuzzy Modelling Tools For Information System Testing. In: International conference proceedings MENDEL 2011. Brno: Brno University of Technology, 2011, pp. 154-161. ISBN 978-80-214-4302-0.
6. BARTOŠ, J., PROCHÁZKA, J., KLIMEŠ, C., et al. Fuzzy Reasoning Model For Decision Making Under Uncertainty. International conference proceedings MENDEL 2010. Brno: Brno University of Technology, 2010. pp. 203-209. ISBN 978-80-214-4120-0
7. DVOŘÁK, A., HABIBALLA, H., NOVÁK, V., PAVLISKA V. The concept of LFLC 2000 – its specificity, realisation and power of applications. Computers in Industry. No. 3/2003, vol. 51, pp. 269-280. ISSN 0166-3615.
8. NOVÁK, V. Fuzzy množiny a jejich aplikace, SNTL Praha, 1992.
9. BUCHALCEVOVÁ, A. Metodiky budování informačních systémů. 1. vyd. Praha: Oeconomica, 2009, 206 p. ISBN 978-80-245-1540-3
10. PROCHÁZKA, J. Agile Support and Maintenance of IT services. In: Proceedings of Information Systems Development 2010. Springer. 978-1-4419-9645-9

Architectural design of a data-oriented solution for streaming services

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Abstract. This paper addresses data processing in streaming platforms, where the goal is to develop a general framework for a data-driven streaming service architecture, with a particular focus on the processing of client data from the use of these services. The reader of the thesis is introduced to the issue of streaming services and the extraction of input data from their use, which is then analyzed in terms of possible processing into data analytics. Finally, a general proposal for a client data processing architecture model is presented, which can serve as inspiration for data stewards in streaming platform services.

Keywords: Streaming, Analytics, Services, architecture, content delivery

1 Introduction

Streaming and streaming services represent a significant phenomenon of our time, whose popularity in society is experiencing a significant development, almost a boom. According to Bacon (2020), during the pandemic of 2020, the use of streaming services increased by 37%. In view of this growth, the operators of streaming services are growing their user (customer) base at the same time as the operators' desire to get to know their users (customers) is growing (AQUINO, GLAGOWSKI,2020).

Very important point for streaming services will be to evaluate and try to get to know their customers. Based on the knowledge of the customer of a given service, suitable content is offered for viewing and, in particular, the life cycle of the user (customer) is analyzed. Each customer carries data information that may be crucial for the streaming company. Each data information can influence not only the direction of the business but also its dimension. If properly grasped, this data can help the streaming service operator increase user retention, increase profits, and improve communication between the user and the operator. Data information is a valuable commodity for any company, as well as for a streaming service operator, that should have attention. Focusing on the processing of this data and its further use is the reason for choosing this topic.

The goal of this paper is to develop a general model for a data-centric streaming service architecture. The proposed data architecture model, should assist data stewards in solving data problems in an organization. The given solution will be based on the analysis of input data in streaming service. In the proposal, I want to focus on ways of automated data collection from streaming service usage, transformation of this data for customer lifecycle processing and subsequent reporting. Automating the collection, processing and evaluation of data will bring greater efficiency and customer satisfaction for streaming services.

2 State of the art

In an extensive search of the literature on streaming services, data-centric solution architectures and architectures in general, there was no solution that addressed or targeted the issue of data-centric streaming service solutions. Based on the search, it can be concluded that to date, the scientific literature has not described how to properly access data within streaming services or how to properly design the architecture of data-centric streaming service solutions. In following sub capitols is described current state of the art regarding streaming services and their surroundings.

2.1 Description of streaming service

A streaming service is a technology that enables the continuous transmission of audiovisual content (material) between a source and an end user. The content is transmitted between the source and the destination by means of a data stream, which can be technologically transmitted over both cable and wireless networks. A streaming service provider is one that delivers content via an internet connection to a subscriber's computer, television or mobile device. Notable examples include Netflix, Amazon Prime, Disney+, Hulu, Spotify and Apple Music (*Pcmag, 2020)*.

2.2 Streaming Options

Streaming is the flow of data from a streaming service provider to end users. A streaming service may include the transmission of audio-only content or the transmission of audiovisual content. The types of streaming can be categorized based on the different categories within the dimensions (by content, by time, and by bitrate variability (Popelka, 2013)) or by the form of streaming (i.e., live streaming or streaming of stored content).

2.3 Architecture requirements for streaming stored content services

According to Akamai (2021), the architecture within streaming services should include the following parts: client part, backend part and Content Delivery Network (CDN). The backend part should include databases, various services, storage, data processing, data presentation, etc. The backend part should basically handle everything except streaming video. Content delivery Network is a highly distributed platform of servers that should help minimize the delay in loading the content of a web page (Akamai, 2021). In case the CDN is not used in a company, the servers within the content must respond to each individual request from the end user. This can lead to significant traffic and more chances of content loading failure (Akamai, 2021).

Streaming service architectures

Amount of the data from streaming services is very large. We can find one-time data (e.g., data about the user of the service) but also data that is continuously growing (e.g., data from the use of the service). The largest amount of data is generated when a user uses the selected platform, where the data is continuously growing over time. This data can be classified, due

to its volume, as big data. According to Omni Sci (2021), a big data architecture can consist of four parts of logical layers that perform four main processes

1) Data Sources - within the big data source layer, the processing of data into sources is dependent on the type of big data architecture
2) Management and Storage layer - receiving data from the source layer, converting the data into an acceptable format for BI analytical tools
3) Analytical layer - analytical tools are used to extract data from the storage layer
4) BI layout - the consumption layer receives the results of the data from the analysis layer and passes it on to the output

According to Hussain Sajjad (2021), the following four types of architectures are classified as general big data architectures: Data Streaming architecture, Lambda architecture, Kappa architecture and Unifield architecture.

2.4 Available data analysis and architecture solution

If a provider has a wide range of service offerings, its data information about the user and their usage can be extensive. The user can use the streaming service in different aspects e.g. topic, time, location. These aspects may form combinations in our data that characterize a given service user. These combinations about the usage of the service carry very valuable information for the provider. Based on this information, the provider can improve its services and retain users for a long time.

Analysis of input data in a stored content streaming service

The input data can be divided into one-time data and continuously increasing data. One-off user data is created when a user registers for the service. Growing data about a user is generated by the use of a streaming service. The difference between one-time data and ever-increasing data is the position in the data acquisition process.

The process of retrieving user data begins with the user registering for the service. As part of the registration process, the user provides personal information such as: First name, last name, address, email, phone, gender, username, password and, in the case of a paid service, bank details. After entering this data, the user can start using the streaming service. As part of using the streaming service, the user also provides additional data about themselves, which increases in volume over time. At this point in the process, ever-increasing data about the use of the streaming service is generated. In the context of using the service, the data information itself is not changed but retained. This means that the data is incremented over time. We can look at the use of a streaming service from three perspectives. The first view is within the user login, the second view is within the user's actual use of the streaming service, and the third view is within the user's data connection. These three views are interconnected and provide the streaming service provider with information about the behavior of a particular user.

3 Streaming Services Architecture Design

Within the framework of the requirements chapters described above and the basic analysis of the architectures for the three basic pillars of a streaming service, we can propose a model

for the architectural design of streaming services. In describing the data type, I concluded that the streaming service architecture will generally fall into the big data architecture.

Firstly, we need to design the architecture of the client part with the connection to the streaming data sources and finally the architecture of the CDN part. All three parts are interconnected and interdependent. In the opposite direction, the client data processing architecture needs to be designed. This data is the most important commodity for streaming platforms and the processing of which is the main focus of this paper.

Client part

In the context of client-side architecture design, the most common type of architecture is micro services. Therefore, I will focus more on this type of architecture within the design. In the design of micro service architecture, the following two layers are important: UI (User interface) and API (Application Programming Interface) layer.

UI (User interface) layer

The application that users run on their mobile or desktop devices includes AI, Security Activation Playback and Platform (for example, NRDP). UI or user interface according to Interaction-desing (2021) "User interface (UI) design is the process designers use to build interfaces in software or computerized devices, focusing on looks or style. Designers aim to create interfaces which users find easy to use and pleasurable. UI design refers to graphical user interfaces and other forms-e.g., voice-controlled interfaces."

Security activation playback and platforms (e.g. NRDR - Netflix Ready Device Platform) are components that monitor and adjust playback quality.

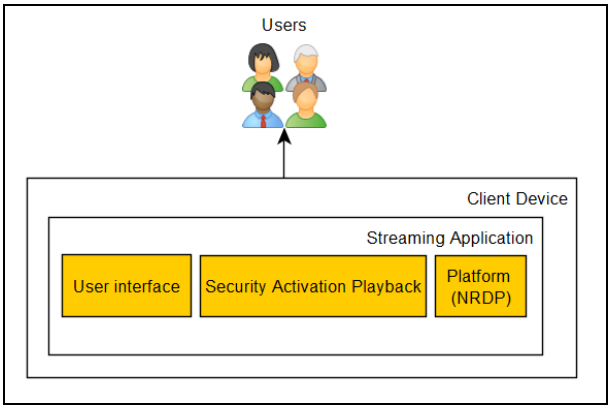

Figure 1 User Interface

API (Application Programming Interface) layer

The Api layer contains several other Api or micro services that provide a particular service and interact with each other. Three micro services are proposed in figure no 2. The first micro service (Customer Business Logic) records events about the customer (IP address, most played genres, etc.). The second micro-service (Billing Business Logic) records the events within the service payment (monthly, yearly, quarterly, discounts granted, etc.). This billing micro service does not need to store data, so it does not need to be connected directly to the database layer. Instead, it interacts and processes data directly from the customer and event micro services.

The third micro service (Event Business Logic) records information about the usage of the streaming service (start times, shutdown times, service interruptions, etc.).

This split client-side architecture brings great advantages in terms of reducing the cost of administration. For example, it is easier to improve or manage the micro service you need rather than the entire application. The advantage of this architecture over the monolith is that the micro service can use a different technical stack as needed, i.e. in case of a language change, it is enough to rewrite one micro service.

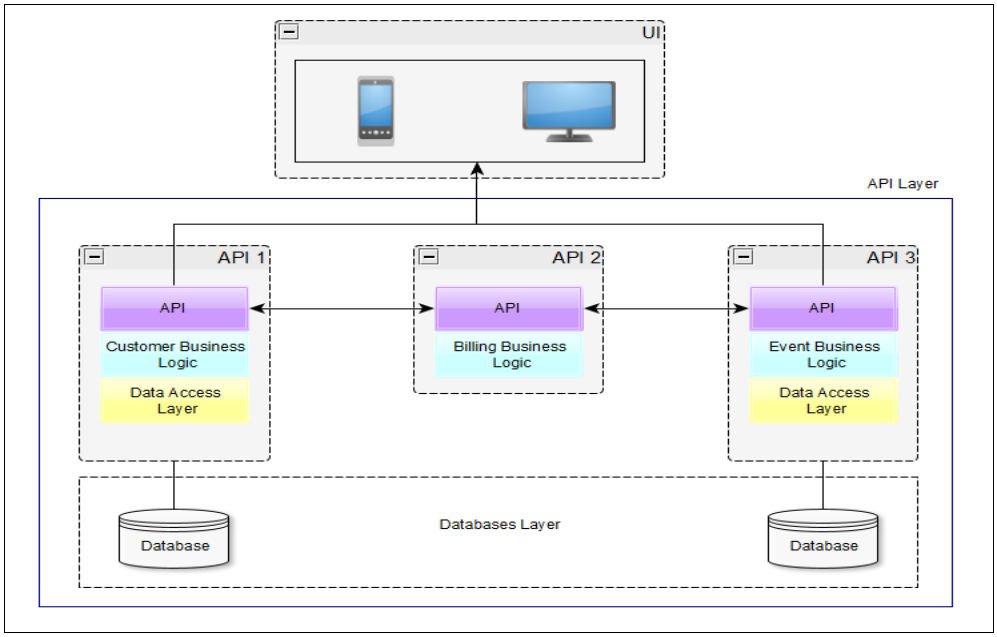

Figure 2 API.

Content Delivery network

The basic architectural design of a CDN should include the following basic elements: Content Provider, Authorization, Reporting, Source, Content, Deliver, Request. Content Provider is the entity that delivers the content. Using Authorization, the Content Provider grants the CDN Provider permission to deliver content. Through Reporting, the Content Provider requests performance analysis from the CDN Provider to evaluate the quality of service of the CDN Provider and to access other relevant data. Subsequently, via Source, the content provider sends a copy of the content. Content here is digital information created or licensed for redistribution. The user uses Request to request the content provider to display or locally store the selected content. The CDN then delivers the content to the user. Most CDN architectures are designed around this process. The process is illustrated in Figure 3.

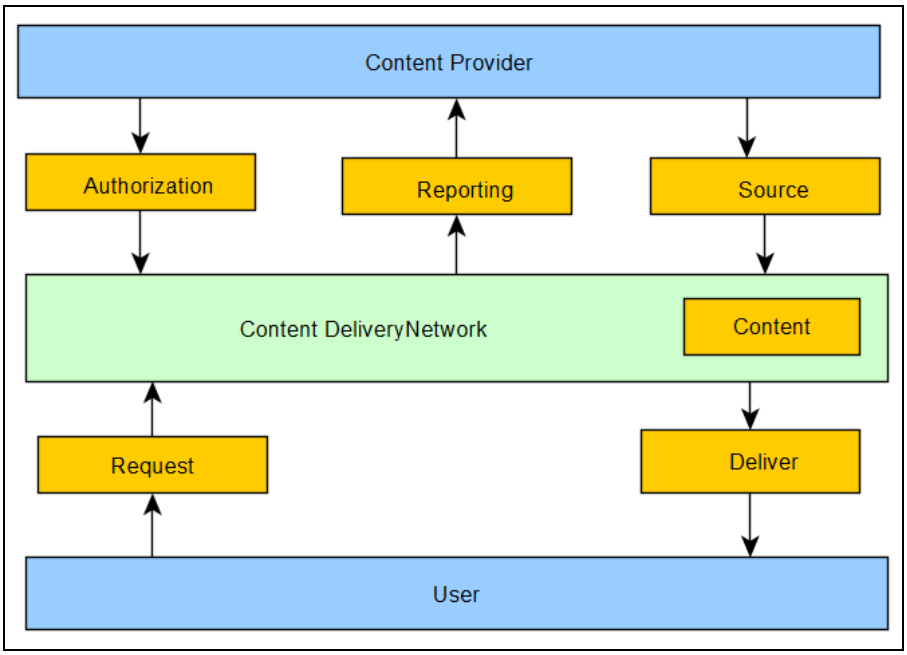

Figure 3 Simple model of content Delivery Network**.**

The content is delivered to the end user using Delivery nodes. Delivery nodes are, according to Nokia (2021), servers that contain caches running one or more content delivery applications. They are usually located as close as possible to the end user. Content can be manually pushed to these nodes (called Push CDN), or delivery nodes can request content from the original nodes based on cache expiration rules (called Pull CDN). The advantage of a Push CDN here is that the end-user receives the content immediately after user acculturation. The advantage of Pull CDN is that it automatically requests content from the content provider. Storage nodes are used to store a copy for further distribution to the user. Subsequent entire distribution of content across the network or on the owner's infrastructure is served by Origin Nodes. For the case of hosting components for CDN management, routing, and monitoring, Control Nodes are used. This process can be seen in Figure 4.

Client data processing architecture

The above data streams were related to the content consumed by clients. However, all of their activity is also recorded, which is a data flow in the opposite direction to the above. This data can then be used to improve the services delivered to clients. However, in order for this to happen the data must first be stored. Registration data that changes minimally is stored in a transactional database. Data from the user's use of the service is stored in a non-relational database, i.e. a NOSQL database. The non-relational database can efficiently hold and process these time varying data. It is also necessary to store logs from the applications for possible debugging.

The data needs to be further processed and as a first step, aggregation and further transformation is required, for which ETL (Extract Transfrom Load) jobs are used to store the data ready for analysis, reporting or data mining in suitable databases. The entire architecture of such a solution is shown in the figure below.

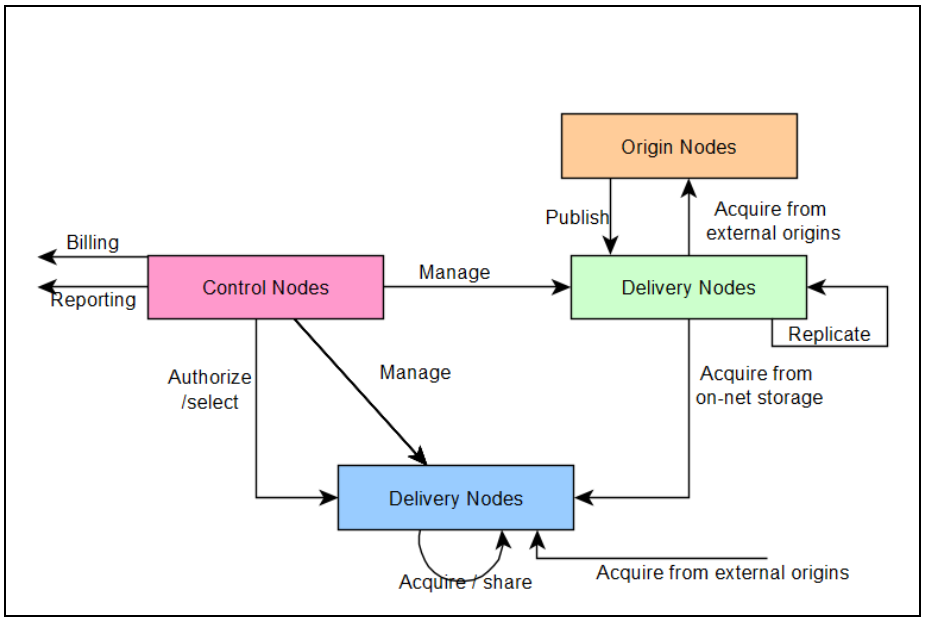

Figure 4 Management of CDN

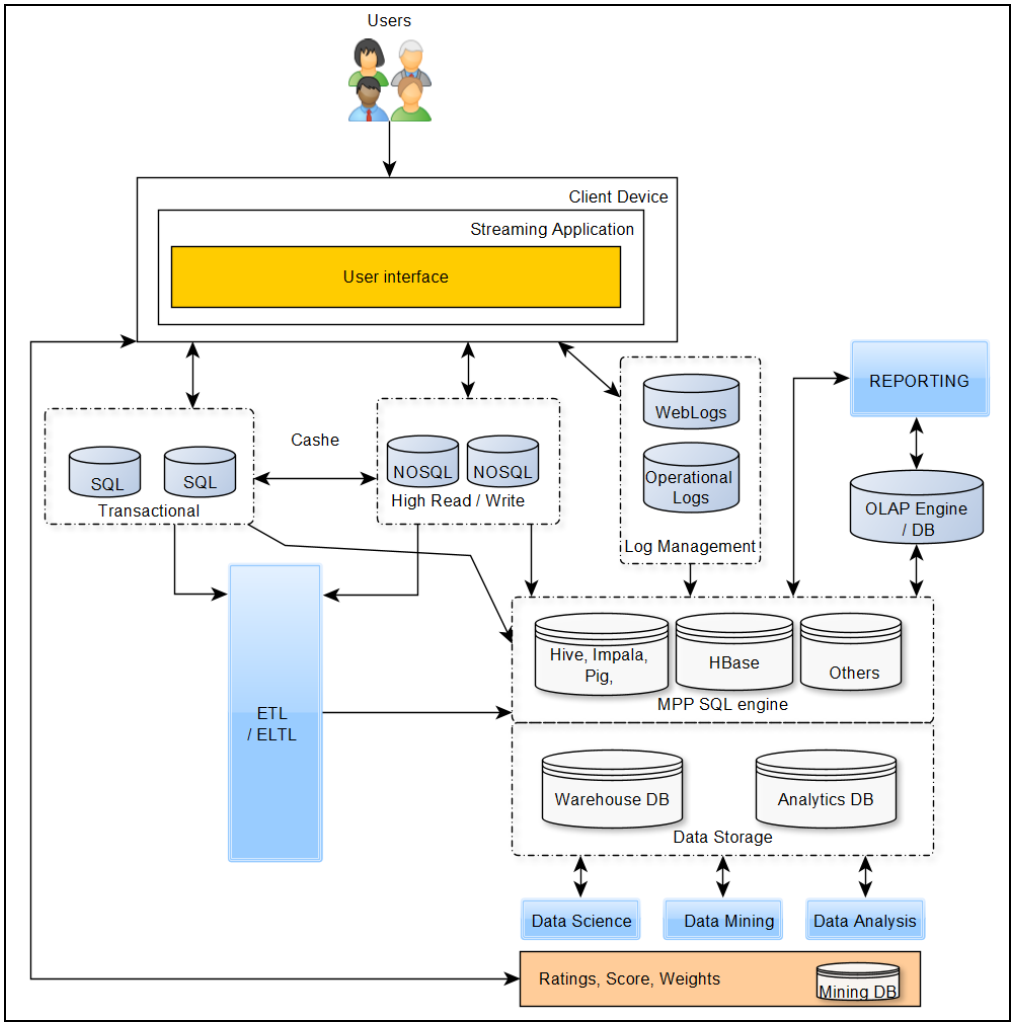

Figure 5 Client data processing architecture design.

4 Conclusion

To develop the model, I followed several steps, the first of which is an introduction to streaming services. Here I focused on the possibilities of streaming content and the classification of streaming. The next step is the analysis of the input data acquisition process within the streaming service. I focus on a detailed view of the data inputs that are generated from user registration to platform usage. The output of the analysis in this step is the evaluation of relevant user data for subsequent data dimensioning and aggregation.

After the analysis of the data inputs, I focus on the design of the architectural data model of the streaming service, where I subsequently address the client data processing part. It is the final design of the client data processing architecture that fulfils the goal of this thesis, where data stewards in streaming platform services can take inspiration from this model.

References

1. Akamai, 2021. What does CDN stand for and how does it work? | Akamai [online] [vid. 2021-05-15]. Available from: https://www.akamai.com/us/en/cdn/what-is-a-cdn.jsp
2. AQUINO, Judith and Elizabeth GLAGOWSKI. Streaming Data Opens the Door to New Customer Insights. Ttec [online]. 2020, 1 [cited 2021-01-12]. Available from: https://www.ttec.com/articles/streaming-data-opens-door-new-customer-insights
3. BACON, Thomas. How Much Streaming Services Actually Grew During 2020. Screenrant [online]. 2020 [cited 2021-01-12]. Available from: https://screenrant.com/streaming-services-2020-growth-pandemic-subscribers/
4. HUSSAIN, Sajjad, 2021. 4 big data architectures, Data Streaming, Lambda architecture, Kappa architecture and Unifield.... Medium [online] [accessed 2021-05-13]. Available from: https://medium.com/dataprophet/4-big-data-architectures-data-streaming-lambda-architecture-kappa-architecture-and-unifield-d9bcbf711eb9
5. Interaction-desing., 2021. What is User Interface Design? The Interaction Design Foundation [online] [vid. 2021-09-04]. Available from: https://www.interaction-design.org/literature/topics/ui-design
6. Omni Sci, 2021. What is Big Data Architecture? Definition and FAQs | OmniSci [online] [vid. 2021-05-13]. Available from: https://www.omnisci.com/technical-glossary/big-data-architecture
7. PCMAG, 2020. Definition of streaming service. PCMAG [online] [vid. 2021-06-04]. Available from: https://www.pcmag.com/encyclopedia/term/streaming-service
8. POPELKA, Václav. Technologies for streaming video. Prague, 2013. Master thesis. CZECH TECHNICAL UNIVERSITY IN PRAGUE. Thesis supervisor Ing. Karel Fliegel, Ph.D.
9. SPURNÝ, František. OPTIMIZEDSTREAMINGVIDEANAPLATFORMANDROID. Brno, 2017. Master thesis. BRNO UNIVERSITY OF TECHNOLOGY. Thesis supervisor Ing.VLADIMÍRVESELÝ, Ph.D.

Neural network model for electricity demand prediction

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Abstract. The development of a reliable prediction model could offer insights in electricity demand prediction and ultimately could provide the opportunity of gaining significant profits. In this work, we propose an RBF NN forecasting model electricity demand prediction. The proposed model exploits the ability of learning the internal representation of time-series data. We conducted a series of experiments and evaluated the proposed model against state-of-the-art machine learning models such as ARIMA and SVM models- The preliminary experimental analysis illustrated that the utilization of RBF NN trained by GA could provide a significant boost in increasing the forecasting performance.

Keywords: Time series models, SVR, learning algorithms, Neural networks.

1. Introduction

Along with the fast development of electricity power market, electricity power industries are getting into free competitive area [1]. Therefore, short-term load demand prediction is becoming important in such power systems. However, electricity load forecasting is challenging. There are many influencing issues such as climate factors and social activities which cause the data to be highly nonlinear [2], [3], [4].

Electricity demand prediction is very important for the reliable and efficient operation of power systems. We consider predicting the electricity demand half hour ahead from previous half-hourly demands. This type of prediction is used for two main purposes: (1) to make decisions about dispatching generators and setting the minimum reserve during the daily operation of power systems and (2) to provide information to electricity market participants for their bidding in competitive energy markets. In both cases the goal is to ensure reliable electricity supply while minimizing the cost. Research on electricity demand forecasting and studies on its influence factors were performed for decades Numerous approaches have been proposed in classic time-series techniques such as multilinear regression and the well-known Auto-Regressive Integrated Moving Average (ARIMA) have been applied in [5].

The paper is organized as follows. In Section 2 we briefly describe the variants statistical ARIMA seasonal model and SVR model. In Section 3 we present the data, conduct some preliminary analysis of the time series and demonstrate the forecasting abilities of classic/seasonal ARMA and SVR models. Section 4 describes design and application of RBF NN trained with BP and GA algorithms. Section 5 presents results and empirical comparison. Section 6 briefly concludes.

2. Seasonal ARIMA and SVR time series models

An extension of the ARMA process is a pure seasonal model abbreviated as *ARMA(P, Q)*$_s$ process in the form

$$1.\quad y_t - \lambda_1 y_{t-s} - \lambda_2 y_{t-2s} - \ldots - \lambda_P y_{t-Ps} - \varepsilon_t = \gamma_1 \varepsilon_{t-s} + \gamma_2 \varepsilon_{t-2s} + \ldots + \gamma_Q \varepsilon_{t-Qs} \tag{1}$$

where $\{\lambda_i\}$ are the seasonal autoregressive parameters, $\{\gamma_j\}$ are the seasonal moving average parameters and the subscripts *s* denote nonzero parameters that are integer multiple of *s*. An extension of the ARMA process is a pure seasonal model abbreviated as *ARMA*(*P, Q*)$_s$ process in the form

$$y_t - \lambda_1 y_{t-s} - \lambda_2 y_{t-2s} - \ldots - \lambda_P y_{t-Ps} - \varepsilon_t \tag{2}$$

Pure seasonal models defined by (1) are often not realistic since they are completely decoupled from each other. That is, (2) represents *s* identical but separate models and we need to take into account the interactions or correlations between the time series values within each period. This can be done by combining the seasonal and regular effects into a single model. We will use a multiplicative seasonal autoregressive integrated moving average process of period *s* (*SARIMA(p, d, q)(P, D, Q)*, with regular and seasonal AR orders *p* and *P*, regular and seasonal MA orders *q* and *Q*, and regular and seasonal differences *d* and *D*. In typical application, *D* = 1, the model is defined in Section 3

The Support Vector Machine (SVM) is a machine learning algorithm proposed by [6] based on statistical learning theory. Structural risk minimization is the basic concept of this method. A version of SVM for regression was proposed in [7]. Support vector regression (SVR) has been widely applied in time series prediction as well as power load demand forecasting and fault prediction [2].

The initial hypothesis for choosing the shape of the SV regression model is the hypothesis that wages show inertia, which can be expressed in a simple causal model in the form of $y_t = \varphi y_{t-1} + \varepsilon_t$, where ε_t is the white noise random component. By taking this hypothesis into account in the SVR Model, its initial shape may take the following form

$$\begin{cases} f(\mathbf{y}, \mathbf{w}, b) = K(\mathbf{y}_i, \mathbf{y}_j)\mathbf{w} + b \qquad \text{or} \\ f(\mathbf{y}, \alpha, b) = \sum_{i=1}^{n} (\alpha_i - \alpha_i^*) K(\mathbf{y}_i, \mathbf{y}_j) + b. \end{cases} \tag{3}$$

where $K(\mathbf{y}_i, \mathbf{y}_j)$ are relevant kernel function, $\mathbf{y}_i, \mathbf{y}_j$, are training data, *b* is a real constant (bias). The real constants are obtained from the solution of the following quadratic programming (QP) problem [3].

$$\begin{cases} \max\ L(\boldsymbol{\alpha}, \boldsymbol{\alpha}_\mathbf{i}^*) = \\ -\frac{1}{2} \sum_{i,j=1}^{n} (\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*) \psi(\mathbf{x}_i^T \mathbf{x}_j) - \varepsilon \sum_{i=1}^{n} (\alpha_i + \alpha_i^*) + \sum_{i=1}^{n} y_i (\alpha_i - \alpha_i^*) \end{cases} \tag{4}$$

subject to constrains

$$\sum_{i=1}^{n}(\alpha_i^* - \alpha_i) = 0 \tag{5}$$

$$0 \le \alpha_i^* \le C, \quad i = 1, n \tag{6}$$

$$0 \le \alpha_i \le C, \quad i = 1, n \tag{7}$$

where L is the Lagrangian with Lagrange multipliers α_i, α_i^*.

In the SV regression, to estimate its parameters the user must further choose some attributes that affect their estimates. These are the following attributes: measure of error approximation (Loss Function ε), the regularization and weights vector norm C, kernel function K and its degree.

3. An Application: Seasonal ARIMA and SVR Mod

To illustrate the statistical methodology, consider half-hourly electricity demand data for the state of New South Wales in Australia for June, July and August 2010. Electricity demand data recorded at half-hourly intervals shows two main cycles: daily and weekly, see Fig. 1(a). The daily pattern shows that the demand is lowest at 4:30am and then reaches its first maximum at 9:30am and its second maximum at 6:30pm, in agreement with the human routine. The weekly pattern shows that he same days of the week (e.g. Mondays) have similar demand profiles. The weekly and daily cycles are 336 and 48 half-hour periods, respectively

We extracted autocorrelation features that were shown to capture the daily and weekly cycles. We applied multiplicative seasonal ARIMA model which can be expressed as $ARIMA(p,d,q)(P,D,Q)_s$. After model identification, selection by using the Akaike criterion, the best fit model was specified as multiplicative seasonal $SARIMA(6,1,1)(1,1,1)_{48}$ process expressed in the following form

$$??? \; Y_t^j = Y_{t-1}^i \circ R_{ij}(t, t\text{ - }1) \tag{8}$$

where B is the backward-shift operator defined as $B = 1 - \nabla$ and $\nabla y_t = y_t - y_{t-1}$, $\nabla^d = (1-B)^d$, $\nabla_s^D = (1-B^s)^D$, where∇ are so called difference operators. For details see [8].

The parameters {λ} and {γ} of the model (11) were estimated by ML procedure. Calculation of the MAPE value for validation data set was performed by e-views (http://www.eviews.com) software.

The SVR application was conducted using the variables and data sets as the statistical model above. In this study, according to the previous result, polynomial kernel was used with the measure of error approximation, ε = 0.001, and the regularization parameter C = 1, which influences a trade-of between an approximation error and weights vector norm. The prediction of half-hourly electricity demand data for the state of New South Wales in Australia has been done using *WEKA* software [9].

4. Neural Network Approach

Neural networks can be understood as a system which produces output based on inputs the user has defined. It is important to say that user has no knowledge about internal working of the NN system. Neural networks work on the Black Box principle. According to some publications such as [10], NN are the prediction models which have the biggest potential in predicting time series and high-frequency financial time series data. The basic concept of RBF (Radial Basic Function) NN is quite simple. In RBF NN (see Figure 1) the potential of the inner neuron is counted as follows: RBF NN defines potential of j^{th} hidden neuron as a difference of Euclidian distance given by vectors

$$u^j = \| \mathbf{x} - \mathbf{w}^j \|^2 \text{ , for } j = 1, 2, \ldots, \tag{9}$$

where s is the number of the RBF neurons. Note that for the RBF NN, the hidden layer weights $\mathbf{w}^j$ represent the centers $\mathbf{c}^j$ of activation function in the hidden layer. To finds the weights or centers of activation functions we used the adaptive (learning) version of the K-means clustering algorithm [11]. The network is supplied with both a set of input data to be learned and the desired output response for each data sample. If the networks output does not match the required target response, the weights $\mathbf{v}$ are adjusted in an adaptive manner so that the error is minimized.

The weights $v_{j,t}$ can be adapted by genetic algorithms (GA) as well (Zamba, 2012). [12]. Genetic algorithms (see *Figure 2*) are implemented as a computer simulation in which a population of abstract representations (called chromosomes) of candidate solutions (called individuals) to an optimization problem evolves toward better solutions.

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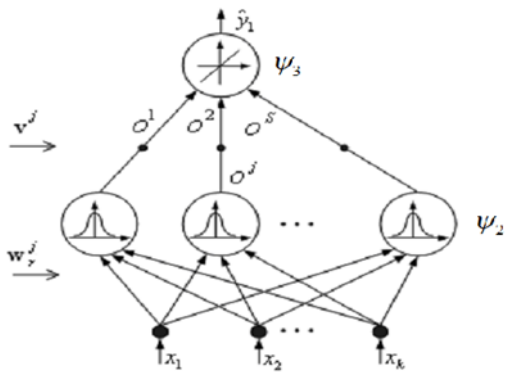

Fig. 1: RBF NN architecture. Source: Own.

The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on the fitness), and modify it (recombined and mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum a number

of generations has been produced or a satisfactory fitness level has been reached for the population.

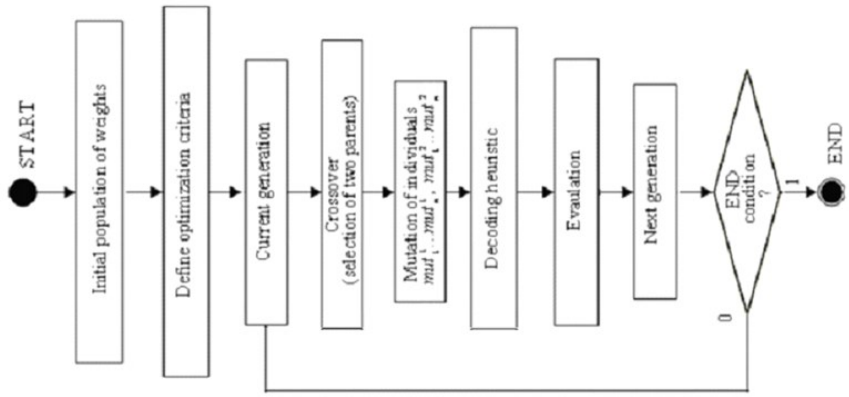

Fig. 2: Flowchart of the GA. Source: Own.]

In the first two blocks of GA we define the initial population of neural network weights, optimization criteria, and fitness functions. Fitness function is set as minimization of the RMSE. Genetic algorithms traditionally work with genes either 0 or 1. The initial population of weights **v** was generated randomly from the interval $(a, b) \equiv (-0.7, 0.7)$ and transformed into the integer digit denoted as l by the following formula

$$l = [(v-a)/(v-b)](2^k - 1) \tag{10}$$

where is the value of weights (v) randomly chosen from the interval *(a, b), k* is the length of binary string in this case of size 16.

According to Darwin's evolution theory the best chromosomes from the population are selected to be parents to crossover. There are many methods how to select the best chromosomes, see e.g. [13, 14]. In this paper the roulette wheel selection was used. Mathematical foundation for the roulette wheel selection can be found in [15].

After the selection of two chromosomes follow two basic operators of genetic algorithm: crossover and mutation. In this work the single-point crossover has been applied. In the chromosome was randomly selected point which divide chromosome into two parts. Then those two parts of chromosomes were exchanged. After a crossover is performed, mutation take. This is to prevent falling all solutions in population into a local optimum of solved problem. Mutation changes randomly the new offspring. For binary encoding we can switch a few randomly chosen bits from 1 to 0 or from 0 to 1. Crossover and Mutation can then be as shown in Fig. 4(a) and Fig. 4(b) respectively. More information about crossover and mutation operators can be find, e.g., in [16].

5. Results and empirical comparison

The parameter settings we used and the details of network topology and learning parameters to estimate the weights for RBF NN classic (BP learning algorithm used) and RBF NN with GA learning algorithm are given in Table 1.

Table 1. Parameter values used in the RBF NN tailed by GA approach. Source: Own.

Model:	RBF NN classic	RBF NN with GA learning
Training/Testing Data	2928/1488	2928/1488
Initial value of v_J	0.01	(-0.7 ; 0.7)
Learning coefficient	0.01	0.01
Number of RBF neurons	92	65
Number of epochs	673	1528

There is no systematic method to determine these parameters in Table I. The optimum number of hidden layer nodes was found to be 92 and in hybrid model to be 65 as shown in Fig. 5(a) and Fig. 5(b) respectively. Training rate was 0.01. The MAE and MAPE functions for testing data set were calculated by the equations (8) and (9) respectively. Fig. 6(a) illustrates the convergence of MAE (error) function versus the number of training epochs for classic RBF NN, and Fig. 6(b) illustrates the convergence of MAE function versus the number of training epochs for RBF NN with GA learning algorithm GA respectively.

Both RBF NN approaches were trained using the variables and data sets as the statistical ARIMA(6,1,1)(1,1,1) $_{48}$ above.

Table 2 shows the accuracy results of the ARIMA, RBF NN and SVR methods expressed in term of MAE and MAPE. MAE is a standard metric used by the research community and MAPE is the metric preferred by the industry forecasters. SVR is the most accurate method. (MAPE = 0.54), followed by ARIMA (MAPE = 1.32), RBF NN trained by GA (MAPE = 3.19%) and Classic RBF NN trained by BP (MAPE = 3.5%). All proposed forecast models based on advanced statistical and soft computing methods have MAPE measures much less than 5%, i.e. they indicate that all forecast models are very good.

Table 2. The performance comparisons for RBF NN, ARIMA(6,1,1)(1,1,48)$_{48}$ and SVR approach. Source: Own.

Approach	MAE	MAPE [%]
Classic RBF NN (BP learning)	323.294	3.50
RBF NN (GA learning)	301.088	3.19
ARIMA(6,1,1)(1,1,1)$_{48}$	115.27	1.32
SVR	50.28	0.54

The use of SVR and ARIMA models is a powerful approach to the solution of many forecasting problems. But, they are not without several limitations. In both AIRMA and SVR models, there is not conventional way to modify or update the estimates of the model parameters as each new observation becomes available. In contrast to NN, another drawback of ARIMA models is, that there is the learning speed very slow. The estimate of the parameters can be not parallelized.

6. Conclusions

In this paper, we considered predicting the electricity demand for half-hourly data. We adapted and evaluated machine learning methods successfully used prediction and compared their performance with the state-of-the-art statistical methods used for electricity demand prediction. We showed that SVR and ARIMA models outperformed the neural

network models. Although we cannot generally to say that statistical models generally outperform NN models, we can say that NN models have equivalent prediction performance comparing to statistical models. We could also see, the NN have such attributes as computational efficiency, simplicity, and easy adjusting to changes in the process being forecast. The importance of having good intelligent forecasting tools for time series is ever more important with increasing number of data when more effort must be devoted to development of efficient data handling.
Future work will include exploring other ways of combining the prediction methods. Our main research objective is also to apply the developed meta-heuristic on various datasets or different time horizons. Selected metaheuristics will be tested with different parameter combinations, and the combination of parameters which can yield approximate feasible solution in an acceptable computation time.

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References

1. Qiu, X and Zhang, L and Ren, Y and Suganthan, P and Amaratunga, G. (2014) " Deep Learning for Regression and Time Series Forecasting," 2014 IEEE Symposium on Computational Intelligence in Ensemble Learning (CIEL), Orlando, pp. c1 – c2.
2. Sousa, J. C.,Jorge, H. M. and Neves, L. P. (2014) "Short-term load forecasting based on support vector regression and load profiling," International Journal of Energy Research, vol. 38, no. 3, pp. 350–362.
3. Taylor, J. W. (2003) "Short-term electricity demand forecasting using double seasonal exponential smoothing" Journal of the Operational Research Society, Vol. 54, pp: 799-805.
4. Sood, R. Koprinska, I. , Agelidis,, V. (2010) "Electricity load forecasting based on autocorrelation analysis," Proc. of. Int. Joint Conf. Neural Networks (IJCNN), Barcelona, pp. 1772-1779.
5. Box, G. E., Jenkins, G. M. and Reinse, G. C. (2013) Time series analysis: forecasting and control , John Wiley & Sons.
6. Cortes, C. and Vapnik, V. (1995), "Support-vector networks" Machine learning," vol. 20, no. 3, pp. 273–297.
7. Drucker, H., Burges, C. J, Kaufman, L., Smola, A. and Vapnik, V. (1997) "Support vector regression machines,"′Advances in neural information, " Processing systems, vol. 9, pp. 155–161.
8. Montgomery, D. C., Lynwood, A. J., Gardiner, J. S. (1990) Forecasting and Time Series Analysis," New York: McGraw-Hill, Inc., pp. 281-283.
9. Hall, M., Frank, E., Holmes, G. (2011) The WEKA Data Mining Software, [Online], Available at: www.weka.com, [Accessed November 2011].
10. Gooijer, J. G., Hyndman, R. J. (2006) "25 Years of Time Series Forecasting," International Journal of Forecasting, Vol. 22, pp. 443-473.
11. Marcek, D., Marcek, M., Babel, J. (2009) "Granular RBF NN Approach and Statistical Methods Applied to Modelling and Forecasting High Frequency Data," IJCIS, Vol. 2(4), pp. 353-364.
12. Zamba, A. M. (2012) "A Genetic Algorithm Approach for Solving Cutting Stock Problem in Lumber Cutting Industry" Proc. 18th Int. Conf. on Soft Computing, eds. R. Matousek, Czech Republic, Unicersity of Pardubice, Pardubice, pp. 70-752.

13. Saini, N. (2017) “Review of Selection Methods in Genetic Algorithms,” International Journal of Engineering and Computer Science, Vol. 6, Issue 12, pp. 22261-22263.
14. Anand, S., Afreen, and Sazdani, S. (2015) “A Novel and Efficient Selection Method in Genetic Algorithm” International Journal of Computer Application, Vol. 129, No. 15, pp. 7-12.
15. Obitko, M. (2012) Genetic Algorithm,” 1998, [Online], Available at: http://www.obitko.com/tutorials, [Accessed January 2012].
16. Kalyanmoy, DEB (2005) Multi objective Optimizationary using Evolutionary Algorithms, Wiley India Edition.

Development of a mathematical model of vegetable production quality under fuzzy constraints

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Abstract. Based on the analysis of the object of research, the problem was set; the target function is defined; restrictions on certain indicators have been introduced, the relationship of indicators with the factors that affect them has been established. The multi-criteria model of quality assessment is reduced to the problem of optimization with the objective function, which is a complex indicator of product quality, and vaguely described the required product characteristics.

Keywords: linear programming, fuzzy sets, objective function, constraints, membership function, defasification

1 Introduction

Agricultural products are characterized by a set of different quality indicators. Systematization of quality indicators makes it possible to approach the main stages of qualimetrics measurements:

I stage - measurement of various unit characteristics (quality indicators) of vegetables - technological measurements. Stage II - evaluation of product quality in general, based on the measurement results of individual characteristics - processing of measurement results. Characterizing the I stage (measurement of unit characteristics of products) it should be noted that part of the characteristics can be measured by technical means, and part can be identified, analyzed, evaluated by involving experts. Often expressing a subjective opinion, experts provide information that we use by converting it into indicators suitable for mathematical processing.

The concept of quality food products can be determined not by specific numerical indicators of certain of its characteristics, but by the belonging of the values of product characteristics to a certain interval. For example, for late cabbage there are the following quality requirements: dry matter content must be at least 9-10%, carbohydrate content - not less than 5-6%, vitamin C content - not less than 40-50 mg per 100 g of dry matter, nitrate content - not more than 400 mg / kg.

At the II stage - the stage of processing the results of measurements to optimize the overall product quality indicator, we propose to use a mathematical apparatus of fuzzy sets (because product characteristics must be in a certain interval), with which we build mathematical models of integrated quality assessment of agricultural products.

Mathematical models in qualimetry must have an optimization character, ie it is necessary to achieve extreme values of the objective function (the goal facing the researcher) with limitations in the set of acceptable solutions.

The first stage of developing a mathematical model is the study of the object of study, the selection of its individual components, their analysis.

The second stage of development of the mathematical model - on the basis of the conducted analysis of object of researches we carry out statement of a problem; determine the objective function; we impose restrictions on certain indicators, establish the relationship of indicators with the factors that affect them. Next, we determine the algorithm for calculating the parameters of the model.

The third stage of mathematical modeling is model analysis, solution analysis, system analysis.

Model analysis: the model must meet the following requirements: adequacy, completeness, adaptability to attract new elements, simplicity and clarity. Solution analysis: Based on the assumptions and rules developed, decisions are made about the conclusions about product quality.

System analysis: based on the principle of feedback, the model is simplified, the model is considered in conjunction with other tasks.

The purpose of qualimetric research can be not only to assess the current level of product quality, but also to provide recommendations for ensuring progressive quality standards to meet the needs of the population and the requirements of the processing industry for raw materials.

Therefore, we will identify the factors that can be influenced to improve the quality of vegetable products. Next, we will describe these factors and make a mathematical model for assessing the quality of crop products, which would establish the relationship between product quality and the indicators that shape this quality. Thus, we implement the idea of mathematical modeling of a complex quality indicator. We will reduce the multi-criteria model of quality assessment to the optimization problem with the objective function, which is a complex indicator of product quality, and vaguely described required product characteristics, ie we will form a fuzzy optimization problem (problem with vaguely defined constraints). Bellman-Zade. This area of research is promising; so I develop it in the aspect of feedback, i.e. on the basis of a multi-criteria model of product quality I will develop recommendations to ensure its quality standards.

2 Mathematical models for assessing the quality of agricultural products

Model I - a mathematical model for assessing the quality of vegetable products. The purpose - to determine the products with the highest content in vegetables of fiber, carbohydrates, proteins - depending on the amount of mineral fertilizers, ie to find the maximum value of the function that determines the complex quality (usefulness) of vegetables in fiber, carbohydrates, proteins depending on the amount of mineral fertilizers.

Model II - a mathematical model to achieve the maximum weight of agricultural products, i.e. to find the maximum value of the mass function depending on the mineral fertilizers.

Model III - a mathematical model to ensure the cultivation of agricultural products with the specified parameters of the specific gravity of nutrients (carbohydrates, proteins). The goal is to achieve the set parameters of the specific weight of nutrients with the least

amount of mineral fertilizers, i,e, to find the minimum value of the function of the amount of fertilizers.

Model IV - a mathematical model of vegetable safety, ie a function for assessing the safety of products for the presence of heavy metals.

The solution quality criterion for deterministic problems depends on the set of deterministic parameters c and controlled variables x, and in general the inverse problem is formed as follows:

$$Q(c, x) \rightarrow \max, \; x \in X \tag{1}$$

Finding the maximum value of the criterion does not narrow the conditions of the problem, because if the problem is formed in the form $Q'(c,x) \rightarrow \min$, $x \in X$, it is easy to convert it to the equivalent problem (1) by substituting $Q(c,x) = -Q'(c,x)$.

The solution of the inverse problem (1) is the value of the vector of controlled variables, which ensures the achievement of the highest value of the criterion of quality (efficiency) among all possible values of the vector of controlled variables

$$x^* = argmax\ Q(c,x), \; x \in X.$$

The general problem of nonlinear programming is formed as follows: we need to find an n-dimensional vector x=(x1,…,xn), which minimizes (maximizes) the function

$$f^0(x) \tag{2}$$

provided that f(i)(x) – are nonlinear functions:

$$f^{(i)}(x) \leq 0, \; i = \overline{1,m} \tag{3}$$

$$x \in X \tag{4}$$

Constraints (3), generally speaking (this can be seen from (1), can be written in the form (4), but the notation (2) - (4) is more appropriate, because in (4) we are able to include restrictions of a special kind, for example, the requirement of inseparability of variables, which does not make sense to write in the form (3).

Function (2) is called the objective function, the goal function (criterion of quality, efficiency), and the functions $f^{(i)}$, $i = \overline{1,m}$ – are called the constraint functions of the nonlinear programming problem. A controlled n-dimensional vector (plan) x that satisfies constraints (3) and (4) is called an admissible vector (plan). The set of all admissible vectors x is called the admissible set (domain) and is denoted by the letter D. The admissible vector minimizing the objective function $f^{(0)}(x)$, is called the optimal solution of the nonlinear programming problem. It is denoted, as for (1), by argmin $argmin\ f^0(x)$, $x \in D$. The corresponding x^* for the new value of the objective function is called the optimal value.

If in (2) - (3) the functions $f^{(i)}(x)$, $i = \overline{0,m}$ are linear in x:

$$f^{(0)}(x) = \sum_{j=1}^{n} c_j \cdot x_j \tag{5}$$

$$f^{(i)}(x) = \sum_{j=1}^{n} a_{ij} \cdot x_j - b_i, \; i = \overline{1,m} \tag{6}$$

$$X = \{x = (x_1, \dots, x_n): x_j \geq 0, j = \overline{1,n}\}, \tag{7}$$

then the problem (2) - (4), reduced to the problem (5) - (7), is called the problem of linear programming.

Classical (clear) set theory uses Archimedes' law of exclusion of the third, according to which an element either belongs to the set or does not belong to it. If it belongs, then the considered element is assigned the number 1, if not - then 0. That is, we introduce a certain function of belonging to the set X:

$$\mu(x) = \begin{cases} 1, & \text{if } x \in X \\ 0, & \text{if } x \notin X \end{cases} \quad (8)$$

where X is a certain base scale (set).

However, this approach is not suitable for the study of problems that operate on the qualitative characteristics of objects. In this case, it is expedient to determine the fuzzy set $\tilde{A}$ through the basic (universal set) scale X and the membership function $\mu_{\tilde{A}}(x)$, which takes values in the interval [0, 1]. Thus, the fuzzy set $\tilde{A}$ – is a set of pairs of the form:

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)), x \in X\} \quad (9)$$

If the base scale is discrete and finite, ie $X = \{x_i\}_{i=1}^{n}$, then the fuzzy set can be written as follows:

If the base scale is discrete and finite, ie $X = \{x_i\}_{i=1}^{n}$, then the fuzzy set can be written as follows:

$$\tilde{A} = \sum_{i=1}^{n} {}^{x_i}/_{\mu_{\tilde{A}}(x_i)}, \quad (10)$$

where xi – i- th value of the base scale.

The membership function $\mu_{\tilde{A}}(x)$ etermines the degree of confidence of the researcher that a particular value of the base scale corresponds to a fuzzy set. In contrast to the discrete case, continuous membership functions can be: triangular: membership functions $\mu_j(x_1, x_2, \ldots . x_n)$ are defined by the kernel q_c; trapezoidal: membership functions $\mu_j(x_1, x_2, \ldots . x_n)$ are determined by the kernel $\left|\underline{q_1}, \overline{q_1}\right|$; $[\overline{q_1}]$ – optimistic parameter estimation - parameter core; $\left|\underline{q_1}\right|$- pessimistic assessment of the parameter - the carrier of the parameter; bell-shaped: membership functions $\mu_j(x_1, x_2, \ldots . x_n)$ are expressed by the dependence:

$$\mu(x) = \frac{1}{1+(\frac{x-b}{c})^2} \quad (11)$$

If the universal set X is a set of real numbers R, then the fuzzy set $\tilde{A}$ is called a fuzzy number.

If the universal set X is a set of real numbers R, then the fuzzy set $\tilde{A}$ is called a fuzzy number.

3 Implementing the proposed model

Product quality is determined by a set of its characteristics that can be measured. The task of assessing the quality of agricultural products can be presented in the form of a fuzzy linear model:

$$Z(x) = c \cdot x \to min \quad (12)$$

The characteristics x=(x_1 ;…; x_n) are chosen from the constraints

$$g_i(x) \equiv a_i \cdot x \lesseqgtr b_i, \qquad b_i + d_i \quad i = \overline{1, m_1}$$

$$g_i(x) \equiv a_i \cdot x \leq b_i, \quad i = \overline{m_1 + 1, m} \quad (13)$$

Vectors $x = (x_1; \ldots; x_n)$, C=(c_1; ….;c_n); $a_i = (a_{i1}; \ldots; a_{in})$ and the numbers b_i $i = \overline{1, m}$, d_i >0 $i = \overline{1, m_1}$ are valid.

Vectors $x = (x_1; \ldots; x_n)$, C=(c_1; ….;c_n); $a_i = (a_{i1}; \ldots; a_{in})$ and the numbers b_i $i = \overline{1, m}$, d_i >0 $i = \overline{1, m_1}$ are valid.

$$Z(x) = x_1 + x_2 + x_3 \to min \quad (14)$$

The structural matrix compiled on the basis of experimental data characterizing the linear optimization problem has the form:

$$A = \begin{pmatrix} -0{,}247 & -0{,}247 & 0{,}207 \\ 0{,}247 & 0{,}247 & -0{,}207 \\ 0{,}08 & 0{,}08 & 0{,}054 \end{pmatrix} \quad (15)$$

It is necessary to ensure the cultivation of spring barley grain of the Vakula brewing variety, which meets the following quality indicators: the starch content in the grain must be greater than 60-70%; the protein content in the grain should be greater than 8% but less than 9-12% (trapezoidal membership function). Let's define kernels and carriers of parameters.

[9; 12] – optimistic evaluation of the parameter - the core of the protein parameter;
[63; 79] - optimistic estimation of the parameter - the core of the starch parameter;
[8; 13] - pessimistic assessment of the parameter - the carrier of the protein parameter;
[51; 84] - pessimistic assessment of the parameter - the carrier of the starch parameter.

Based on these quality requirements, we write the following flexible restrictions:

$$g_1(x) = -0{,}247 \cdot x_1 - 0{,}247 \cdot x_2 + 0{,}207 \cdot x_3 \le -0{,}03$$
$$g_2(x) = 0{,}247 \cdot x_1 + 0{,}247 \cdot x_2 - 0{,}207 \cdot x_3 \le 0{,}13; 0{,}13 + 0{,}3 \quad (16)$$
$$g_3(x) = 0{,}08 \cdot x_1 + 0{,}08 \cdot x_2 + 0{,}054 \cdot x_3 \le 0{,}78$$
$$g_4(x) = x_1 \ge 0{,}1$$
$$g_5(x) = x_1 \le 0{,}3 \quad (17)$$
$$g_6(x) = x_2 \ge 0{,}1$$
$$g_7(x) = x_2 \le 0{,}3$$
$$g_8(x) = x_3 \ge 0{,}15$$
$$g_9(x) = x_3 \le 0{,}4$$
$$X \ge 0;$$

According to the Bellman-Zade approach, the solution is the intersection of goals and constraints.

To defasify the problem, the following problems must be solved:

$$\underline{w} = x_1 + x_2 + x_3 \to min \quad (18)$$

under conditions

$$-0{,}247 \cdot x_1 - 0{,}247 \cdot x_2 + 0{,}207 \cdot x_3 \le -0{,}03$$
$$0{,}247 \cdot x_1 + 0{,}247 \cdot x_2 - 0{,}207 \cdot x_3 \le 0{,}13 \quad (19)$$
$$0{,}08 \cdot x_1 + 0{,}08 \cdot x_2 + 0{,}054 \cdot x_3 \le 0{,}78$$
$$0{,}1 \le x_1 \le 0{,}3 \quad (20)$$
$$0{,}1 \le x_2 \le 0{,}3$$
$$0{,}15 \le x_3 \le 0{,}4$$
$$\overline{w} = x_1 + x_2 + x_3 \to min \quad (21)$$

under conditions

$$0{,}247 \cdot x_1 - 0{,}247 \cdot x_2 + 0{,}207 \cdot x_3 \le -0{,}03$$
$$0{,}247 \cdot x_1 + 0{,}247 \cdot x_2 - 0{,}207 \cdot x_3 \le 0{,}43 \quad (22)$$
$$0{,}08 \cdot x_1 + 0{,}08 \cdot x_2 + 0{,}054 \cdot x_3 \le 0{,}78$$
$$0{,}1 \le x_1 \le 0{,}3 \quad (23)$$
$$0{,}1 \le x_2 \le 0{,}3$$

$$0{,}15 \le x_3 \le 0{,}4$$

x≥0;

Thus, we obtain the value $\underline{w} = z(x_1,x_2,x_3) = z(1;1;1{,}5) = 3{,}5$ and $\overline{w} = z(x_1,x_2,x_3) = z(1;1;1{,}75) = 3{,}75$. We write down the functions of belonging

$$\mu_z(x) = \begin{cases} 0 & w = z(x) < \underline{w} \\ \dfrac{z(x) - \underline{w}}{\overline{w} - w} & \underline{w} \le w = z(x) < \overline{w} \\ 1 & w = z(x) \ge \overline{w} \end{cases}$$

$$\mu_z(x_1,x_2,x_3) = \begin{cases} 0 & x_1 + x_2 + x_3 < 3{,}5 \\ \dfrac{x_1 + x_2 + x_3 - 3{,}5}{0{,}25} & x_1 + x_2 + x_3 < 3{,}75 \\ 1 & x_1 + x_2 + x_3 \ge 3{,}75 \end{cases}$$

$$\mu_z(x_1,x_2,x_3) = \begin{cases} 1 & 0{,}247x_1 + 0{,}247x_2 - 0{,}207x_3 \le 0{,}13 \\ 1 - \dfrac{0{,}247x_1 + 0{,}247x_2 - 0{,}207x_3 - 0{,}13}{0{,}3} & 0{,}13 < 0{,}247x_1 + 0{,}247x_2 - 0{,}207x_3 \le 0{,}43 \\ 0 & 0{,}247x_1 + 0{,}247x_2 - 0{,}207x_3 > 0{,}43 \end{cases}$$

Using the obtained values, we reduce the fuzzy optimization problem to a deterministic form

$$Z(x) = x_1 + x_2 + x_3 \to min \quad (24)$$

under conditions

$$0{,}25 \cdot \lambda - (x_1 + x_2 + x_3) \le -3{,}5$$
$$-0{,}247 \cdot x_1 - 0{,}247 \cdot x_2 + 0{,}207 \cdot x_3 \le -0{,}03$$
$$0{,}3 \cdot \lambda + 0{,}247 \cdot x_1 + 0{,}247 \cdot x_2 - 0{,}207 \cdot x_3 \le 0{,}43 \quad (25)$$
$$0{,}08 \cdot x_1 + 0{,}08 \cdot x_2 + 0{,}054 \cdot x_3 \le 0{,}78$$
$$0{,}1 \le x_1 \le 0{,}3 \quad (26)$$
$$0{,}1 \le x_2 \le 0{,}3$$
$$0{,}15 \le x_3 \le 0{,}4$$
$$\lambda \ge 0 \; x \ge 0;$$

Solving the problem of linear programming and deterministic form under these conditions, we obtain the following solution x1=1, x2=1, x3=1,6. According to this solution, we will provide recommendations for the cultivation of crop agricultural products, in particular the grain of spring barley variety Vakula for use in brewing. Barley grain is high quality and suitable for brewing with the use of fertilizers N30 P30 K45, N45 P45 K60 та N60 P60 K95. However, the task of obtaining quality grain with a minimum amount of fertilizer is achieved by using fertilizers N30 P30 K50.

4 Conclusion

To optimize the overall product quality indicator, it is proposed to use a mathematical apparatus of fuzzy logic. The following mathematical models for complex assessment of agricultural product quality under fuzzy constraints are constructed: model for determining vegetables with the highest content of fiber, carbohydrates and proteins, depending on the amount of mineral fertilizers (maximum value of the function that determines the complex quality indicator); model for achieving the maximum weight of agricultural products (maximum value of the mass function depending on mineral fertilizers); model for ensuring the cultivation of agricultural products with the specified

parameters of the specific weight of nutrients (carbohydrates, proteins); model for assessing the safety of products for the presence of heavy metals.

References

1. Voronina L.M., Desenko V.F., Madiievska N.M. et al. (2000). *Biolohichna khimiia.* Kharkiv: Osnova, Vydavnytstvo NFAU.
2. Romodanova V.O. (2009). Metody kontroliu produktsii v haluzi. *Open International University of Human Development «Ukraine».* [Online], Available: http://vo.ukraine.edu.ua/mod/url/view.php?id=3568
3. Mazur A. (2010). 'Influence of the pre-dam reservoir on the quality of surface waters supplying reservoir «nielisz»'. *TEKA Komisji Ochrony i Kształtowania Środowiska, 7*, pp. 243–250.
4. Syavavko M., Rybytska O. (2008). *Mathematical modeling under uncertainty.* – Lviv: Ukrainian technologies. – 320p.
5. Syavavko M. (2006). *Fundamentals of economic informatics.* Lviv: «Magnolia Plus». – 236p.
6. Pokhodylo Ye.V., Stolyarchuk P. H. (2012). *Imitansnyi kontrol yakosti.* Lviv: Vydavnytstvo Lvivskoi politekhniky.
7. Foreit I. (1966). *Emkostnye datchiki neelektricheskih velichin.* Moscow-Leningrad: Energiia: Pearson publishing.
8. Pohodylo E., Stolyarchuk P., Chyrka M. (2002, October). 'PC-based devices for immittance control of multidimensional objects'. *IEEE Transactions on Instrumentation and Measurement, Vol. 51, № 5*, 1133–1136. doi:10.1109/tim.2002.806014
9. Majewski J., Malacziwskyj P., Yatsuk V., Stolyarczuk P., Michalewa M. (2010). 'Zastosowanie sensorów pojemnościowych do szybkiej kontroli parametrówroztworów wieloskładnikowych'. *Przegląd Elektrotechniczny, 10*, pp. 92–95.
10. Ivakhiv O., Pokhodylo Ye., Stolyarchuk P. (2002). 'Production Quality Testing with Immitance Sensors Using Instrumentation'. *VII Konferencja naukowa «Czujniki optoelektroniczne i elektroniczne» (COE'2002), Rzeszow, 5-8 czerwca 2002, Vol. 2*, pp. 297–300.

Use of chatbots in reallife economical

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Abstract. Paper summarize history and progress of chatbot technology, discusses characteristics and possibilities of chatbots, its development over past decade and the pace at which it changes right now.
It tries to map the current chatbot market, analyze trends and newest features of chatbots and try to answer, why businesses should consider chatbots. At the end of the article it presents the most popular chatbot development platforms of today.
Keywords: chatbots, market, characteristics.

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1 Introduction

What was once a dream is now obsolete and what never was a dream is now a new standard. This change can easily be seen on how jobs that once were considered essential and impossible to be done by anyone than humans are now done by machines. Most people think, only human can recognize emotions in other human's speech or actions. Yet nowadays AI can scan phone calls you made with your operator and tell you a lot more about the calling person, than any human ever could. Most people think, psychologists are always going to be the only ones being able to help troubled minds, yet there already is an app for your phone, that takes care of your mental wellbeing as well as a regular psychologist would and is always at your arm's reach.

History of chatbots

A chatbot is a program with a certain degree of artificial intelligence that interacts with a human by emulating a conversation with a real person. This perception can be so authentic that consumers unknowingly accept these devices as if they were human beings in the laws of social norms, relationships, and responsibilities.

In the growth of chatbots, programmers rely specifically on two aspects: emotions and agency. With the massive expansion of the Internet and particularly of social networking sites, a boom in the use of chatbots, whether with simple or more advanced artificial intelligence, has begun. These services are used in online shops to connect with a person, such as customer support, promotion and advertisement, entertainment, data collection and they are also used as tools for hybrid threats used to influence public opinion. (Neff et al, 2016)

List of selected chatbots

ELIZA

The history of chatbots started in 1950 when Alan Turing began pondering them. He dreamed of robots that were indistinguishable from humans in text communication (Turing's

test). In 1966, the world's first chatbot ELIZA was created. It mimicked a psychoanalyst and held a conversation with a patient for a while. It has just scripted answers. (Neff et al, 2016).

Parry

Parry, which was introduced in 1972 at Stanford's Psychiatry Department by Kenneth Mark Colby, a psychiatrist and computer scientist, is another wellknown chatbot. An opposite technique from Eliza was used by this application to draw focus from itself. It did not operate like a psychiatrist but as a schizophrenic patient who was paranoid.

Jabberwacky 1988

One of the earliest attempts at creating artificial intelligence through human interaction mainly in a form of entertainment. It had the goal of moving from textbased system to one wholly voice operated.

Dr. Sbaitso 1992

Artificial intelligence speech synthesis program created for MSDOSbased PCs, aimed at displaying digital speech. Dr. Sbaitso is far from lifelike. Although it has assumed the role of a psychologist when interacting with users.

A.L.I.C.E. 1995

Artificial Linguistic Internet Computer Entity. A.L.I.C.E. was a natural language processing bot. It could reply apply heuristic pattern matching rules to human input in the other words have a conversation. (Neff et al, 2016)

Smartechild 2001

Smart bot widely distributed across SMS networks. With highlights, for example, snappy information access and fun customized discussion. It was viewed as an antecedent to Apple's Siri and Samsung's S Voice.

Google now 2012

It was created by Google for the mobile app Google Search. It uses a user interface in a natural language, which allows individuals to answer questions, make decisions and act by delegating requests to a range of Google resources. (Sandeep et al, 2018)

Eugene Goostman 2014

Is a chatbot that some consider to have passed the Turing test of a computer's ability to interact indistinguishably from a human being. Built in St Petersburg in 2001 by a group of three programmers, Russianborn Vladimir Veselov, Ukrainianborn Eugene Demchenko and Russianborn Sergey Ulasen, Goostman is depicted as a 13yearold Ukrainian child. (Mann, 2017)

ALEXA 2015

Inhabiting the Amazon Echo device, Alexa is an open API voice service capable of voice interaction, using natural language processing algorithms to receive, understand and respond to voice commands.

Cortana 2015

In same year as ALEXA was created Cortana. It is a Microsoftdesigned intelligent personal assistant that is included by default on all Windows 10 platforms. Using the Bing search engine, Cortana detects natural voice commands and addresses questions.

Bots for Facebook Messenger 2015

To understand questions, provide responses, and execute tasks, bots are programmed. From a client's point of view, they are a cordial and open efficient device. Your customer can just type a message, like they would to a friend, instead of opening an app, making a phone call, running a search, or loading a webpage.

Google Assistant 2016

It is an artificial intelligence virtual assistant created by Google that is mainly available on smartphones and smart home platforms. The Google Assistant will participate in twoway discussions, unlike the company's previous virtual assistant, Google Now.

Google revealed earlier in 2020 that it will introduce a new feature for Google's CES assistant. A functionality called "Scheduled Actions" enables the assistant to use smart devices. With Google Assistant, consumers will be able to use a smart coffee machine, vacuum cleaner, etc. Amazon Alexa has been selling this feature for a long time because it is a huge feature because it helps assistants to communicate with the real world. (Sandeep et al, 2018)

Emirates Airlines chatbot 2018

For their travel recommendation app, Emirates Airlines has developed a chatbot. Since they merged conversational AI technology with onsite display advertising, their chatbot approach is more creative than its peers.

The bot asks questions about what kind of trip you are searching for. In its question, the chatbot uses user intent as well as the context of the page where it appears. Then by offering them travel packages and providing relevant details about the venue, she personalizes the vacation planning process.

The chatbot was created just for 30 days and the results of their 30day trial were positive. They are seeing an 87 percent rise in customer interest that saw the chatbot ad compared to those that saw a regular show ad. [5]

Mobile Monkey

MobileMonkey is a Facebook Messenger bot builder which helps marketers create highconverting chatbots. MobileMonkey specializes in integrating your chatbot with your broader marketing stack, including your ad campaigns, unlike many other chatbot constructors in this post.

Paid versions start from 390 Kc/month and this gets you advanced automation, integrations, SMS and more. (MobileMonkey, 2016)

About chatbots

Are chatbots that smart indeed? How are they responding to the questions we are asking? No, they're not themselves intelligent, they're built by humans to do so. To submit a predefined response and access the database, chatterbots recognize keywords from the user's input. For example, the receiver sends a text containing the word 'car.' "It is most likely that the chatbot will ask something like: "Which model is your car? Or is it possible for me to know anything about your car? ".

A chatbot is a program that executes an automatic operation, such as completing a workflow or addressing FAQs. Chatbots are online and typically evolve over time by using artificial intelligence and machine learning on chat platforms or on social media.

Chatbots are embedded into chat platforms that each have their own features, such as Slack, Facebook Messenger or SMS. Each platform's features decide the ways in which the

chatbot will communicate with people, communities, or teams, but the bot determines the chatbot's actions. (Kim, 2018)

For example, SMS and email bots can only view text and attach multimedia widgets. On the other hand, Facebook Messenger, Kik or Telegram Bot will communicate with users using several different graphical widgets. Users of these platforms can also have access to web views, which effectively enables infinite flexibility in terms of the user interface that can be provided to users.

Chatbots are a fantastic way for companies to meet consumers if they already have messaging apps. Chatbots allow companies to deliver services in a highly customized manner, where communications, operations and human support can be integrated in one experience. (Kim, 2018)

Why businesses should consider chatbots?

Chatbots are gaining popularity as they bring new ways of how businesses run marketing. They have become the latest addition to every marketer's bag of strategies, as being an early adopter can give you a major advantage from customer support to lead generation. (Kim, 2018)

Chatbots represent a very huge opportunity for business to communicate and engage their customers through messaging apps. Here are some reasons why to get one:

1. The global Chatbot market is expected to grow exponentially between 2016–2023. - Credence Research
2. 85% of customer interactions will be managed without a human by 2020. - Gartner
3. 32% of executives say voice recognition is the most widely used AI technology in their business. — Narrative Science
4. 6 billion connected devices will proactively ask for support by 2018 - Gartner
5. 44% of executives believe artificial intelligence's most important benefit is "automated communications that provide data that can be used to make decisions." - Narrative Science
6. By the end of 2018, "customer digital assistants" will recognize customers by face and voice across channels and partners. - Gartner
7. 40% of mobile interactions will be managed by smart agents by 2020. - Gartner
8. 10k+ developers are building chatbots in Facebook Messenger. - Facebook (Kim, 2018)

Types of chatbots

There are many types of chatbots available on the market, but generally they can be divided into following categories:

Textbased chatbot

In a textbased chatbot, a bot answers the user's questions via text interface.

Voicebased chatbot

In a voice or speechbased chatbot, a bot answers the user's questions via a human voice interface. (GreatLearning, 2020)

There are mainly two approaches used to design the chatbots, described as follows:

Traditional chatbot

Traditional chatbots are driven by system and automation, mainly through scripts with minimal functionality and the ability to maintain only system context. (GreatLearning, 2020)

Current chatbot

Current chatbots are driven by backandforth communication between the system and humans. They have the ability to maintain both system and task contexts.

Future chatbot

Future chatbots can communicate at multiple levels with automation at the system level. They have the ability to maintain the system, task, and people contexts. There is a possibility of introduction of master bots and eventually a bot OS. (GreatLearning, 2020)

Most Popular Chatbot Development Frameworks

Microsoft Bot Framework

Designed to interact, talk, listen, and communicate with customers, Microsoft Bot Framework builds phenomenal frameworks. This A.I. chatbot platform comes with the ability to integrate with the most popular application offered by Microsoft suite like Cortana, Office 365, and so on.

Businesses can use Microsoft Bot framework and train chatbots using the existing conversation and Azure cognitive service. Chatbots can understand people's communication through text, SMS, video, and speech. It deploys active learning and includes preexisting, prebuild models that allow chatbots to interact with users on chat programs they're already using, such as Skype, Slack, Facebook Messenger, Cortana, Microsoft Teams, Kik, and more. The opensource SDK allows businesses to test chatbot products even before it is deployed into a channel. Powered by A.I. and machine learning, Microsoft Bot based chatbots can also reply to the most complicated questions asked by the visitors. (Kim, 2018)

Wit.ai

Wit.ai is a free and opensource Natural Language Processing API that businesses use to create textbased and voicebased bots. These chatbots can be integrated on all kinds of the messaging platform. The framework supports almost any languages spoken all over the world.

Dialog Flow

Businesses can use Dialog Flow to digitize business processes to save time and money that goes into hiring expert community managers.

This framework uses Speechtotext and natural language conversations to facilitate automated humancomputer interaction. Dialog Flow framework leverages Google cloud architecture and AIpowered sophisticated system to convert speech into text. Google also used big data to understand what users are saying and respond accordingly. The framework comes with an Inline code editor that makes it easy for everyone to integrate multifunctional intelligent chatbots into their systems. Users can interact with brands through the website, on Google Assistant, Alex, Facebook Messenger, and other platforms, when the chatbot is built using Dialog Flow. (PromaticsTechnologies, 2020)

I.B.M. Watson

The framework is extensively used to develop chatbots for healthcare units which can actively take patient data and identifies potential diseases using the power of natural language processing. Chatbots build on I.B.M. Watson framework can even help doctors prescribe proper treatments and medicines. It is primarily designed to work as a question answering system with dynamic dialogue flow.

Pandorabots

Businesses use Pandorabots to build intelligent chatbots for businesses and third party applications. Pandorabot chatbot builder has been used to develop chatbots for voice

interfaces, eCommerce, customer service, marketing and more, in the past. While the basic version is offered free of cost, the company provides multidimensional pricing plans for businesses with advanced requirements. (PromaticsTechnologies, 2020)

Botpress

It promises a developerfriendly environment through an intuitive dashboard and its flexible technology. Botpress framework runs on a threestage installation process. First, the developers start building the bot, then they deploy it to their preferred platform and thirdly, they handoff access so that it can be efficiently managed. Businesses can build chatbots locally and use their favourite cloud hosting.

Botkit

Botkit has a free version and paid versions starts from $5/month, the cost varies depending on how many bots and active users a business interacts with. (PromaticsTechnologies, 2020)

RASA Stack

Being an independent service, all the data fed to the framework or received by it, don't need to run through a third party API. Chatbots built with RASA Stack can perform contextual dialogues, recognize user intent, and even exact entities.

The framework is production ready. A paid and functionally advanced version of RASA Stack is also available in the name of RASA Platform.

ChatterBot

ChatterBot framework allows chatbots to slowly pickup learning after its deployment, which contributes to the accuracy and speed of the responses over time. Each interaction with an end customer allows Chatbots to gain knowledge and improve its performance of producing replies, thanks to machine learning algorithms. (PromaticsTechnologies, 2020)

2 Conclusion

The future of chatbots will bring an increase in the ecommerce area. Many companies already have chatbots around the clock to answer customer questions and provide support. Customers will no longer need to send an email to a company mailbox and then wait for that employee's response to question during business hours. Immediate responses, provided by chatbots, to questions or concerns can help perpetuate buyer momentum, which translates to more sales without more employees. [(Discover.bot, 2016)

- 24/7 availability: Chatbots provide 24/7 responses to customer service questions, shopping assistance, and curated product options.
- An understanding of the problem: Chatbots are becoming more adaptable to the variety of consumer frustrations and they can learn from past interactions.
- The chatbots are able to learn from behavior of costumers: The more that chatbots interact with users, the more opportunity there is for chatbots to learn more.

Chatbots can enhance existing technology

The second thing is, that chatbots can be programmed to enhance existing technology. For better understanding, informational chatbots can provide live updates on sports and weather, and other task chatbots can even make purchases for you. Integrating bots into already popular applications can alleviate user burden by handling the heavy lifting of user(Neff et al, 2016) performed tasks.

And firms already have chatbots to complement their websites and chat with clients/customers. For example, in a city full of trendy options, imagine trying to find the perfect restaurant. You could spend a significant amount of time slogging through endless menus and reviews. A chatbot could find the information for you, make recommendations and preferences, and even execute the order. Chatbots that help the customer find and purchase a product or service are of great benefit to businesses. [(Discover.bot, 2016)

Chatbots can enhance existing technology

Chatbots are getting smarter

IT experts are currently working on how to improve Artificial Intelligence and to increase bots' learning capabilities while relying less on data. And they're making progress. For example, chatbot functionality has transformed in a way that makes it more convenient for us to voice our requests instead of typing them. Since millennials today prefer handsfree conversations, the use a voice assistant, like Cortana or Siri, is expected to increase to 8 billion within the next few years.

These breakthroughs hold limitless possibilities for taking bot technology, AI, and virtual conversational abilities to the next level. [(Discover.bot, 2016)

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References

1. Discover.bot (2016) The Future of Chatbots & Conversational Marketing AI discover.bot. A Bot Development and Information Portal Discover.bot [online]. Retrieved May 10, 2021. From https://discover.bot/bottalk/whatisthefutureofbots/
2. GreatLearning (2020) Introduction to Chatbot | Artificial Intelligence Chatbot Tutorial. Great Learning, Retrieved March 10, 2021. From https://www.mygreatlearning.com/blog/basics ofbuildinganartificialintelligencechatbot?utm_source=pinterest26
3. Kim, L. (2018, June 20). The Importance of Chatbots in Every Business (Infographic). [online]. Retrieved June 10, 2020. From https://chatbotsmagazine.com/the importanceofchatbotsineverybusinessinfographic8a8f990be0aa
4. Mann, A. (2017, June 03) That Computer Actually Got an F on the Turing Test. Retrieved March 15, 2021. From http://www.wired.com/2014/06/turingtestnotsofast/
5. MobileMonkey (2016) Review Facebook Messenger Chatbot Platform for Marketers. 99signals | SEO and Online Marketing Blog by Sandeep Mallya [online]. Retrieved June 1, 2020. from https://www.99signals.com/mobilemonkeyreview/
6. Neff, G., Nagy, P. (2016) Talking to Bots: Symbiotic Agency and the Case of Tay, International Journal of Communication. 10 491531.
7. PromaticsTechnologies (2020) Here Are The Most Popular Chatbot Development Frameworks The Promatics | Promatics Technologies [online]. Retrieved March 10, 2021. From https://www.promaticsindia.com/blog/herearethemostpopularchatbotdevelopment frameworks/
8. Sandeep Mallya, et al. (2018) "MobileMonkey Review: Facebook Messenger Chatbot Platform for Marketers." 99signals. [online]. Retrieved June 1, 2021. From www.99signals.com/mobilemonkeyreview.

Analysis of selected economic software used in business practice

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Abstract. Economic software is an important and effective tool for process management in a company. The use of economic software in the company will ensure faster and more efficient human resources management, production and warehouse management or even asset management. With the help of economic software, the user obtains comprehensive information, which serves as a basis for further business planning, reporting, controlling or audit. Economic software with an accounting extension is used by most companies in the Czech Republic, whether they are small businesses or large companies. Due to the large range and diversity of economic software available on the Czech market, this article is intended to help users navigate this area faster. Part of the article is an analysis of selected economic software that are commonly used in business practice. The aim of this article is to evaluate selected economic software. This article will provide the user with comprehensive information about selected economic software, and on this basis can decide on the applicability of the software in his company

Keywords: Economic software, EMR, company, information system

1 Introduction

With the ever-growing trend of integrating information technology into business practice, the company's management is facing decisions on the implementation of information systems. The Czech market offers a wide range of economic information systems and it is difficult for users to easily navigate the offer. In addition, the amount of information that the company's management must process every year is growing, so we are encountering the implementation of economic software more and more often and are becoming a common tool not only in large and medium-sized companies but also in small companies.

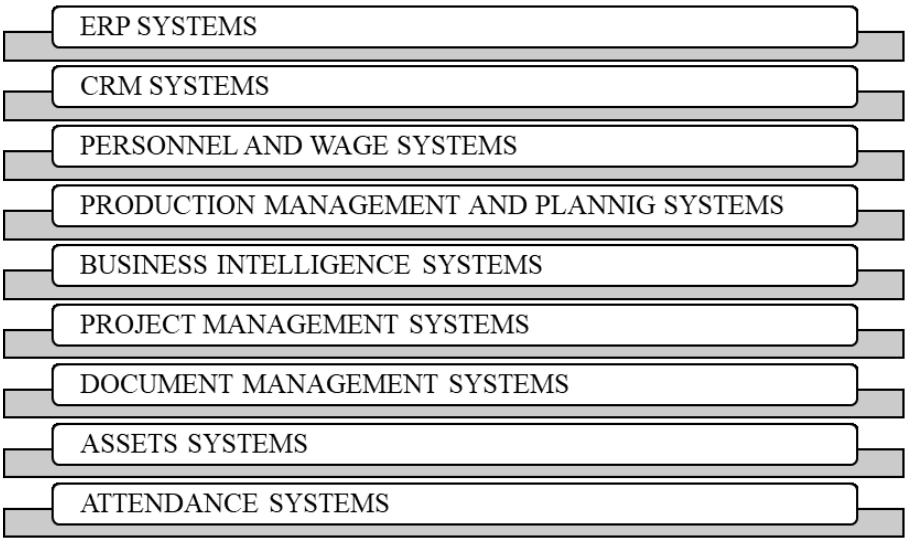
Quality IS is currently a necessary condition for the success of companies in all areas of business. The main reason for the need to own a quality IS is that the information system is one of the main factors in the effectiveness of management and competitiveness of the company (Šmíd, 2009). Today's information systems support all important business functions, such as finance, human resources, planning, sales, purchasing, logistics and e-business (Basl, 2008). Due to the fact that there is a large number of information systems with economic software on the Czech market, it is necessary to bring this software closer so that the user can choose according to their requirements. The main goal of this article is to summarize basic information about available economic software in our market with a focus on ERP systems.

2 Information system

Information system is the interconnection of information and processes that work with this information. We can perceive information as data stored in a database used for decision-making and management in a larger system. By process we mean functions that process information and transform it into output data. In general, it can be said that IS serves as a source of information that helps managers to be able to manage, plan, coordinate work and control all processes in the company (Mejzlík, 2006).

3 Information system

We divide economic information systems according to their functions and content. We have systems related to the area, for example for monitoring assets or production, and then we have systems such as the ERM system, which is a comprehensive economic information system. The following Table 1 shows a diagram of available economic information systems



Tablee 1 Division of economics information systems

ERP SYSTEMS

In short, for ERP systems, it is from the English "Eterprise Resource Planning". It is a comprehensive information system of the company, which includes categories, namely production management and planning, customer relationship management or personnel management. It is a combination of CRM and HRM.

CRM SYSTEMS

The abbreviation is based on the English "Customer Relationship Management". These are customer relationship management systems. It is used to manage salespeople, sales networks, manage business contacts and manage sales campaigns. The system is used to analyze customer data, to evaluate and describe customer behavior, customer retention, customer distribution, evaluation of the effectiveness of marketing strategies and the search for new sales opportunities (Beitlová, 2011).

PERSONNEL AND WAGE SYSTEMS

The abbreviation of the system is from the English term "Human Resource Management". These are systems for processing payroll and personnel agenda of companies and for human resources management. The main benefits of these software are payroll processing, attendance control, vacation planning records, employee appraisals, and compensation.

PRODUCTION MANAGEMENT AND PLANNING SYSTEMS

These are systems for optimizing production processes, production planning and evaluation of machine utilization and downtime. The system also provides information on the fulfillment of production plans, planning of production capacity of machines, availability of materials in the warehouse and registration of orders from the demand phase to the final invoicing.

BUSINESS INTELLIGENCE SYSTEMS

It is a system of tools for managing and controlling the company's finances. The system primarily monitors the company's performance and cost-effectiveness. The system also creates analyzes of business processes, which are the output for business planning, budgeting, benchmarking, controlling and reporting. V Management information systems are often referred to as Business Intelligence Systems. Management information systems obtain data from the ERP and CRM system.

PROJECT MANAGEMENT SYSTEMS

These are systems that record the life cycle of a project. They effectively control and monitor all types of corporate projects.

DOCUMENT MANAGEMENT SYSTEMS

These are complex systems that can accommodate complex company documentation. It is a tool for unifying company documentation. The content of the system includes samples of company documents, valid directives and regulations, news from the company environment.

ASSETS SYSTEMS

These are systems for electronic registration of company property. The systems help facilitate asset inventory and asset audit. The systems can manage assets throughout their life, from the initial proposal for acquisition, through the approval of the purchase, to the commissioning or eventual decommissioning of the asset and its disposal. At the same time, the system provides information and notification to the relevant employees about the allocation of assets to care and the maintenance of clear lists with a record of the necessary data on assets.

ATTENDANCE SYSTEMS

These are systems that deal with wages, personnel agenda, records of employees' working hours, as well as their remuneration. The systems are based on valid legislation, thanks to which the company prevents violations of payroll and personnel regulations.

3.1 Reasons for introducing ERP systems

The reason for the introduction of complex economic systems in companies is

- control over the accounting agenda,
- fast tracing and issuing of invoices, contracts and accounting documents,
- the possibility of immediate delegation of tasks to employees through the system,

- creation of summary reports, reports and summaries for the company's financial management,
- easy and clear registration of assets
- thorough management of salaries and personnel agenda,
- monitoring the performance of the company (Čech, Bureš, 2009).

3.2 Reasons for introducing ERP systems

There are a number of complex economic software on the Czech market, so-called CRP systems, with various features. When choosing a suitable economic information system, it is necessary to focus and define the necessary parameters, which include:

- size of enterprise,
- financial possibilities of the company,
- legislation,
- individual software requirements,
- many elements of the information system,
- options for expanding functions in the future,
- user interface,
- system and software management,
- approaches to the system,
- the amount of data required for processing,
- client support,
- degree of adaptability,
- data protection (Sodomka, Klčová, 2010).

For the analysis of current economic ERP systems on the Czech market, three economic software for large, medium and small companies were always selected. The following table 2 contains information on the functions of the individual economic software.

	POHODA KOMPLET	MONEY S5	HELIOS NEPHRITE	POHODA PREMIUM	MONEY S3 PREMIUM	KELEXPRESS	MONEY S3 START	HELIOS EASY	POHODA STANDARD
Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✗
Tax records	✓	✓	✓	✗	✓	✓	✓	✓	✓
Invoices	✓	✓	✓	✓	✓	✓	✓	✓	✓
Orderes	✓	✓	✓	✓	✓	✓	✓	✓	✓
Financia	✓	✗	✓	✓	✗	✗	✗	✗	✓
Wages	✓	✓	✓	✓	✓	✓	✓	✓	✓
Warehouses	✓	✓	✓	✓	✓	✓	✓	✓	✓
Property	✓	✓	✓	✓	✓	✓	✓	✓	✓
Log book	✓	✗	✓	✓	✓	✓	✓	✓	✓
Human resources	✗	✓	✓	✗	✓	✓	✓	✓	✓
CRM	✗	✓	✓	✗	✗	✓	✗	✓	✗
Atendance	✗	✗	✓	✗	✗	✓	✗	✓	✗
Homebanking	✓	✗	✗	✓	✓	✓	✗	✗	✓
GDPR	✓	✓	✗	✗	✗	✓	✗	✗	✓
E-shop	✓	✓	✗	✓	✗	✓	✓	✗	✗
EET	✓	✗	✗	✓	✓	✗	✓	✗	✓
Business size	big	big	big	medium	medium	medium	small	small	small

Table 2 Analysis of choice economics information systems

Analysis of economic software selection is an individual matter. Each user has different parameters. The performed analysis was evaluated on the basis of the basic functions of selected economic software. Three economic software were selected for each company size. Three economic software suitable for large companies, three for medium-sized companies and three for small ones.

In terms of monitored parameters, Helios Nephrite was the most user-friendly for large companies. Based on the analyzed parameters, the economic software Kelexpress is the most suitable for medium-sized companies. For small businesses, the economical Helios Easy software came out the most suitable from the selected parameters.

4 Conclusion

The technological boom requires the use of economic information systems in business practice. Business management is faced with the important decision of which economic software to purchase. There are dozens of companies on the Czech market that offer attractive economic software. Some software products have been on the market for many years and have thousands of satisfied customers, others are on the market for a short time and are just gaining their customers. The aim of the article was to select nine economic software and compare their functional possibilities for each category of business size. The Helios product is the most suitable product for large and small companies, on the other hand, the Kelexpress economic information system has emerged as the most suitable for medium-sized companies.

References

1. ŠMÍD, Vladimír. Management informačních systémů [on-line]. 2009 [cit. 2011-04-13]. Dostupné z: < http://www.fi.muni.cz/~smid/mis-infsys.htm>
2. BASL, Josef. Podnikové informační systémy. Praha: Grada Publishing, a.s., 2008. ISBN 978-80-247-2279-5.
3. ČECH, Pavel a Vladimír BUREŠ. Podniková informatika. Vyd. 1. Hradec Králové: Gaudeamus, 2009, 232 s. ISBN 978-807-0414-798.
4. MEJZLÍK, Ladislav. Účetní informační systémy. Využití informačních a komunikačních technologií v účetnictví. 1. vydání, Praha: Oeconomica, 2006, 173 s., ISBN 80-245-1136-3
5. SODOMKA, Petr., KLČOVÁ, Hana. Informační systémy v podnikové praxi. 2. vydání. Brno: Computer Press, 2010. ISBN 978-80-251-2878-7
6. BEITLOVÁ, Michaela. Systémy ERM: Co je dobré vědět před tím, než systém nakoupíme/vytvoříme a implementujeme [online]. 2011 [cit. 2021-10-24]. ISSN edsbas. Dostupné z: https://search.ebscohost.com/login.aspx?direct=true&db=edsbas&an=edsbas.

Managerial dashboards related to resource process consumption accounting in business management

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Abstract. Maintaining a competitive advantage makes it necessary to search for new solutions that enable making the right management decisions. The use of controlling for the continuous improvement of the management of individual processes in the enterprise can be supported by specialized software that enables the tracking of current cost parameters in individual processes in relation to the available resources. In this article, the author presents an example of the practical application of a readable computer information system in the form of dashboards related to resource-process consumption accounting (RPCA) for business management. The use managerial dashboards related to RPCA enables, among others: support for management in strategic planning, systematic monitoring
of goals and deviations, measures and budgets in organizational units, setting standards. At RPCA, detailed records and cost allocation are kept, broken down into individual organizational resources, processes, products, services and customers. Specialized software processes data from the financial and accounting system in relation to individual cost centers. The data is presented on the manager's computer screen and allows to determine the current and periodic cost of production according to the selected filter in relation to key parameter indicators.

Keywords: management, controlling, cost accounting

1 Introduction

Cost analysis is one of the most important measures characterizing the economy of an enterprise, as the cost price reflects the quality of all processes in its activity (Kaplan and Cooper, 2000, Lukić, Radowić and Lalić, 2011). The task of cost analysis is to provide detailed information on the development of costs in various classification cross-sections

1.1 Cost accounting

Cost accounting is an essential element of the accounting system. The oldest concept of cost accounting was equated with the widely understood calculation, which, in addition to accounting and financial reporting, formed the accounting system (Stefan and Cardos, 2010, Mehta 2019). In this sense, the scope of the cost accounting was limited to enabling the determination of the financial result after posting (Nowak, 2018). According to Sojak (2015). One should strive to shape the appropriate structure and size of costs, taking into account the level of functionality and quality of the product desired by buyers. Kenneth, Bowles, and Durlauf (2000) believe that cost accounting is probably one of the most important functions in the field of accounting, as the key to supporting strategic business decisions and improving profitability. Cost accounting is separate from general financial accounting, which

is governed by Generally Accepted Accounting Principles (GAAP) and is critical to the formation of financial statements. Often the simplest and most important purpose of cost accounting is to establish selling prices and to control costs (Shukla, Gupta and Grewal 2018, Bhimani Datar, et all. (2019). Cost accounting can contribute to the preparation of the required financial statements. Detailed information on cost accounting is presented extensively in the literature. Among others, the works of Keys and van der Merwe (2002), Kilger, Pampel and Vikas (2004), Sharman and Vikas (2004) were analyzed. Managing costs and process efficiency with IT support provides managers with financial and operational information supporting cost management and resource utilization. Entrepreneurs and business managers rely on practical information before making allocation decisions. Cost accounting supports decision making as it can be adapted to the specific needs of each individual company (Keys 2001).

1.2 Resource process consumption accounting

Resource Consumption Accounting was first introduced as a concept of cost accounting around 2000 (Keys and van der Merwe 2001). In 2009, the International Federation of Accountants (IFAC) included Resource Consumption Accounting in its International Good Practice Guidelines publication (IGPG 2009). In Polish literaturę for ex. Zieliński (2017), assuming that the value of an enterprise is an important measure of the success of management processes, believes that it is reasonable to combine elements of the American ABC and the German Grenzplankostenrechnung under one management cost account. (GPK). Earlier in the US, attempts to link GPK and ABC were presented by Keys and van der Merwe (2001) and Bleeker (2002), under the name resource consumption accounting (RCA). These issues were also taken up by Clinton and van der Merwe (2006), and Perkins and Stovall (2011). Numerous definitions describe the process quite generally, hence, for the purposes of resource-process costing, a definition has been adopted that better emphasizes the essence of this cost accounting, formulated by Sharp and McDermott (2009): ‘A business process is a set of interdependent actions, initiated in response to an event, to achieve a specific result for the customer of the process’. This view was developed by Fliegner (2014), who believes that providing information on the costs of activities allows the calculation of unit costs of activities that can be used as measures of the company's operating efficiency. On the other hand, the separation of fixed and variable costs in activities makes it possible to analyze the cost flexibility of activities and supports outsourcing decisions. RPCA is a cost accounting comprehensively covering the entire activity of the enterprise, which on the one hand focuses on the valuation of the costs of manufacturing products, costs of providing services, and on the other hand supports the calculation of customer service costs and profitability. This means that next to the type system and the process system of costs, a third system must appear - the resource system of costs. RPCA was developed by, among others by ABC Akademia and implemented in the Doctor Coster® software (Grajewski 2016, Zieliński 2018). This information concerns both the costs and profitability of services, products, as well as customers, regions and customer segments. Financial and operational information is also provided on the basic, support and management processes, which is the basis for making decisions about their improvement and optimization. In addition, information on costs, variability and resource use is created, which allows for easier planning and precise control of their costs, as well as effective management of the level and use of resources.

1.3 The use of IT in management

Process management in an enterprise is closely related to the maturity of the quality management system in an organization. This problem is highlighted by Hys and Hawrysz (2016). In the discussion on the elements that make up the inherent features of a mature management system, he points to the cost management aspect described in Polish and foreign literature. This issue was developed in the work by Kozel, Hys et all. (2017) analyzing the use of pro-quality solutions in making management decisions in an organization. In this regard, they pay attention to the use of IT solutions in management. The development of information technology and the increasing availability of operational data in enterprises are key success factors for the dissemination of advanced cost accounting, which a dozen or so years ago could be considered too difficult or even impossible to implement. The evaluation of processes is determined by material criteria (refer to the method of process implementation, i.e. process duration, timeliness of the process, process quality, customer satisfaction, including the internal customer, process flexibility, social approval for the method of process implementation, the importance of the process for and for the organization) and financial (mainly related to revenues and costs generated by processes and related efficiency measures). The visualization of individual data using mobile devices is shown in Figure 1.

Figure 1 Access to data on screens of mobile devices. Source: https://demo.baseline.pl/

Such visualization of processes and costs, containing current data processed into information understandable for managers, immediately informs about threats such as exceeding established indicators, changing trends, abuses, etc. BI systems allow for easy connection of data from many sources, e.g. ERP systems, CRM systems, sheets Excel or the Internet.

2 Materials and methodology

According to Wnuk-Pel (2010), the case study method has the greatest potential in adapting theoretical models of management accounting to practice. Resource, process-based costing has already been successfully implemented in dozens of Polish companies in industries such as manufacturing, retail, energy, financial services and infrastructure. Sample management support software is presented in Table 1.

Table 1 Sample management support software. Source: own study based on information from producers.

Application	Characteristic
Baseline ™	It enables convenient budget planning, both broken down into costs and revenues. Budgeting is carried out in three dimensions: by units (departments), types of costs / revenues and by months. (*https://www.baseline.pl/*)
IBM Cognos Business Intelligence	Integrated solution for intelligent data analysis and planning for midsize enterprises. It provides key reporting functions, analysis, dashboards, scorecards, planning, budgeting and forecasting mechanisms. (*https://controlling.info.pl/cognos)*
TETA Business Intelligence	It enables the collection, collection and processing of data from various sources and systems. Information is made available in real time and via a mobile device or web browser, you can use it from anywhere (*https://controlling.info.pl/teta*)
Infor d / EPM	The main modules support planning, budgeting and prediction, strategy management. Consolidation - both managerial and statutory. Additionally, a compliance monitoring module is available (*https://www.cogit.pl/systemy-it/*)
Oracle Hyperion Planning	An application for planning, budgeting and forecasting based on interactive access to all functionalities via a browser or MS Office applications (*https://www.oracle.com/pl/performance-management*)
Eureca Desktops	It enables the presentation of data using advanced visualizations (one page reporting) and detailed analyzes (data discovery) in the form of extensive dashboards (*https://eureca.com.pl/eureca/eureca-pulpity*)
Doctor Coster ®	Software that uses resource-process costing. Costs assigned to resources divided into variables (costs incurred proportionally to produce products and their sale) and fixed costs (structure costs) presented on dashboards (*https://abcakademia.com.pl/doctor-coster/)*
Oracle Business Intelligence	an analytical and reporting platform providing a whole set of functionalities: including interactive information dashboards, ad-hoc inquiries, business and financial reporting (*https://www.oracle.com/pl/business-analytics/business-intelligence*)

As a case study of the use of IT technology in cost accounting to business management will be discussed further use of the software Doctor Coster ®. In this system, the costs are recorded on a multiple accounts assigned to resources. Appearance sample dashboards are shown in Figure 2.

This software allows the presentation of data for managers on specialized cockpits. Cooperation with managers to customize reporting system and replacing parts of reports prepared outside the system (Fliegner 2014). The author of this paper analyzed the cases of 3 RPCA in Polish enterprises. In the case of high water company set more than 2500 of cost centers resourses. In another embodiment, in 1700 cost centers resources for the production of packaging. In the case one of the a milk processing plant was more than 1,500 centers resource costs. The costs assigned to them have been divided into variables (costs incurred in proportion to produce products and sell them). These include raw materials and

packaging materials, energy, maintenance services, transport, labor costs and other production workers. It presents the costs of individual processes, including both the costs of direct resources and the proportional costs of resources shared with other processes. These costs depend which are associated with the operation of the company as a whole: depreciation, taxes and fees, insurance, non-salary employees, sales and marketing costs. on the size and structure of production. The organization and implementation of the department responsible for controlling the application. An example of cost settlement for basic products in a manufacturing enterprise is shown in Figure 3.

Figure 2 Examples of management dashboards in Doctor Coster ® Dashboard powered by Qlik Source: own study based on https://abcakademia.com.pl/doctor-coster

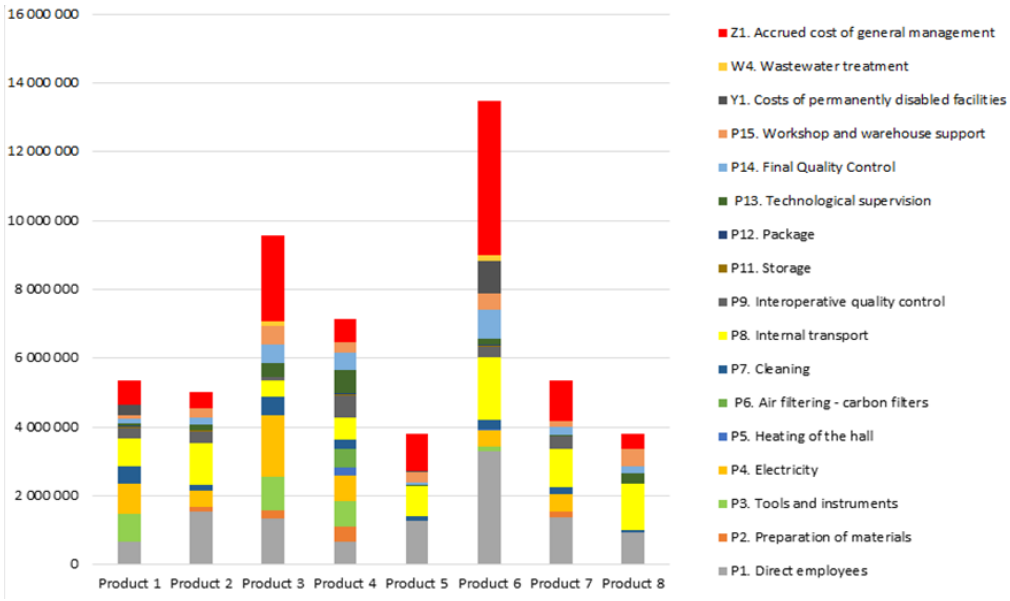

Figure 3 An example of cost settlement for basic products in a manufacturing enterprise, Source: Own study

Especially important is the possibility of cost data reference to physical size, which are managed by managers. The clear presentation of the collected and processed data allows them

to manage utility use. Managers use dashboards to customize managerial strategic objectives in relation to the tactical plans, reporting the management and analysis of deviations. as well as the daily monitoring of key performance indicators (Zielinski 2017). An example of cost settlement for one of the branches of a water utility company is shown in Figure 4. The software includes detailed data covering all designated and accounted for cost centers.

This makes it possible to obtain data with high accuracy and allows you to analyze and make better management decisions.

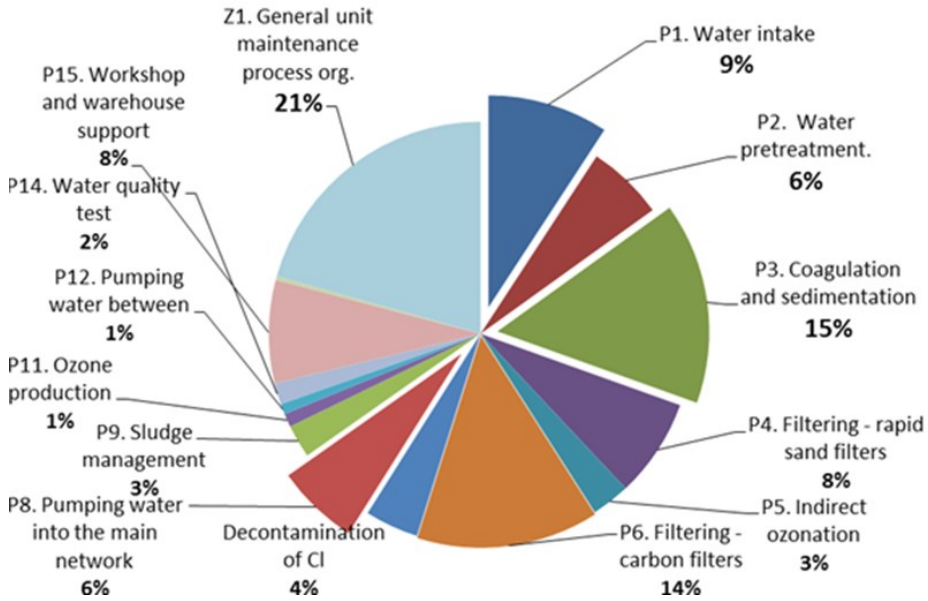

Figure 4 An example of cost settlement for one of the branches of a water utility company. Source: own study based on data from GPW SA Katowice

3 Conclusions

There are still many areas in the company where optimization activities can be carried out. For this purpose, the use of IT software and managerial dashboards for company management based on current data. It is planned to supply the model with further data allowing to measure resource consumption (working time, kWh, km, m2) or introduce cost calculation of unused resources. The presented solution can be successively supplemented with new cost centers.

As a result, decisions will be made based on more and more accurate data. The author points to the The author points to the observed benefits of combining RPCA with the possibility of presenting data on managerial dashboards. These include:

- support for the management in strategic planning, systematic monitoring of goals and deviations, measures and budgets in organizational units, and setting standards.
- increasing the efficiency of operational, service and sales processes and striving to achieve operational excellence
- improving the use of resources and eliminating and avoiding the
- costs of unused resources,
- the ability to determine the current and periodic cost of production according to the selected filter in relation to key parameter indicators (KPI)

- increasing the effectiveness of posting and increasing the accuracy of decisions on all levels of water company management. Implementation of advanced supported controlling concepts by IT is associated with barriers and limitations. production.

The author of this study proposes to consider the possibility of delegating powers to lower-level managers. For this purpose, new managerial dashboards containing specialized data and information supporting management at individual decision-making levels should be developed. This may constitute the direction of further research and implementation.

References

1. Bhimani A., Datar S., Horngren C. and Rajan M. (2019). '*Management and Cost Accounting with MyLab Accounting*', Pearson SKU 9781292232744.
2. IFAC (2009). '*Evaluating and Improving Costing in Organizations*', New York: International Federation Of Accountants.
3. Fliegner W. (2014). 'Discovering processes as a component of the procedural maturity of local government administration offices', Warsaw: *Annals of the College of Economic Analyzes* , issue 33, pp. 155–169, polish.
4. Grajewski P. (2016). '*Process organization',* Warsaw: PWE, pp. 82–91, *polish.*
5. Hys K. and Hawrysz L. (2012). '*Advantages of quality management systems in the light of accredited certification bodies in Poland'*, [in:] Integration in management. E. Skrzypek. , Lublin: Wydawnictwo UMCS w Lublinie, s. 197-209.
6. Kaplan R.S. and Cooper R. (2000). '*Cost anf effect. Using integrated Cost Systems to Drive Profitability and Performance* ', Boston: Harward Business School Press.
7. Kenneth W. Boyd. (2013). *'Cost Accountin* ', Kindle Edition For Dummies. ISBN-13 978-111845380.
8. Kenneth A., Bowles S. and Durlauf S.N. (2000). ' *Meritocracy and economic inequality* ', New Jersey: Princeton University Press.
9. Keys D.E. and Merwe A. van der, (2001). 'The case for RCA: Excess and idle Capacity', *Journal of Cost Management*, July/August.
10. Keys D.E. and Merwe A. van der (2002). 'The Case for Resource Consumption Accounting', *Strategic Finance* , April.
11. Kilger W., Pampel J. and Vikas K. (2004). 'Introduction: Marginal costing as a management accounting tool', *Management Accounting Quaterly* , Winter.
12. Kozel R., Hys K., Vilamova S. and Hudak M. (2017). 'ISO 9001 as a standard of quality management in Poland and Czech Republic: an analysis based on the global data. Business Perspectives, publishing company', *Problems and perspectives in management*, 15, Iss. 3 (contin. 1).
13. Lukić R., Radović R. and Lalić S. (2011). 'Customers' profitability analysis', Sarajevu: *Zbornik Radova Ekonomskog Fakulteta u Istocnom* , No. 5, 2011, p. 95-107.
14. Mehta B. K. (2019). 'Cost and Management Accounting', SBPD Publications, ISBN-10 9388724933, ISBN-13 978-9388724937.
15. Nowak E. (2018) '*Management accounting in capital groups*', CeDeWu Sp. z o. o. ISBN 23155398.
16. Sharman PA, Vikas K. (2004). 'Lessons from German Cost Accounting, *Strategic Finance*, December.
17. Sharp A. and McDermott P ,. (2009). ' *Workflow Modeling: Tools for Process Improvement and Application Development'* , 2nd edition, Boston – London: Artech House Publishers,, p. 56.
18. Shukla M.C., Gupta M.P. and Grewal T.S. (2018). 'Cost Accounting Text and Problems' SChand Publications, ISBN 9788121919630.
19. Sojak, S. (2015). '*Management Accounting and Cost Accounting'* , Toruń, Organizer's House, vol. 1s. 46-49.

20. Stefan P. and Cardos IR (2010). '*A managerial and cost accounting approach of customer profitability analysis* ', Annals of the University of Oradea, Economic Science Series, Vol. 19, No. 1, 2010, p. 570-576.
21. Wnuk-Pel T. (2010). 'Changes in company's management accounting systems: Case study on activity-based costing implementation and operation in medium-sized production company', *Eurasian Journal of Business and Economics* ", No. 3 (6), p. 85-111.
22. Zieliński T.M. (2017). *'Resource and process cost accounting',* Poznań: Akademia Controllingu, polish
23. Zieliński T.M (2018). *'Zasobowo-procesowy rachunek kosztów w przedsiębiorstwie wodociągowym'*, in: Chudziński, P. 'Zarządzanie przedsiębiorstwem wodociągowym – tom II, Warszawa: Polskie Wydawnictwo Ekonomiczne, polish.

Proposal, Verification, and Implementation of a Methodical Cycle for Small-Scale IT Projects

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Abstract. The research objective is to propose, verify, and implement a methodical cycle for small-scale IT projects. The research is carried out in an IT company within a project whose output is an e-shop implementation. The reason for this project is to increase small-scale contracts as well as the profit with respect to long-term stagnation and a decrease in profits from projects during the pandemic. The created methodical framework applies the rules of the SCRUM agile methodology. The research results propose a methodical cycle for small-scale IT projects, stabilising costs and increasing profits from such small-scale projects if implemented across the whole company.

Keywords: methodical cycle, agile methodology, SCRUM, small-scale IT projects

1 Introduction

Traditional, verified methodologies of software development have proven to be rigid and clumsy. As a reaction, agile methodologies have been developed to control software development. They strive to respond to new market conditions, trends, and requirements. Agile methodologies have gradually proven to be a flexible, efficient and functional project management approach not only in the field of software engineering. (Cohen, 2010), (Dennis, 2012)

The objective of this research was to create and validate a methodical cycle for selecting and implementing a project management methodology that will help the company overcome its current problems caused by lower order volumes during the pandemic and improve overall project implementation.

In order to fulfil the primary objective, the following steps have been carried out:

- Analysis of significant findings in the area of project success and current trends in project methodologies.
- Establishing the rules, processes and principles supporting the implementation of the chosen methodology.
- Implementation of the methodology cycle in a corporate environment on two real pilot projects.
- Analysis of the implementation results.

2 Critical factors of SW project success

The research involved 21 SW projects managers, all with more than 10 years of experience. It resulted in a list of critical factors, which include:

- Implementing the agreed extent.
- Respecting the budget.
- Respecting the plan.
- Client satisfaction.
- Achieving strategic advantages.
- User satisfaction.
- Adequate cost-benefit ratio.
- Compliance with quality requirements.
- Efficient implementation.
- Reasonable resource planning.
- Eliminating capacity overload.
- Extensive preparation.
- Perceived usability. (McLeod, 2021), (Iriarte, Bayona, 2020)

To make the picture complete, the world-renowned PRINCE2 certification training manual lists some of the following causes of a project failure (Turley, 2010):

1. Inadequate specification at the beginning of the project, which may cause the development of the wrong product.
2. Lack of communication between the project team, project manager, and client.
3. Inaccurate and wrong time and budget estimates that may cause the project to run out of resources before completion.
4. Failure to include project risks that may cause the project to be unable to respond quickly and appropriately when a problem arises.
5. Inadequate monitoring causing inaccurate information on the current status of the project.
6. Inadequate quality measurement may cause the final product to be inconsistent with the client's desired quality and may ultimately be virtually unusable.

A current report from 2020 elaborated by an internationally-respected Project Management Institute includes answers of 3,234 professional project managers from all over the world, primarily from the area of information technology. The report states that 71 % of the participating software-oriented organisations use agile methodologies, and 11.4 % of investments are wasted due to low project performance. Organisations will then re-evaluate their vision and purpose as well as implement new ways of thinking and project management (PMI, 2020)

The 11 Annual Stage of Agile Report from 2020 elaborated by Versionone Inc., which annually investigates 50 000 teams and 1000 companies, states that:

- 94 % of the respondents claimed that their organisation practised agile methodologies.
- 98 % of the respondents who use agile methodologies stated that their implementation resulted in successful projects.
- 80 % of the companies still learn to use and correctly set the processes of agile methodologies.

3 Project observation

The implementation and validation of the proposed methodical cycle were carried out on a real project conducted according to the SCRUM methodology. To find out the impact of the proposed methodical cycle with the support of SCRUM, a comparison of a similar project with the traditional methodology was carried out.

The post-implementation project on which the proposed methodical cycle was applied was of the eshop type. This shop project was a typical example of e-commerce implementation with:

- Planned budget: 95 000 CZK
- Planned cost: 34 000 CZK
- Planned profit: 61 000 CZK
- Planned total implementation time: 135 hours
- Planned implementation period: two months
- Project methodology: waterfall model
- Project Team: Project manager, web front-end developer, web back-end developer, graphic designer, system administrator and tester
- During the execution of this project, the following were identified:
- The project was not divided into sequential phases from the beginning.
- Inappropriate planning that was not in line with the methodology used.
- Project management was not documented, and the phases were not formally approved.
- Requirements were not precise at the start of the project, and the product specification changed during development.
- The project was reverting to previous phases.
- Time estimates were not entered in the project tool for individual tasks or units, and thus developers were not aware of the time.
- The developers created their own tasks in the project tool according to their judgement.
- There was no testing phase in the project.
- The client was not fully informed about the type of project management methodology, its basic principles and the rules to be followed by all parties.
- The client did not agree to pay for additional work because the instructions on entering the specification had not been made clear to the client before the project started.

Project outcome

- budget: CZK 95 000 (plan: CZK 95 000)
- cost: CZK 51 000 (plan: CZK 34 000)
- profit: CZK 44 000 (plan: CZK 61 000)
- implementation time: 204 hours (plan: 135 hours)
- implementation period: three months (plan: two months)
- project methodology used: incorrectly used waterfall model
- project team: project manager, web front-end developer, web back-end developer, graphic designer, and system administrator
- client’s evaluation of the project implementation: negative
- client's evaluation of the final product: positive

The economic results of the project are shown in Table 1.

Table 1 Economic results of the project

	Plan	Reality	Ratio
Budget	95 000 CZK	95 000 CZK	100,00 %
Costs	34 000 CZK	51 000 CZK	150,00 %
Profit	61 000 CZK	44 000 CZK	72,13 %
Implementation time (hours)	135	204	151,11 %
Implementation period (weeks)	8	14	175,00 %

4 Proposal of the methodic cycle

Considering the above-stated reasons and problems of the current project management, there has been the need to come up with a unified and staff supported methodology to eliminate or at least decrease the level of current deficiencies. The project management methodology's criteria and objectives were determined in cooperation with project managers and company executives.

A correct definition of objectives and criteria to implement the project management methodology required the SMART analytical technique.

Criteria

- To cut costs of project implementation. Keeping to the budget. Tolerance of 120% to the plan.
- To cut the time of project implementation. Keeping to the time estimated to implement the project. Tolerance of 120% to the plan.
- To cut the period of project implementation. To complete the project within the planned deadline. Tolerance of 120% to the plan.

Objectives

- Inexpensive and fast implementation of the methodology into practice and complex training of the staff.
- Transparent and effective project environment for both the staff and customer.
- Project management complying with the used methodology.
- Unified and standardised project management methodology for all projects.
- Implementation of unified rules, principles, processes and tools of project management.
- Creation of formalised, approval, and control rules.
- Unification of project tools.

4.1 Proposal of rules and principles

Initialisation process

- Contract of work has a clearly defined price, extent, and deadline.
- Contract of work includes a list of functional and non-functional requirements.
- Project has a WBS diagram for a detailed specification of the implementation process.

- Client must formally present their requirements.
- Client has filled in the questionnaire and signed the Contract of work.

Planning process

- Project has a directory on Google Drive.
- Project has an issued and paid advance invoice totalling 50 %.
- Project has a signature and the objective in EasyRedmine.
- Project has tasks and categories in the product backlog.
- Each task category has its estimate.
- Project is divided by the project manager in cooperation with the project team into sprints ranging from 2 weeks as a minimum up to one month as a maximum.
- Project has a schedule approved by the client.
- The highest priority is to satisfy the client by fast and regular delivery of functional software.

Implementation process

- It is acceptable to change and add new requirements by the client, even in the latest development phases.
- It is acceptable for the customer to change and add new requirements later in the development phase.
- New requirements are added to the product backlog.
- Only one sprint is implemented at a time.
- The project manager assigns tasks to project team members.
- The project team is self-organising and chooses tasks based on its own decision with respect to their priority.
- The project team always looks for the simplest and most appropriate solution.
- Each task must have a set priority.
- At the end of each sprint, the project team deploys the functional unit of the software to the stage environment.
- No changes to the tasks and sprints during the sprint that could affect its goal.

Monitoring and control process

- Any item beyond the specification affecting the time, cost or extent is included in an amendment to the contract.
- The project team holds a 15-minute meeting each day.
- At the end of each sprint, the client reviews the functional unit and the team holds a retrospective meeting in which they evaluate what was/was not completed and what can be improved for the future.
- At the end of each sprint, a report is sent to the client.
- The project team uses a Burndown chart.

Closing process

- At the end of each project, the project manager creates a report.
- At the end of each project, the client is requested to provide evaluation of the project by completing a questionnaire.
- Each completed project must have a signed acceptance report.
- The production version is implemented after payment.
- If the client has project support, the project manager must specify the responsibility.

5 Implementation of the methodology

To validate the proposed agile SCRUM methodology and its customised processes, rules and principles, an e-shop for a client that sells a complete range of products for bathrooms and wellness was selected as the first pilot project. The client required a specific solution that was not supported by any of the current products on the market and, therefore, a customised solution was the only choice.

- Planned budget: 139 000 CZK
- Planned cost: 40 000 CZK
- Planned profit: 99 000 CZK
- Planned total implementation time: 198 hours
- Planned lead time: 9 weeks
- Project methodology: agile SCRUM methodology
- Project team: Project manager, web front-end developer, web back-end developer, graphic designer, system administrator and tester.

Project outcomes

- Budget: 139 000 CZK (plan: 139 000 CZK)
- Cost: 45 000 CZK (plan: 40 000 CZK)
- Profit: 94 000 CZK (plan: 99 000 CZK)
- Total implementation time: 225 hours (plan: 198 hours)
- Total implementation period: 10 weeks (plan: 9 weeks)
- Project methodology used: Correctly applied agile SCRUM methodology
- Project team: Project manager, web front-end developer, web back-end developer, graphic designer, tester, and system administrator
- Client's evaluation of the project implementation: positive
- Client's evaluation of the final product: positive

The results show an increase in costs compared to the plan from 40,000 CZK to 45,000 CZK, representing an increase of 12.5%. The profit compared with the plan of 99 000 CZK reached 94 000 CZK, representing a decrease of 5.05 %.

Table 2 Economic result of the project with new methodical cycle

	Plan	Reality	Ratio
Budget	139 000 CZK	139 000 CZK	100,00 %
Costs	40 000 CZK	45 000 CZK	112,50 %
Profit	99 000 CZK	94 000 CZK	94,95 %
Implementation time (hours)	198	225	113,64 %
Implementation period (weeks)	9	10	111,11 %

6 Results

To evaluate the results of implementing the selected project management methodology and the related processes, rules and principles, we have described the predefined evaluation criteria and objectives.

Criterion 1: Reduction of project implementation costs. Compliance with the planned cost of the project implementation. Tolerance of 120 %.

In the case of the pilot project, costs were kept within 112.50%.

Criterion 2: Reduction of the project implementation time. Compliance with the planned project implementation time. Tolerance of 120 %.

In the pilot project, the resulting project implementation time was 113.64% of the plan.

Criterion 3: Reduction of the project implementation time. Delivery of the project within the estimated time. Tolerance 120 %.

In the case of the pilot project, the implementation time was 111.11% of the plan.

Objective 1: Cost-effective and rapid implementation of the methodology in practice and complete staff training

The implemented methodical cycle did not require any additional resources, tools, certifications, or licenses. The training was efficiently distributed to the project managers during the actual implementation of the project in terms of cost savings. The implementation required three two-hour meetings of project managers to explain the processes, rules, and principles.

Objective 2: Transparent and efficient project environment for employees and the customer

A transparent environment for the client resulted in regular increments of functional software that were implemented to the client's stage environment at the end of the sprint.

Objective 3: Project management in accordance with the proposed methodical cycle

In this project, 27 of the 31 defined rules and principles supporting the agile SCRUM methodology were thoroughly followed. The result of applying the methodical cycle was evaluated very positively by the company's executives. The non-compliance with some rules was due to the imperfection of the designed processes, which did not take extreme cases into account.

Objective 4: Uniform and standardised project management methodology for all projects

The proposed project management methodical cycle for all projects was implemented in the company's project management environment.

Objective 5: Establishment of unified project management rules, principles, processes, tools, and techniques

Uniform rules, principles, processes, tools, and techniques were introduced in the company's project management environment.

Objective 6: Creation of formalised, approval and control rules

Formalized, approval, and control rules were established at the level of each process phase of projects in the company's project management environment.

Objective 7: Unification of project tools

After analysing the project management in the company, it was found that most employees think that the company realistically needs one project management tool instead of the four used. Together with the company directors and project managers, it was agreed to use only one project tool, which ultimately covers all the relevant needs of the company.

7 Discussion and conclusion

Our motivation for presenting this research was to improve almost a critical situation in project management in a selected company during the pandemic as well as to increase the overall project success rate. The proposed methodical cycle has been implemented within the company and evaluated on three pilot projects (this paper only presented one due to the extent of the project outputs). The results of the implementation have shown an overall positive impact and improvement of project management.

Future research should combine the CRUM methodology with some project management standards, such as PRINE2 or PMBOK. Such combination could complement the SCRUM with, for example, Gantt chart, risk register, or other quality control tools.

The project contribution can be divided into two main parts. First of all, it increased the value of the company which profited from the remedy of the critical situation. Another contribution is the developed methodology that can help other companies solve their problems of similar nature.

References

1. Dennis, A., Wixom, B. and Roth, R. (2012) 'System analysis and design.' Hoboken. ISBN 1118057627
2. McLeod, L. And MacDonell, S. (2021) 'Factors that Affect Software Systems Development Project Outcomes.'ACM Computing Surveys. pp. 24-56.
3. Cohen, S. and Dori De Haan, D. U. (2010) A software system development life cycle model for improved stakeholders [Online]. Available: http://csse.usc.edu/TECHRPTS/1988/usccse88-500/usccse88-500.pdf [15 Sep 2021].
4. Iriarte, C. and Bayona, S. (2020) IT projects success factor: a literature review [Online]. Available: www.sciencesphere.org/ijispm [5 Aug 2021].
5. PMI (2020) Pulse of the Profession 2020 [Online]. Available: https://www.pmi.org/learning/thought-leadership/pulse/pulse-of-the-profession-2020 [15 Sep 2021].
6. Turley, F. (2010) The PRINCE2® Training Manual [Online]. Available: http://pmstudent.com/wp-content/uploads/The-PRINCE2-Training-Manual.pdf [20 Sep 2021].

Modern Aspects of Using Information Systems and Technologies in Management

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Abstract. Thanks to existing innovation and technological developments, doing business has become much larger and more efficient. Quite often the success of the planned projects depends on the efficiency of their management, and information and communication technologies greatly facilitate the process of managing organizations and enterprises in optimal terms. Thanks to the relevant communicators, managers can quickly give orders and monitor their execution (for example, modern platforms and cloud computing allow you to place large volumes of information and make quick access to the required data).
Regardless of whether social progress or commercial leadership will contribute to revealing the essence of economic growth processes, which promises digitalization, company and governments should act quickly, decisively and strategically significant measurements. A critically important aspect is a properly developed strategy that clearly defines the main competitive priorities of the enterprise based on the introduction of information technologies. The most successful enterprises clearly understand their purpose and place in a changing market environment, realizing how they create value added. As a result, they remain faithful to its unique specifics that are able to introduce innovative developments to build their own capacities, which, at the same time, are repulsed and able to find directions of diversification of production (provision of services) to flourish in a modern digital world.

Keywords: innovation, properly developed strategy, modern innovative, information and knowledge, global information technology market

1 Introduction

At present, our society lives in the era of grandiose digital transformations characterized by huge volumes of technical and technological changes, operating enormous volumes of information, access to world innovation processes and significant development in methods of use by enterprises of various information technologies. Communications and exchange of information in the 21st century become very important elements of both personal and professional life. Modern integration processes of business structures into the world information space are one of the priority factors of their effective activity in the future and maintaining competitiveness in market conditions. Available transformations need to be carried out on the basis of the formation of an innovative and investment model of the formation of an economy, which is positioned on scientifically grounded high-tech production, sustainable development and the creation of branched infrastructure for the formation of the intellectual information space. Information systems and technologies

include all activities and decision-making developed in society with computers and related applications. They provide widespread use of certain types of inhuman resources intended for obtaining, processing, storing and transmitting information, as well as management and organization of these resources in the system capable of performing a set of specific tasks and technological solutions.

The objective of this research was to create and validate a methodical cycle for selecting and implementing a project management methodology that will help the company overcome its current problems caused by lower order volumes during the pandemic and improve overall project implementation.

One of the most important elements of modern innovative transformations are information systems and technologies that can produce large volumes of information and knowledge, transfer them to significant distances, accumulate, store and form new intellectual products both in national and international economic systems [1, p. 409]. The dynamic development of the global information technology market carries out a significant impact on the development of the world economy, the development and implementation of new information technologies optimizes production processes, allows you to more efficient use of resources, contributes to accelerating the exchange of information. In modern conditions, effective management is a valuable resource of the organization, together with financial, material, human and other resources. The rapid development of information computer technologies, improvement of the technical platform and the emergence of fundamentally new classes of software products brought today to change approaches to automation of production management [2, p. 74].

2 Modern information and communication technologies

Modern companies and institutions use information and communication technologies to optimize the effectiveness of its activities and increase its profits. Thanks to the Internet, any enterprise is capable of covering customers from all over the country and even find new customers from abroad. An important element is also a marketing that is increasingly "progressing" with the Internet. Almost every large company has its own website, through which it does not only inform potential customers on the direction of its business, as well as new advertising campaigns or important events. In addition, there are increasingly organizations using social networks to cover more potential customers. The famous Social Networking site "Facebook" is very popular in this area: more and more companies create accounts here to maintain their activities in the course and check the interest potential clients [3].

Qualitative changes in the personnel management system are a prerequisite for the effective functioning and development of any industrial enterprise. Increasing the volume of material goods has a significant impact on the modification of the employee's consumption structure, which in turn should have a positive effect on the formation of motives for labour, as well as on the relevant principles of production and economic behaviour [4, p. 155]. Information systems and technologies play an extremely important role in the business environment, allowing not only to keep contact with employees, clients or suppliers, as well as contribute to an effective advertising campaign.

However, Ukraine has a high potential for the development of innovation activities, if the favourable conditions for such development will be formed, a policy of supporting innovation. This policy should support conceptual bases, criteria and mechanisms of economic policy, which in our environment, relying on financial, structural restrictions, has to be able to provide an increase in investment and increase in innovations [6]. An innovative component

in our country still remains outside the attention, because there are many urgent problems that need to be faster, in particular budget distribution of funds, taxation reform and monetary policy. Consequently, the slogan "transition to an innovative development model" today is still formal, because it does not quite correspond to the reality of the economy in the country.

For innovation activity, the main normative legal framework, mechanisms for innovation policy are formed. Despite this, the innovative component of economic development is poorly used. In the future, due to the support of the state of innovation, the share of domestic products will increase, which will have modern scientific provision.

3 Recommendations and implementation of strategies and solutions

The correct formed strategy should be bold in terms of planning profitability of the enterprise, but, at the same time, based on a practical component, determining the possibility of realizing and stimulating the implementation of sustainable and inclusive growth.

Secondly, it is important that governments in the centre have set user information systems and technologies, providing the necessary Internet access [4]. It is necessary to understand behaviour, needs and problems of users of information systems and technologies to create better technological decisions, solve urgent problems and achieve significant socio-economic changes. Permanent listening to mass reviews and user recommendations and implementation of strategies and solutions based on a deep observation sense of needs of citizens and consumers will contribute to the introduction of effective innovations and greater economic success [5].

Thirdly, digital leadership requires rapid actions and prompt response to the challenges of the changing market environment. Organizations and businesses that quickly create or acquire the necessary opportunities to be "first and fast" will have the best competitive advantages in the future to ensure effective economic activity in the market conditions that are increasingly managed by information technologies. It should be noted that ensuring the mobilization of rapid adoption of managerial decisions and actions may be particularly complicated to most governments and state enterprises, but many established, historically successful business structures also faced with such a problem.

Under the influence of globalization processes, a transformational transition from the differentiation of the control system focused on the final product produced by the enterprise to differentiation focused on servicing the customer's customers, which determines the development of integration processes that are characterized by the departure of the management system from the physical boundaries of the enterprise to a full cost chain. Therefore, in the conditions of globalization under the influence of changes taking place in the external environment, the management systems that meet today's realities should be developed with the involvement of various stakeholders, adapting to the interests of suppliers, buyers, shareholders and other partners. Modern management systems should be automated, intellectualized and integrated, which allows you to cover the entire chain of value creation at the enterprise from business processes, products, production to sales and service, as well as ensure the efficiency of this process throughout the chain, demonstrating interested parties that they are together creates a general value. Due to the high rates of development of information technology and digital economics, the enterprise management system becomes a real-time communications tool with constant interaction with stakeholders.

4 Conclusion

1. Execution and observance of these measurements, determines strategic directions to significant socio-economic growth. Governments of countries and enterprises leaders have enormous economic opportunities, using full potential of digital technology. Information and communication technologies undoubtedly have a huge impact on the development of not only enterprises, but also the economy as a whole, as a result of a significant expansion of the scope of activity engaged in the generation and drafting of communication and information technologies.
2. There is an increase in investment in the sector of information and communication technologies, which actually improves the level and quality of their products, a decrease in pricing policy, and the popularization of the Internet and the development of e-commerce is carried out. In this case, an effective management process, as a complex integrated task, requires optimal interaction of various types of resources.
3. Taking into account the current trends of globalization in the development of the economy, information resources play a key role in the activities of any business economy subject, providing automation of business processes of the enterprise and more clear and flexible management. Introduction of information technologies in the manufacturing process is capable of ensuring its competitiveness, and therefore the ability to take the most advantageous position in the marketing environment that is constantly changing and formed under the influence of various external and internal factors.
4. Thus, due to the need for simultaneous processing of a large number of operational and analytical data characterizing real financial and production and economic processes, to accelerate the adoption of managerial decisions there is a need for the use of automated information systems and technologies.
5. Their introduction leads to changes in the forms and methods of management of the enterprise, providing a more voluminous and operational organizational structure of management and acquiring more and more significance as the most important tool of scientific and technical and socio-economic development of society.

References

1. Polishchuk O.O. (2018). Sutnist poniattia “innovatsiina diialnist” yak sotsialno-ekonomichnoi katehorii [The essence of the concept of “innovation” as a socioeconomic category]. Ekonomichnyi visnyk Donbasu, vol. 3, no. 21, pp. 169–171.
2. Shkvir V.D., Zahorodnii A.H., Vysochan O.S. (2003). Informatsiini systemy i tekhnolohii v obliku : Navch. Posibnyk [Information systems and technologies in accounting: Textbook]. Lviv: Vydavnytstvo Natsionalnoho universytetu “Lvivska politekhnika”. (in Ukrainian)
3. Kuzmin O.Ye., Heorhiadi N.H. (2006). Formuvannia i vykorystannia informatsiinoi systemy upravlinnia ekonomichnym rozvytkom pidpryiemstva: Monohrafiia. [Formation and use of information management system of economic development of the enterprise: Monograph]. Lviv: Vyd-vo Nats. un-tu “Lvivska politekhnika”. (in Ukrainian)
4. Denysenko M.P., Holubieva T.S., Kolos I.V. (2009). Informatsiine zabezpechennia innovatsiino-investytsiinoi diialnosti pidpryiemstva [Information support of innovation and investment activities of the enterprise]. Lvivska politekhnika (electronic journal), vol. 11, no. 115, pp. 43–49.
5. Diakiva R.V. (ed.) (2000). Entsyklopediia biznesmena, ekonomista, menedzhera [Encyclopedia of businessman, economist, manager]. Kyiv: Mizhnarodna ekonomichna fundatsiia. (in Ukrainian)
6. Law of Ukraine on innovative activity from July 4 2002, No 40-IV] (2002, August 9). Voice of Ukraine, 144, pp. 10–12 (accessed: 20 May 2020). (in Ukrainian)

INFORMATION SECURITY

Aspects of Forensic-Ready SoftwareSystems in Public Service Domain

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Abstract. The increasing threat of cybercrime goes hand in hand with the need to investigate it properly. However, such investigation is very difficult and costly to perform correctly. To mitigate the issue, forensic-ready software systems were introduced to prepare the systems to ease the investigation by providing valid data and performing forensically sound processes. Currently, forensic readiness is not widely recognized as a possible requirement for software systems. Yet, many of its aspects fit into a larger context of secure system design. This paper aims to establish such context by exploring various aspects of forensic-ready software systems and their relations to other fields. Namely, the area of public domain systems.

Keywords: Forensic Readiness, Forensic-Ready Software, Forensic-By-Design, Software Requirements, Secure Software

1 Introduction

To get insight into IT security-related incidents, they need to be investigated. Such incidents are typically understood as instances of cyber-dependent crime (e.g., hacking, DDoS) and cyber-enabled crime (e.g., fraud, industrial espionage, personal information theft) (McGurie and Dowling, 2013). However, the need for investigation can be generalized to other serious IT incidents caused by operational failures and natural disasters (Erol-Kantarci, 2013). The investigation itself is performed with the aim to establish answers for questions related to the incident and its context. In a general sense, they are: What exactly happened? Who is responsible? When, Where, and How exactly did it happen?

Digital forensics is a discipline that uses proven methods to derive digital evidence from digital sources to reconstruct the events of the incident of matter (Palmer et al., 2001). In other words, it facilitates the answers to the questions regarding the incident in a highly trustworthy manner. Very often, the resulting digital evidence is presented in a court of law. To enable that, the methods must ensure that the meaning of the data on which the digital evidence is built is not changed in any way, and the results must be independently verifiable (McKemmish, 2008). These properties are collectively addressed as the admissibility of evidence (Casey, 2011). However, this requirement is, in addition to the increasing

volume of the data (Garfinkel, 2010), one of the reasons that make digital forensic investigation a highly costly and time-consuming endeavour, with uncertain success.

Digital forensic readiness was formulated to address the issues aiming to lower the cost of investigation and increase the value of digital evidence (Tan, 2001) (i.e., increasing the odds of success and evidence admissibility). The idea is to proactively prepare for the possibility of an investigation by having the people and tools prepared, and ensuring that the data exists when needed (Carrier and Spafford, 2004). Such planning for an investigation involves the implementation of various measures and exercising activities, which often does overlap with other related areas. It includes ensuring that proper logging and auditing is enabled, the potential evidence data is securely stored, an incident-response strategy is formulated and aligned with forensic needs, and staff is appropriately trained (Rowlingson, 2004).

In recent years, the concept of addressing forensic readiness during the development of software systems culminated in the definition of forensic-ready software systems (Pasquale et al., 2018), also called forensic-by-design (Ab Rahman et al., 2016). The idea is to consider forensic readiness as a high-level, non-functional requirement on software like privacy or security. As a result, software engineering methods are utilized to design and develop them.

For proper development of forensic-ready software systems, their purpose must be clearly aligned with the needs and policies within the organization deploying them. For example, a proposed extension for security risk management has been used to define the specific forensic-ready requirements aligned to cybersecurity (Daubner and Matulevičius, 2021). Additionally, the forensic-ready properties must conform to the organization's business requirements, legal framework, and privacy constraints.

The aim of this paper is to outline and discuss the aspects of forensic-ready software systems and their alignments to a larger scope. Specifically, an organization within public administration is considered.

2 Aspects of Forensic-Ready Software Systems

Forensic-ready software systems cannot function as standalone regardless of the context. Primarily, digital evidence itself must be put into proper context to be admissible. Additionally, various aspects influence forensic readiness and, in extension, the cost and probability of success of the investigation. This section maps the aspects influencing the forensic-ready software systems with a particular focus on public administration information systems. Figure 1 visualizes the aspects which are discussed in the following subsections.

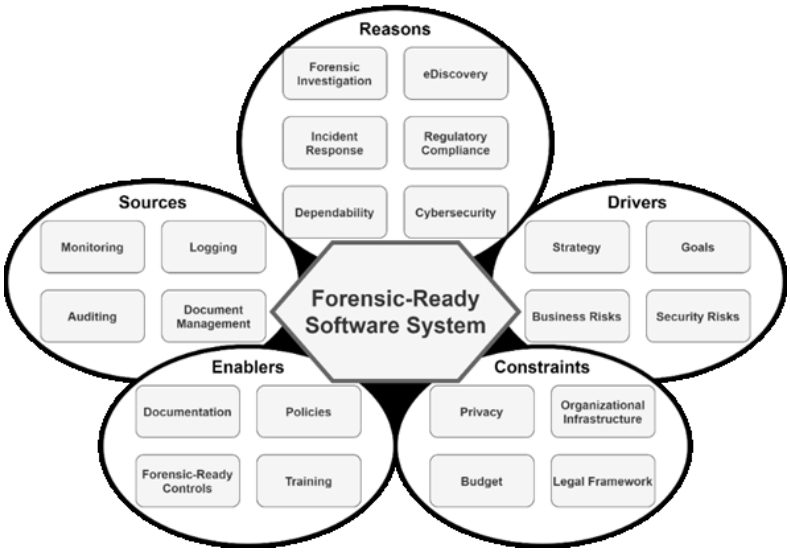

Figure 1 Aspects of Forensic-Ready Software Systems

2.1 Reasons

First and foremost, the reasons why forensic-ready software systems should be considered needs to be established. Naturally, *Forensic Investigation* is an obvious reason for the need for forensic-ready software systems. The important part here is the assumption that the incidents will happen and, consequently, they will be investigated. Furthermore, cooperation with law enforcement during an investigation might be mandated by law[1], including the provision of relevant data. However, the quality of the data is critical, as misleading data used as digital evidence could lead to miscarriage of justice (Henley, 2019). Very similar reasons apply for *eDiscovery* (Lawton, Stacey and Dodd, 2014), for which forensic readiness can be seen as an enabler (Elyas et al., 2015).

The inevitability of the incidents touches other subjects, which creates reasons for forensic-ready software systems. Essentially, the whole idea of forensic readiness could be understood as an enhancement of Cybersecurity. Specifically, preparing for the situation when the employed measures fail. Once they do, it is up to the Incident Response to restore the function, investigate the incident, and patch it for the future. Forensic readiness must be included in incident response planning so that restoration of the system would not hamper the investigation and vice versa (Kent et al, 2006). In a broader scope, the Dependability of the systems could make use of the forensic readiness as well because unintentional errors might cause incidents which a serious impact (Erol-Kantarci, 2013).

Lastly, forensic readiness might be mandated by regulations. Thus, Regulatory Compliance is an important reason as well. In fact, forensic readiness is already getting traction and becoming a mandatory practice (Park et al., 2018). Consequently, mandating forensic-ready software systems is just another logical step towards a more secure environment. Systems that are part of critical infrastructure are a prime candidate in this manner.

[1] Collection of Laws of the Czech Republic, § 8 odst. 1 zákona 141/1961 Sb.

2.2 Drivers

The second area includes aspects that drive the implementation of forensic-ready software systems. Still, there is considerable overlap with related areas creating a broad context of forensic readiness, essential for proper alignment within the organization and other software systems.

To properly drive forensic readiness in general, the organization must have a clearly defined *Strategy* that establishes the role and scope of forensic readiness (Elyas et al., 2015), and in extension, forensic-ready software systems. One of the strategy's main purposes is to align forensic readiness with cybersecurity and business requirements. Subsequently, *Goals* based on the strategy drive the effort towards specific areas, systems, and data. Additionally, they establish a set of requirements and expectations.

A key forensic readiness driver is the risks, defining specific scenarios that forensic-ready controls should mitigate. Importantly, the risks should be built on the existing analyses from both cybersecurity and business area (Daubner and Matulevičius, 2021). Forensic readiness utilizes the defined *Security Risks* to drive the effort in preparation that the established security controls fail. Additionally, *Business Risks* describes scenarios where digital evidence might help solve disputes and where cooperation with law enforce-ment should be expected (Rowlingson, 2004).

2.3 Constraints

Several aspects are constraining the implementation of forensic readiness, limiting the capabilities and scope. A natural limitation concerning digital forensics is the *Legal Framework* mandating the content, form, and handling of digital evidence and the requirements on the forensic process. While the precise manner is dependent on the legal area, several common points exist (Kent et al., 2006). A related aspect is *Privacy*, which is often mandated by a regulation (e.g., GDPR[2]) as potential digital evidence consists of highly sensitive data. Additionally, the whole purpose of digital forensics is tracing, which might be seen as a violation of privacy if misused. A typical impact posed by privacy is formulating a reason for proactive potential evidence collection and retention to prove that the collection is minimal and not excessive. Therefore, forensic readiness needs to find a balance regarding privacy.

Among the organization-specific constraints is the alignment to *Organizational Infrastructure*. It influences the support for forensic-ready processes, including potential evidence handling, escalation, and responsible persons. Therefore, the operations of forensic-ready software systems must be considered with organizational infrastructure in mind before their deployment.

Lastly, it is infeasible to fully implement forensic readiness in all conceivable areas, as the *Budget* limits the effort. The forensic-ready controls must be carefully chosen based on strategy, goals, and risks to maximize the gain. Therefore, the high-risk scenarios should be prioritized.

[2] https://eur-lex.europa.eu/eli/reg/2016/679/oj

2.4 Enablers

Several publications describe the process of implementation of forensic readiness within the organization. Namely, Rowlingson's (Rowlingson, 2004) Ten-step approach is highly renowned. Implementation of forensic-ready software systems must indeed include organizational controls. The prime aspect is the establishment of Policies giving a proper mandate to teams tasked with forensic investigation, eDiscovery, and incident handling. Furthermore, the correct operation of the systems is enabled by the Training of the appropriate staff (Rowlingson, 2004).

Nevertheless, the main enabler for forensic-ready software systems is *Forensic-Ready Controls*, an umbrella term for any technical control implemented within the target system (Daubner and Matulevičius, 2021). This include controls like logging, auditing, integrity controls and tamper-evident storage, to name a few. It is essentially a control, implementing a forensic-ready requirement regarding the production of potential digital evidence or its handling. This goes hand-in-hand with *Documentation*, which is a cross-cutting aspect. It includes documentation of implemented controls, incident handling scenarios, and sources of potential digital evidence (van Staden and Venter, 2012). But also explicitly formulated reason and for collection of potential digital evidence meeting privacy regulations.

2.5 Sources

Contemporary software systems commonly contain multiple potential digital evidence sources and thus somewhat contribute to forensic readiness. A prime example of such a source is *Logging* and *Monitoring* (Marty, 2011). Both are considered good development practices. However, both practices are em-ployed for different roles like debugging and operations, which does not usual-ly consider the produced data's integrity, authenticity, or likability (Daubner et al., 2020). A slightly different situation is *Auditing*, which typically considers security-related utilization (Amir-Mohammadian and Kari, 2020).

A rather specific potential evidence source is *Document Management* commonly employed in the public administration domain. Proper document management records all actions made with the document (Jones, 2012) and typically provides high assurance of its authenticity and integrity. Consequent-ly, it is a viable source of potential digital evidence concerning the managed documents. These properties go in line with EU eIDAS regulation[3]. Further-more, this need is also reflected in the National Architectural Plan of the Czech eGovernment[4]. Nevertheless, forensic-ready document management should be considered in relation to the other parts as part of a larger software ecosystem.

3 Conclusion

Forensic readiness with its implementation in forensic-ready software systems is essential for critical and high-secure environments. It provides the means to prepare for a possible investigation, which might be launched in response to a cybersecurity incident, suspicion or in a case of a dispute. Furthermore, law enforcement might demand access to a system's

[3] https://eur-lex.europa.eu/eli/reg/2014/910/oj
[4] https://archi.gov.cz/en:nap_dokument:architektura_a_sdilene_sluzby_verejne_spravy_cr

data based on the legislation. Forensic-ready software systems combine several aspects of secure design good practice and organizational forensic readiness to ease the investigation costs while increasing the evidentiary value of the data originating from the systems. This paper outlined the aspects of forensic-ready software systems to introduce a wider context influencing their implementation and operations. Concretely the specifics of the public administration area were included.

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References

1. Ab Rahman, N. H., Glisson, W. B., Yang, Y. and Choo, K. R. (2016) 'Forensic-by-Design Framework for Cyber-Physical Cloud Systems', *IEEE Cloud Computing*, vol. 3, no. 1, pp. 50-59.
2. Amir-Mohammadian, S. and Kari, S. (2020) 'Correct Audit Logging in Concurrent Systems', *Proceedings of LSFA 2020, the 15th International Workshop on Logical and Semantic Frameworks, with Applications (LSFA 2020)*, vol. 351, pp. 115-141.
3. Casey, E. (2011) *Digital evidence and computer crime: forensic science, computers and the Internet 3rd ed.*, Waltham, MA: Academic Press.
4. Carrier, B. and Spafford, E. (2004) 'An event-based digital forensic investigation framework', *Digital Investigation*.
5. Daubner L. and Matulevičius R. (2021) 'Risk-Oriented Design Approach For Forensic-Ready Software Systems', *In The 16th International Conference on Availability, Reliability and Security (ARES 2021)*, Association for Computing Machinery.
6. Daubner, L., Macak, M., Buhnova, B. and Pitner, T. (2020) 'Towards verifiable evidence generation in forensic-ready systems', 2020 IEEE International Conference on Big Data (Big Data), IEEE.
7. Elyas, M., Ahmad, A., Maynard, S. B. and Lonie, A. (2015) 'Digital forensic readiness: Expert perspectives on a theoretical framework', *Computers & Security*, vol. 52, pp. 70-89.
8. Erol-Kantarci, M. and Mouftah, H. T. (2013) 'Smart grid forensic science: applications, challenges, and open issues', *IEEE Communications Magazine*, vol. 51, no. 1, pp. 68-74.
9. Garfinkel, S. (2010) 'Digital forensics research: The next 10 years', *Digital Investigation*, vol. 7, Supplement, pp. S64-S73.
10. Henley, J. (2019) 'Denmark frees 32 inmates over flaws in phone geolocation evidence', *The Guardian*, Guardian News & Media Limited, [Online], Available: https://www.theguardian.com/world/2019/sep/12/denmark-frees-32-inmates-over-flawed-geolocation-revelations [15 Nov 2021].
11. Jones, S. (2012) 'eGovernment Document Management System: A case analysis of risk and reward', International Journal of Information Management, vol. 32, pp. 396-400.
12. Kent, K., Chevalier, S., Grance T., and Dang, H. (2006) 'Guide to Integrating Forensic Techniques into Incident Response', National Institute of Standards and Technology, United States, [Online], Available: https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=50875 [11 Jan 2022].
13. Lawton, D., Stacey, R. and Dodd, G. (2014) 'eDiscovery in digital forensic investigations', Home Office, United Kingdom, [Online], Available:

https://www.gov.uk/government/publications/ediscovery-in-digital-forensic-investigations [15 Nov 2021].

14. Marty, R. (2011) ‘Cloud Application Logging for Forensics‘, Proceedings of the 2011 ACM Symposium on Applied Computing, New York, NY, USA, pp. 178–184.
15. McGurie, M. and Dowling, S. (2013) ‘Cyber crime: a review of the evidence‘, Home Office, United Kingdom, [Online], Available: https://www.gov.uk/government/publications/cyber-crime-a-review-of-the-evidence [15 Nov 2021].
16. McKemmish, R. (2008) ‘When is Digital Evidence Forensically Sound?‘, *Advances in Digital Forensics IV*, Boston, MA: Springer US, pp. 3-15.
17. Palmer, G., et al. (2001) ‘A Road Map for Digital Forensic Research‘, *Report From the First Digital Forensic Research Workshop (DFRWSR)*, DT-T001-01.
18. Pasquale, L., Alrajeh, D., Peersman, C., Tun, T., Nuseibeh, B. and Rashid, A. (2018) ‘Towards Forensic-ready Software Systems’, *Proceedings of the 40th International Conference on software Engineering: New Ideas and Emerging Results (ICSE-NIER ’18)*, New York, NY, USA, pp. 9-12.
19. Park, S., Akatyev, N., Jang, Y., Hwang, J., Kim D., Yu, W., Shin, H., Han, C. and Kim, J. (2018) ‘A comparative study on data protection legislations and government standards to implement Digital Forensic Readiness as mandatory requirement‘, *Digital Investigation*, vol. 24, Supplement, pp. S90-S100.
20. Rowlingson, R. (2004). ‘A Ten Step Process for Forensic Readiness‘, *International Journal of Digital Evidence*, vol. 2, no. 3
21. Tan, J. (2001) *Forensic readiness*, [Online], Available: https://citeseerx.ist.psu.edu/viewdoc/
22. download?doi=10.1.1.644.9645&rep=rep1&type=pdf [15 Nov 2021].
23. van Staden, F. and Venter, H. (2012) ‘Implementing Forensic Readiness Using Performance Monitoring Tools‘, *Advances in Digital Forensics VIII*, pp. 261-270.

Information Security Audit

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Abstract. The article analyzes problematic areas in information security in 440 small and medium-sized enterprises, as identified by audits performed in the Czech Republic and the Slovak Republic during 2015-2019. The aim of the article is to identify the most problematic areas in information security management systems in SMEs and to present the preparation of a database for an artificial intelligence model that will provide support to auditors. The audit findings are analyzed according to the size of audited enterprises. The taxonomy of enterprises respects the EU methodology: small enterprises – with up to 50 employees, medium-sized enterprises with up to 250 employees. The performed audits are divided into four categories - initial, periodical, certification and other. The audits respect the areas of the ISO/IEC 27001:2013 standard from a material point of view. The data were analyzed in MS Excel, using contingency tables. This database will be used as a starting point for designing a system which, based on the identified non-conformities in company security audits, will also examine the areas identified by correlations. A model of these relationships, which is currently under development, will become the basis of the system design. The findings show that categories "A12" - Operations Security a "A18" – Compliance are the biggest problem of today's small and medium-sized enterprises.

Keywords: ISMS, Security audit, audit procedures, SMEs, ISO/IEC 27001:2013

1 Introduction

Current situation in companies' day-live is related to dealing with a lot of various information security risks which can be directly related to information technologies (IT) or which can have impact into IT and in general IT services only. Examples of risks which can have impact into providing IT services can be for example earthquakes floods, fires or any disaster which can destroy information processing facilities and critical documents. Risks related directly to IT can be theft and loss of data based on terrorist attack. Such lost can lead to impacts on profitability, businesses' reputation, customer confidence and companies' growth. [17]\

The audit of information systems has become an integral part of business informatics management. The current audit procedures are indispensable for assessing the initial state of business informatics as a whole as well as its parts making any strategic plans in the organization [1, 2]. It is used to put together the starting points of the information strategy, to determine the global or partial security policy of the organization [3]. Audit findings and conclusions are then provided in the form of lists of projects designed to increase the security of the organization's information system [4].

The current business information system must then meet many different characteristics in order to be able to operate in compliance with the current Business Requirements [5]. A very important feature, without which it is not possible to operate a company information system, is its security. A secure information system is primarily a system that meets the confidentiality, integrity and availability requirements [6]. Additional features, such as operations traceability, reliability, access control, etc., are required to ensure, check and audit security [7]. Besides the characteristics of information systems, it will become increasingly important for our world how the information system (program) was developed and by whom, i.e. whether or not the provider or developer of the information system is reliable and what security guarantees it can provide [8]. "New" technologies, such as cloud computing and its different business models, provide a completely different view of the security of information systems [9, 10]. Another area that is very topical nowadays is the integration of the Internet of Things into company information systems – generally speaking, the integration of elements of "Industry 4.0" [11]. While the world of technology is markedly technocratic, legal relationships are lagging behind [12] the development and implementation of technologies into economic processes and are significantly slowing down innovations [13].

One of the information security areas related to all types of technologies (on-premise / cloud) is audit of various database systems which keep various types of data about all important situations (production, cash-flow, access to company systems etc.) in the enterprises. This area is covered by plenty of various standards and processes. The most important in the financial sector is Sarbanes-Oxley Act whose impart into information security is described in [16]. Although the highest importance of information security is mentioned in financial sector, we have to emphasize that the level of importance of information security increased significantly almost in all data-related sectors, for example automotive via connected cars, sport via intelligent watch etc. Importance is caused by GDPR (General Data Protection Regulation) and processing of personal data in all of above-mentioned sectors.

Analysis of information security concerns identified as a major one around the world showed us, that these concerns are:

- Cyber-attack; Data breach; Unplanned IT and telecom outages; Interruption to utility supply; Adverse weather [18]
- Recognizing that you are a target to cyber-attack; Underfunded cyber security teams; Missing security patches; Email security; Missing backup plans [19]
- Unprecedented Attacks; Cyber espionage; Data theft [20]
- DDos Attacks; Malware; Phishing scams; Internal misuse [21]

Although various authors are using different names, the description of concerns is similar, and they have common roots. The most important is cyber-attack followed by data lost.

Our article mainly focuses on the security in small and medium-sized enterprises (SMEs) in the Czech Republic and the Slovak Republic. Our research questions in this article are as follows:

RQ1: What are the main problematic areas in information security for SMEs?

RQ2: What is the relationship between different problematic areas of information security in SMEs?

The data we obtained are not only used for research as such, but also for a model that we are working on in cooperation with the developers of support software for company information system security auditors. This model is based on artificial intelligence and could be used by auditors in their daily work.

2 Methodology

The data we evaluate in our research come from information system audits performed in the Czech Republic and Slovak Republic during the years 2015-2019. A total of 440 audits were performed in small and medium-sized enterprises.

2.1 Audit method

The audits were carried out in compliance with the effective Czech standards, especially in compliance with the ČSN EN ISO 19011 standard from a procedural point of view [14] and the ISO/IEC 27001:2013 standard from a material point of view [6]. Fig. 1 provides the basic structure of this standard.

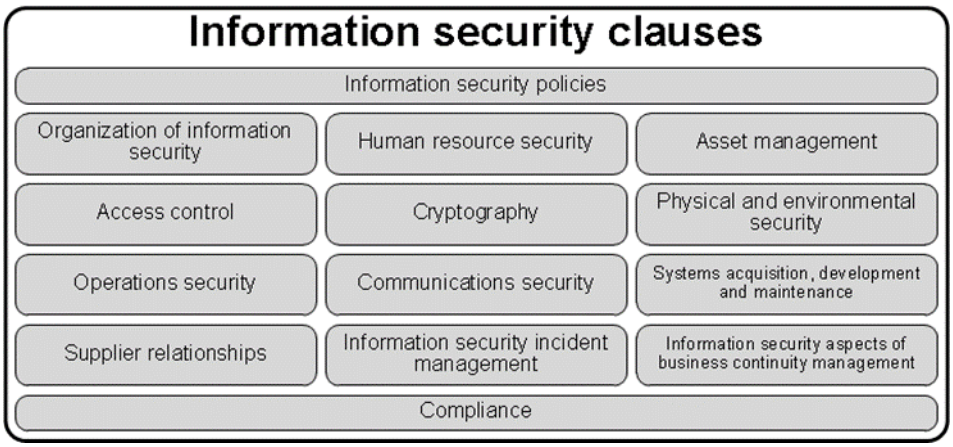

Fig. 1: Information Security Areas According to ISO/IEC 27001:2013 [6]

The identified non-conformities were classified in compliance with the audit areas of this international standard (the audit findings are presented in Table 1 and Table 2).

The numerically marked audit categories correspond to the sections of this standard as following categories:

- "4" – Context of the Organization – Understanding of the organization, its needs and expectation of interested parties and scope of the information management system.
- "5" – Leadership – Leadership and commitment, security policy, organizational roles, responsibilities and planning to achieve them.
- "6" – Planning – Action to address risks and opportunities, information security objectives and planning to achieve them.
- "7" – Support – Resources, competencies, awareness, communication and documented information.
- "8" – Operation – Operational planning and control, information security risk assessment and treatment.
- "9" – Performance Evaluation – Monitoring, measurement, analysis and evaluation, internal audit, management review.

- "10" – Improvement – Nonconformity and corrective action, continual improvement [6].

The next categories marked with an A before the number correspond to the sections of the annex to this standard.

- "A05" – Information Security Policies – To provide management direction and support for information security in accordance with business requirements and relevant laws and regulations.
- "A06" – Organization of information security – To establish a management framework to initiate the implementation and operation of information security within the organization and to ensure the security of teleworking and use of mobile devices.
- "A07" – Human Resource Security – To assure that employees and contractors understand their responsibilities and are suitable for the roles for which they are considered.
- "A08" – Asset Management – Responsibility for Assets, Information Classification, Media Handling.
- "A09" – Access Control – Business requirements on access control, User access management, User responsibilities, System and application access control.
- "A10" – Cryptography – To ensure proper and effective use of cryptography to protect the confidentiality, authenticity and/or integrity of information.
- "A11" – Physical and Environmental Security - Secure areas, Equipment.
- "A12" – Operations Security – Operational procedures, responsibility, Protection form malware, Back up, Logging and monitoring, Control of operational software, Technical vulnerability management, Information system audit and consideration.
- "A13" – Communication Security – Network security management and information transfer.
- "A14" – System acquisition, development, and maintenance – Security requirements of information systems, security in development and support process and data testing.
- "A15" – Supplier relationships – Information security in supplier relationship and supplier service delivery management.
- "A16" – Information Security Incident Management – To ensure a consistent and effective approach to the management for information security incidents, including communication n security events and weaknesses.
- "A17" – Information security aspects of business continuity management – Information security continuity shall be embedded in the organization´s business continuity management system.
- "A18" – Compliance – Compliance with legal and contractual requirements, Information security review [6].

In total, there are 21 categories (sections of the standard and its Annex A).

The following text and tables show the audit findings in the form of categories marked either with a number (for the categories from the text of the standard) or with A and a number (for the areas listed in Annex A of the standard).

2.2 Data collection and origin

The initial data for our research comes from an analysis of findings from 440 information system security audits performed in the various economic sectors in the Czech Republic and the Slovak Republic. Since these enterprises varied in size, we used the European Union's standard taxonomy to classify Data collection and origin SMEs - small enterprises

with up to 50 employees, medium-sized enterprises with 50-250 employees and large enterprises with more than 250 employees. Our article does not focus on the findings concerning large enterprises. Based on this classification, the following number of audits was performed - 232 audits in small enterprises and 208 audits in medium-sized enterprises.

We also analyzed the audit findings based on the seriousness of discovered non-conformities. There were again four categories. The first one is CAT1 - critical – there were no positive findings, CAT2 - medium – there was a total of 16 non-conformities, OBS - observation – there was a total of 219 non-conformities, OFI - opportunity – there was a total of 205 findings. This criterion is only mentioned at the end of the article and is not used for the analysis.

The standard statistical functions of MS Excel were used to evaluate the obtained data.

3 Results

Based on the above-mentioned criteria, we evaluated the findings by enterprise size. A very interesting discovery is that there are only two findings in area "5" – Leadership – Leadership and commitment, security policy, organizational roles, responsibilities and planning to achieve them a pro oblast "A5" – Information Security Policies – To provide management direction and support for information security in accordance with business requirements and relevant laws and regulations – for the entire analyzed period of 2015-2019.

3.1 Evaluation of audit findings by size of audited enterprise

First, we analyzed the data from audits, i.e. non-conformities in audits broken down by enterprise size, i.e. the difference between small enterprises and medium-sized enterprises. The number of non-conformities discovered in audits based on the number of enterprise employees is shown in Table 1 and Table 2.

Table 1. Audit findings in SMEs by number of employees - main section of the standard [authors]

	4	**5**	**6**	**7**	**8**	**9**	**10**
1 Small	8	1	25	7	3	14	4
2 Medium	12	1	18	8	2	17	4
Total	20	2	43	15	5	31	8

Table 2. Audit findings in SMEs by number of employees – Annex A [authors]

	A05	**A06**	**A07**	**A08**	**A09**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**
1 Small	2	2	9	16	14	4	3	41	5	12	13	10	10	29
2 Medium		12	2	19	14	1	6	22	9	8	8	8	12	25
Total	2	14	11	35	28	5	9	63	14	20	21	18	22	54

The data presented in Tab. 1 and Tab.2 clearly show that category "A12" – Operations Security is the most problematic. There are mostly problems with ensuring the secure operation of company information systems as well as with protecting these systems against attacks from the outside and against the failure of employees inside the enterprise. This mainly concerns the monitoring of the system operation, the collection of operation data and

the subsequent or online evaluation of data in order to detect any potential and actual security attacks.

Small and medium-sized enterprises also show problems in the following categories:

- Category “A18” – Compliance – Compliance with legal and contractual requirements, Information security review – i.e. compliance between the internal and external documentation of the system and in particular their mutual compliance with applicable legislation.
- Category “6” – Planning – Action to address risks and opportunities, information security objectives and planning to achieve them – i.e. periodical risk analyses performed due to changing conditions on the market and in the enterprise and the follow-up formulation of one or several security policies of the organization.
- Category “A08” – Asset Management – Responsibility for Assets, Information Classification, Media Handling – i.e. asset management and the regularly performed and updated classification of information. This category is interesting in terms of when the audits were performed, as the implementation of personal data protection systems in accordance with EU Directive 2016/679 was very topical at that time [15].
- Category “A09” – Access Control – Business requirements on access control, User access management, User responsibilities, System and application access control – i. e. the implementation of strategic plans expressed in the security policy into the specific job descriptions of individual employees responsible for the management or implementation of security in the organization.

3.2 Evaluation of the relationship between audit findings

When examining the audit findings in detail, we also formulated the second question of whether the audit findings are somehow related, i.e. whether we can expect with some reasonable probability, e.g. at a 5% confidence level, that if an auditor identifies a finding in one area, it is very likely that there will be an audit finding in another area as well. The result is shown in Table 3.

Table 3. Correlation between security audit findings in small and medium-sized enterprises [authors]

Finding	*4*	*6*	*7*	*9*	*10*	*A06*	*A07*	*A08*	*A09*	*A11*	*A12*	*A13*	*A14*	*A15*	*A16*	*A17*	*A18*
4		0,26	-0,32	0,54	0,32	-0,45	-0,36	0,11	0,09	-0,52	0,26	-0,41	-0,06	0,11	0,80	0,03	0,39
6	0,26		0,10	0,51	0,51	-0,97	0,77	-0,16	-0,32	-0,64	0,23	-0,82	0,13	0,52	0,15	0,48	0,40
7	-0,32	0,10		1,00	N/A	N/A	1,00	0,50	-0,50	N/A	-0,96	N/A	1,00	0,50	-0,50	1,00	-0,24
9	0,54	0,51	1,00		-0,61	-0,51	0,41	0,67	-0,37	-0,15	-0,12	-0,53	0,53	-0,22	0,17	-0,17	0,11
10	0,32	0,51	N/A	-0,61		-0,58	0,50	-0,70	-0,51	-0,52	0,27	-0,76	-0,97	0,38	1,00	0,20	-0,05
A06	-0,45	-0,97	N/A	-0,51	-0,58		-0,56	0,09	0,48	0,92	-0,73	0,85	-0,07	-0,71	-0,51	0,00	-0,65
A07	-0,36	0,77	1,00	0,41	0,50	-0,56		-0,12	-0,97	N/A	-0,14	-0,59	0,30	-0,03	-0,60	0,59	-0,27
A08	0,11	-0,16	0,50	0,67	-0,70	0,09	-0,12		-0,19	0,48	-0,36	-0,10	0,70	-0,45	-0,09	-0,48	-0,18
A09	0,09	-0,32	-0,50	-0,37	-0,51	0,48	-0,97	-0,19		0,20	-0,10	0,76	-0,19	0,13	0,33	0,29	0,54
A11	-0,52	-0,64	N/A	-0,15	-0,52	0,92	N/A	0,48	0,20		-0,70	0,36	N/A	-0,79	-0,36	-0,27	-0,66
A12	0,26	0,23	-0,96	-0,12	0,27	-0,73	-0,14	-0,36	-0,10	-0,70		-0,36	-0,59	0,51	0,51	-0,15	0,58
A13	-0,41	-0,82	N/A	-0,53	-0,76	0,85	-0,59	-0,10	0,76	0,36	-0,36		0,35	-0,07	-0,51	0,10	-0,17
A14	-0,06	0,13	1,00	0,53	-0,97	-0,07	0,30	0,70	-0,19	N/A	-0,59	0,35		0,07	-0,68	0,25	-0,31
A15	0,11	0,52	0,50	-0,22	0,38	-0,71	-0,03	-0,45	0,13	-0,79	0,51	-0,07	0,07		0,19	0,33	0,61
A16	0,80	0,15	-0,50	0,17	1,00	-0,51	-0,60	-0,09	0,33	-0,36	0,51	-0,51	-0,68	0,19		-0,09	0,82
A17	0,03	0,48	1,00	-0,17	0,20	0,00	0,59	-0,48	0,29	-0,27	-0,15	0,10	0,25	0,33	-0,09		0,26
A18	0,39	0,40	-0,24	0,11	-0,05	-0,65	-0,27	-0,18	0,54	-0,66	0,58	-0,17	-0,31	0,61	0,82	0,26	

Remarks for Tab. 3: N/A this value represents fact, that we did not get enough findings for calculation of the correlation coefficient for this combination of findings. Warm colors (red, orange, yellow) represent positive correlation. The red color is the most positive, the orange is the middle stage and yellow color represents the weakest positive correlation between findings. Cold colors (dark green, green and green light) represent negative correlation. The dark green presents the strongest negative correlation, the green color is the middle stage on correlation and the green light shows the weakest negative correlation.

Based on this table and its expansion over time, we intend to come up with a model that will include input data about previous audit findings that will make it possible to steer auditors towards other potentially problematic areas in the audited enterprise.

4 Evaluation of the relationship between audit findings

Based on the analyzed 440 findings from information security audits performed in Czech and Slovak enterprises during 2015-2019, we formulated the following answers to our research questions:

RQ1: What are the main problematic areas in information security for SMEs?
For small enterprises, we found the following audit areas that are listed in Table 4.

Table 4. The most problematic category of security in SMEs Source: authors

	Small	Medium
1.	"A12" – Operations Security	"A18" – Compliance
2.	"A18" – Compliance	"A12" – Operations Security
3.	"6" – Planning	"A08" – Asset Management
4.	"A08" – Asset Management	"6" – Planning
5.	"9" – Performance Evaluation	"9" – Performance Evaluation

A very positive finding from all security audits performed in small and medium-sized enterprises is that no CAT1 non-conformities (critical non-conformities) and only 16 CAT 2 non-conformities were discovered. Therefore, we can conclude that even though security management systems show some non-conformities, these non-conformities are not of any major significance and do not impact the quality and reliability of the information security management system in the organization. OBS - observation, OFI - opportunity findings are mainly used for the continuous improvement and further development of the security management system in organizations.

RQ2: What is the relationship between different problematic areas of information security in SMEs?

The identified relationships between the individual finding areas are shown in Table 3. We will continue to work with them in two directions:

- We will examine the trend of correlations between the individual areas over time by analyzing more audit findings in the following years, and we will also try to eliminate any suspected trend events from our findings. For instance, a trend event is the application of EU Directive 2016/679 [15] and the obligation to ensure that all internal regulations, including information systems processing personal data, of the enterprise are in compliance with this EU directive. We will see whether or not the findings concerning GDPR will decrease in the future.
- We will come up with an artificial-intelligence-based model for information security auditors, which will be based on the discovered experience, and we will test this model during actual audits performed in Czech and Slovak organizations.

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References

1. Drivas, G., Maglaras, L., Janicke, H., Loannidis, S.: Cybersecurity Assessment of the Public Sector in Greece. In: Proceedings of the 18th European Conference on Cyber Warfare and Security (ECCWS 2019), pp. 162-171. ACAD CONFERENCES Ltd., Coimbra, Portugal (2019).
2. Pironti, J. P.: Developing Metrics for Effective Information Security Governance. Information Systems Control Journal 2, 1-5 (2007). https://iparchitects.com/wp-content/uploads/2016/07/Developing-Metrics-and-Measures-for-Information-Security-Governance-ISACA-Member-Journal-March-2007.pdf
3. Liebetrau, T., Christensen, K.K.: The ontological politics of cyber security: Emerging agencies, actors, sites, and spaces. European Journal of International Security 6(1), 25-43 (2021). https://doi.org/10.1017/eis.2020.10
4. Novák, L., Doucek, P.: Regulation of Cyber Security in the Banking Sector. In IDIMT-2017 Digitalization in Management, Society and Economy, pp. 49-54. Linz: Trauner Verlag Universität, Kutná Hora, Czech Republic (2017). https://idimt.org/wp-content/uploads/proceedings/IDIMT_proceedings_2017.pdf
5. ISACA: COBIT® 2019 Framework: Introduction and Methodology, ISACA, USA (2018).
6. ISO/IEC 27001:2013 – Information technology – Security techniques – Information security management system – Requirements. International Organization for Standardization.
7. Livshitz, I. I., Yurkin, D. V., Minyaev, A. A.: Formation of the Instantaneous Information Security Audit Concept. In: Vishnevskiy V., Samouylov K., Kozyrev D. (eds) Distributed Computer and Communication Networks. DCCN 2016. Communications in Computer and Information Science, vol 678. pp 314-324. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-51917-3_28
8. M. Pahwa. What is DevSecOps? Defined, Explained & Explored. Learning Security with Mayur (2019). https://www.mayurpahwa.com/2019/06/what-is-devsecops-defined-explained.html.
9. Djemame, K., Armstrong, D., Guitart, J., Macias, M.: A Risk Assessment Framework for Cloud Computing. IEEE Transactions on Cloud Computing, 4(3), 265–278 (2016). https://doi.org/10.1109/TCC.2014.2344653
10. Svatá, V., Zbořil, M.: Areas of Focus for Cloud Security Providers Assessment. In: *10th International Conference on Advanced Computer Information Technologies (ACIT),* pp. 806–810. IEEE, Deggendorf, Germany (2020). https://doi.org/10.1109/ACIT49673.2020.9208856.
11. Lezzi. M., Lazoi, M., Corallo, A.: Cybersecurity for Industry 4.0 in the Current literature: A Reference framework. Computers in Industry 103, pp. 97–110 (2018).
12. Riigi Teataja: Cybersecurity Act. (2018). https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/523052018003 /consolide
13. Zgodavova, K.; Sutoova, A.: Training and Development Tool for the Open Innovation Quality Management System. In: 15th International Conference on Emerging eLearning Technologies and Applications (ICETA 2017). pp. 523-526. IEEE, Stary Smokovec, Slovak Republic (2017). https://doi.org/10.1109/ICETA.2017.8102543.
14. ČSN EN ISO 19011:2019 Směrnice pro auditování systémů managementu. Praha: Úřad pro technickou normalizaci, metrologii a státní zkušebnictví. Třídící znak: 01 0330
15. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Official Journal of the European Union.

16. LI, Chan, K.K. RAMAN, Lili SUN a Da WU, The SOX 404 internal control audit: Key regulatory events [online]. [cit. 2021-09-19]. DOI: 10.1016/j.racreg.2015.09.006. ISBN 1052-0457. Source: http://linkinghub.elsevier.com/retrieve/pii/S1052045715000351
17. Pereira, Teresa & Santos, Henrique. (2014). Challenges in Information Security Protection. URL: https://www.researchgate.net/publication/264116803_Challenges_in_Information_Security_Protection
18. Luke Irvin (2018) The 5 biggest information security concerns facing organisations, URL: https://www.itgovernance.co.uk/blog/the-5-biggest-information-security-concerns-facing-organisations
19. Brianna Flavin (2019) 9 Cyber Security Problems Nearly Every Organization Struggles With. URL: https://www.rasmussen.edu/degrees/technology/blog/cyber-security-problems/
20. Three Cyber Security Issues Organizations Face. URL: https://online.maryville.edu/blog/three-cyber-security-issues-organizations-face/
21. Kalie Gyarmathy (2019). Top Cybersecurity Problems and Solutions Companies Face. URL: https://www.vxchnge.com/blog/cybersecurity-problems-and-solutions

DIGITALIZATION OF PUBLIC ADMINISTRATION

Waste management information technology and investment evaluation

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Abstract. In January 2021, the Czech Republic adopted new waste legislation in the form of new laws and implementing regulations. This new legislation is based on the current plans of the European Union, which responds to the deteriorating state of the environment with the measures taken. The achievement of the set goals should take place by 2035 in several phases. One of the goals of the new legislation is to make the use of recyclable waste more efficient and to eliminate the amount of municipal waste. This waste ends up in landfills.

Keywords: Information system, municipality, waste, management

1 Introduction

Waste is based on a waste hierarchy, according to which the priority is waste prevention and, if waste cannot be prevented, then in the following order its preparation for re-use, recycling, other uses, including energy recovery, and it is not possible or possible In the Czech Republic, the first Waste Act was created in 1991. At present, waste management is regulated by Act No. 541/2020 Coll., Waste, which is effective from 1 January 2021. The Act sets out the rights and obligations of persons in the field of waste economy and promotes the basic principles of the circular economy, environmental protection and human health in waste management. The management of end-of-life products is regulated by Act No. 542/2020 Coll., Effective from 1 January 2021. The management of packaging waste is regulated by Act No. 477/2001 Coll., On packaging, as amended. Efficient waste management is a fundamental environmental problem worldwide. Cities and organizations not only try to motivate citizens, employees, etc. to sort waste, but also add opportunities for sorting. The presented contribution responds to the already published article entitled Introduction and innovation of a new sorting line for mixed municipal waste. This article defined the project of implementation of new sorting lines in the conditions of the statutory city of Havířov. The effectiveness of the project implementation is also given by the possibility of using information systems, which are necessary today. This fact is supported by the lingering global situation of the COVID 19 pandemic.

1.1 Analysis of the evaluation of the efficiency of not only corporate investments

Decision making is one of the most important types of managerial decisions. Such a decision involves accepting or rejecting an investment project that the company has defined.

It is a logical fact that the greater the investment, the greater the impact it can have on prosperity and the very existence of the company.

From the point of view of economic theory, investments are understood as the postponement of current consumption in order to increase the production of goods, the development of new technologies or the acquisition of human capital in the future. The investment therefore links the present value with the future value. In the national concept, a distinction can be made between gross and net investment. Gross investment represents the total amount that has been invested in capital goods throughout the economy. On the other hand, net investment represents a year-on-year increase in the value of capital goods. Investment goods are those goods that are to be used for the production of other goods, both production and consumer. They therefore include buildings, equipment, machinery or know-how. From the point of view of the company's financial management, investments are defined as one-off funds that are expected to be converted into future cash inflows. Investments generally have a time horizon of more than one year and represent goods that are used to produce other goods in the future. Their goal is therefore an appreciation that will bring an increase in the original capital. In the corporate perception of investment, a narrower and broader concept of the view of investment can be distinguished. In a narrower sense, it is an asset that is intended to create additional assets instead of consumption, which the company then sells on the market. The broader concept understands investments as currently sacrificed funds for the acquisition of assets that will bring the company higher benefits in the long run and thus allow to obtain higher financial effects. From an accounting point of view, the investment is considered to be the acquisition of tangible fixed assets, the acquisition of intangible fixed assets or the acquisition of long-term financial assets. Tangible fixed assets are considered to be assets with a purchase price of at least CZK 40,000, the period of use of which is longer than one year. For intangible fixed assets, the acquisition price must be at least CZK 60,000 and the period of use must be longer than one year. The term investment project can be defined as a set of technical and economic studies that serve to prepare, implement, finance and effectively operate planned investments. Each investment project should have a goal and purpose for which it will be implemented. The investment project should have several objectives chosen from a technical, economic and time point of view.

2 Evaluation of an investment project by selected methods

The evaluation of investments within the public sector, resp. dealing with public handles funds differently than in the business sector. The investment primarily responds to legislative requirements. Achieving the greatest possible profit or the greatest possible market value in the area of urban companies is not the main priority. In this case, they are the basic income legal fees of the population in connection with waste treatment. Your fees are each, the self-governing entity determines at its own expense and should focus on the amount of profit very much negative impact on the inhabitants of the affected or affected municipalities. This topic is above all "sensitive" from a human and political point of view. Because the author ran out during the processing of the work, the conclusion that not all the methods listed in the theoretical work are appropriate to use was subsequently, a selection of investment evaluation methods was made and this selection was implemented in the MS Excel.

2.1 Internal rate of return method

The method is based on calculating the rate of return that characterizes the project. It is thus a rate of return at which the present value of the future expected investment income equal to the necessary capital expenditure on the investment.

$$PVCF = IN \tag{1}$$

$$\sum_{t=1}^{n} \frac{CF_t}{(1+i)^t} = IN \tag{2}$$

PVCF	present value of cash flow
IN	investment costs
i	corporate discount rate
CFt	cash flow in individual years of investment life

3 Investment evaluation using IRR

Since it was necessary to calculate the method of internal rate of return, the input data, respectively. the calculations themselves in excel are adjusted so that the cost of the investment is no longer included in the entire life of the investment, but at the beginning.

The data cover the years 2020-2034 within the first 15-year lifetime. In the given evaluation method, it is already possible to calculate the investment evaluation method using internal rate of return because the costs are spread over the life of the investment, i.e. 30 years.

Table 1. Investment evaluation with IRR, Source: own.

Year / quantity	1	5	10	15	20	25	30
CF	-316 399 660	33 600 340	33 600 340	33 600 340	33 600 340	33 600 340	33 600 340
Cumulated CF	-316 399 660	-181 998 300	-13 996 600	154 005 100	322 006 800	490 008 500	658 010 200
Discounted CF.	-313 266 990	31 969 571	30 417 949	28 941 635	27 536 973	26 200 485	24 928 826
NPV	-313 266 990	-183 457 714	-28 295 601	119 335 825	259 802 062	393 450 866	520 613 117
IRR	---	-27,93 %	-1,88 %	4,74 %	7,20 %	8,30 %	8,85 %

The internal rate of return method could already be calculated, because the investment costs of approximately CZK 350,000,000 are included in the first year of construction. IRR in this case, it indicates the relative return (profitability) that the project has during its life cycle.

At the end of the first five-year period, the IRR is - 27.93%, the first positive IRR is achieved within 15 years of the life of the investment, resp. in 11 years of investment and its life. In the last year of life, an IRR of 8.85% is considered. The turning point of the investment is set in positive terms in the period up to 25 years of life, more specifically in the 24 years of the life cycle.

3.1 Investment evaluation using IRR

The aspect of fulfilling the legislative requirements not only of the European Union, but also of the legislation of the Czech Republic is completely unquestionable. The municipalities involved in the project, by not implementing the given measures due to the strategic plan, would transfer to the citizens of the affected municipalities a significant increase in legal fees for the processing of mixed municipal waste. Investment valuations are developing differently in the public sector than in the private sector. Above the investment evaluation factor, resp. its return gets in the public sector gets the factor of "services to the population".

4 Conclusion

In conclusion, it can be briefly added that the investment project is also in terms of return, profitable in the project life cycle. Its profitability, in addition to reducing the burden in the threat of a disproportionate increase in legal fees for citizens of the municipalities concerned and legislative obligations, thus adds another variable for deciding on the construction of a new technology for the treatment of mixed municipal waste.

References

1. Brooks, R. (2016). Financial management: core concepts. Third edition. Boston: Pearson, Pearson series in finance.
2. Danel, R., Kozel, R., Chlopecký, J., Vilamová, Š. and Piecha, M. (2015). 'Information Support for Sales Management in the Company OKD a.s.', Proceedings of 11th International Conference on Strategic Management and its Support by Information Systems, Uherské Hradiště, pp. 46-54.
3. DLUHOŠOVÁ, Dana. (2010). Finanční řízení a rozhodování podniku: analýza, investování, oceňování, riziko, flexibilita. 3., rozš. vyd. Praha: Ekopress, 2010. ISBN 978-80-86929-68-2.
4. HRDÝ, Milan. (2009). Hodnocení ekonomické efektivnosti investičních projektů EU: jak hodnotit investiční záměry a řídit podnikové investice. Praha: ASPI, 2009. ISBN 80-735-7137-4.
5. Chlopecký, J., Rolčíková M. and Kratochvíl M. (2015). 'Decision making influence of some macroeconomic factors concerning prospective sales of fine silicon carbide.', Proceedings of 15th International Multidisciplinary Scientific GeoConference SGEM 2015, Albena, Bulgaria.
6. JÁČOVÁ, Helena a Martina ORTOVÁ. (2013). Finanční řízení podniku v příkladech. 2., aktualiz. vyd. Praha: Wolters Kluwer Česká republika, 2013.ISBN 978-80-7478-001-1.
7. Ključnikov, A. (2017). Financial management in the segment of SMEs. Praha: Wolters Kluwer, ISBN 978-80-7552-585-7.
8. KOZEL, Roman, PODLASOVÁ, Anežka, ŠIKÝŘ, Petr, SMELIK, Roman. Innovations in Waste Management. In: Doucek, P., Chroust, G., Oškrdal, V. (eds.). IDIMT-2018: Strategic Modeling in Management, Economy and Society: 26th Interdisciplinary Information Management Talks: September 05-07, 2018, Kutná Hora, Czech Republic. Linz: Trauner Verlag, 2018, pp. 119-126. ISBN 978-3-99062-339-8.
9. SCHOLLEOVÁ, Hana a Adriana KNÁPKOVÁ. (2009). Investiční controlling: jak hodnotit investiční záměry a řídit podnikové investice: investiční proces jako základ budoucí prosperity, nástroje a metody investičního controllingu, volba financování a technologie, monitoring průběhu investice a postaudit. Praha: Grada, 2009. ISBN 978-80-247-2952-7.
10. VALACH, Josef. (2010). Investiční rozhodování a dlouhodobé financování. 3. přeprac. a rozš. vyd. Praha: Ekopress, 2010. ISBN 978-80-86929-71-2.

Process management of personal information in healthcare provider organizations

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Abstract. Demographic changes, emerging new disease threats, modifications in disease composition and the growing role of disease diagnosis and prevention are the priority factors determining the development of medical services. In additinally, the growing awareness of patients and their expectations make it necessary to continuously develop medical service providers.

At the same time, this type of organisation is expected to produce economic effects while making rational use of its resources. The essential role in this process is played by not only tangible resources, but also intangible resources such as knowledge or information.

A specific type of information, which is at the disposal of each organization of this type, is personal data, which is its intangible resource.

The article presents the nature of personal data as sensitive data collected and processed in organizations providing medical in the context of process management.

The process-oriented approach to personal data management gives an opportunity to improve the quality of decision-making at all management levels, influencing the unit's competitiveness. The presented important factors shaping management processes in terms of personal data management, as well as elements in the field of shaping the personal data protection policy and model personal data management of healthcare organizations may become a reason for discussion in the area of specific resources at the disposal of organizations providing medical services.

Keywords: resources, information, personal data, process management

1 Introduction

The health care sector is one of the actively developing sectors of the economy of any country. Demographic changes, emerging new disease threats, modifications in disease composition and the growing role of disease diagnosis and prevention are the priority factors determining the development of medical services. In addition, the growing awareness of patients and their expectations make it necessary to continuously develop medical service providers. At the same time, this type of organisation is expected to produce economic effects while making rational use of its resources. Despite the specificity of units providing health services, their activities and assessment (at least in some areas) are subject to economic categories and market laws, thus the continuous improvement of decision-making processes and internal business processes is essential [1].

This is particularly important in the dynamic development of technology and the progressive computerisation of medical services, as well as the use of increasingly advanced and automated processes in organisations providing medical services. Innovative

technologies that improve patient services, on the one hand, affect the speed and quality of services, affecting their safety, on the other hand, improve the work of the entire organisation, thereby reducing the costs of its operation. Electronic records, data sets, data mining and their secondary use create opportunities for improving the quality and efficiency of health care and the work of employees, while deepening concerns about privacy [2]. The technologies dedicated to service improve the work efficiency of employees working in the units providing medical services and, in connection with the streamlining of organisational processes, influence the level of employees' satisfaction with their work.

Innovative technologies also generate certain risks related to their failure to comply with current regulations and the limitations that come with them, as well as causing privacy and security concerns affecting trust in organisations. The year 2021 is exceptional in terms of personal data breaches, where the number of hacks, phishing and identity theft has increased by about 17% [3].

In the conditions of systematic transformations in the health services sector, the essential role is played by not only tangible resources, but also intangible resources such as knowledge or information. A specific type of information, which is at the disposal of each organization of this type, is personal data, which is its intangible resource. The unique nature of personal data is proved by the information they contain. Still, in many healthcare institutions, personal data is perceived as a resource that only generates costs. Such an approach to the resources, which are personal data, is influenced by the lack of their location in the organisation, which in turn affects the proper shaping of some of the internal processes, causing conflicts of goals within a traditionally organised institution providing medical services.

In view of these conditions it seems justified to introduce process-oriented management of personal data. Undoubtedly, this requires the intensification of management activities, since for many years these resources have not been sufficiently identified, organised, systematised and inventoried, and therefore have not been taken into account in the organisation's development strategies.

The aim of this article is to present a process-oriented approach to the management of information with a special character - personal data in organizations providing medical services. The process-oriented approach to personal data management, in the author's opinion, increases the security of information exploration and reduces the related threats to the organisation. To achieve the aim of the article, the method of analysing the leading Polish and foreign literature on the subject and the available documents published by institutions was used.

The topic is widely discussed in the literature and is still relevant because of its undeniable importance as it affects everyone directly or indirectly. Data and information are becoming commonplace even for non-specialists and it is becoming increasingly difficult to define and understand them [4]. This is also the reason why it is necessary to use innovative management tools, especially in the management of organizations providing medical services. Management is the process by which, with the use of various resources, a set goal is achieved, and in this case, it is the provision of quality medical services to the public [5].

2 Personal data as a resource for organisations providing specialised healthcare services

The conscious management of a unit providing medical services requires the managers to have medical and economic information. Information, next to other resources[1] of the organization, is one of the most important and valuable resources determining the success of performance of the set goals and tasks [8], [9].

Considering information as a manageable resource of an organisation has become accepted in the organisational management literature, and the term information resource management (IRM) has been recognised and widely used [10], [11], [12].

A resource is a stock, a capital accumulated in quantity and for future use by an organization [13]. Resources form its strengths, which are used to prepare a strategy and put it into practice [6].

The awareness that information behaves like any other active economic resource (capital, infrastructure or human resources) led to the situation that information started to be managed as a strategic resource [14]. The specificity of information as a resource results from its distinguishing features, i.e. its diversity, abundance, manifested synergy effect [15]. The value of information, as opposed to material resources, is not easily measurable - information has no intrinsic value, and its value is determined by its content and the possibility of its use by individual users [14]. The usable form of data that is the result of observation is information [16].

An integral part of medical information is personal data, which is an intangible[2] resource of a unique nature that contains personalised information relating to identified or identifiable natural persons and concerns all areas of their life, including their private, professional or social life, with varying degrees of vulnerability. It should be specified that an identifiable natural person is one who can be recognised on the basis of identifiers such as, inter alia, name, surname, identification number, location data, factors determining the physical, physiological, genetic, cultural or social identity of the natural person [20].

Personal data undoubtedly constitute an intangible resource of any organisation which is part of information, on the other hand it can be a commodity (e.g. purchase of data for marketing purposes). Personal data resources should be subject to special protection hence their management is connected with a special responsibility for the whole organisation. There is no doubt about the principle recognizing the confidentiality of personal data collected by organizations providing medical services as a fulfilment of patients' privacy rights [21]. Hence the need to review the existing approach to personal data management. The need to revise the existing approach to personal data management was also necessitated by the EU reform of the personal data protection regime. Member States have been obliged since 25 May 2018 to implement the so-called General Data Protection Regulation [20].

In the view of this EU regulation, an organization that carries out treatment activities should be considered as a controller of personal data. It is a function which is connected with autonomous decision-making regarding the purposes and means of personal data processing [20] in order to guarantee protection of personal data processing with the use of technical

[1] For more on resources see [6] and [7].

[2] Intangible resources represent the so-called hidden potential of a company. Due to the lack of material form and complications in their quantitative identification, they are characterised by high subjectivity. The consequence of the diversity of intangible resources is their division and typology. On the resources and typology of intangible resources in [17], [18], [19].

and organizational means which are adequate to the existing threat and the category of protected data. The personal data controller shall also be obliged to ensure the compliance of personal data processing processes with the binding legal regulations, as well as to present the way of managing these data including the construction and updating of the security procedure.

The protection of personal data is closely related to the issues of access to data [22].

In an organization providing medical services, the main user of information is the managerial staff controlling the processes taking place in the organization, but in the case of information such as personal data, the user is everyone processing this data at particular levels within the scope of their duties. Hence, the management of personal data as personal information must be strictly controlled and adjusted to the whole system of data protection functioning in the organization. This interpretation of the organization's personal data management and protection in this way complies with the norms of the health care system, on the one hand strengthening the guarantees of patients' rights [23], e.g. to confidentiality and secrecy, and on the other hand equipping data controllers with a number of instruments which enable a more complete performance of medical services and a more efficient management of the related processes. The right to privacy derives from the constitutional regulations [24], it acquires particular significance in the sectoral regulations dedicated to health care mainly by shaping the rules of access to medical information and other generated information about the patient. Covering this information with legally protected secrecy clauses, so-called medical secrecy, is the right thing to do.

Personal data belongs to the category of personalized information and is divided into ordinary data and special categories of data [20]. Medical institutions are the holders of both categories of data, however, due to the specificity of their activity they process special categories of data - sensitive data, e.g. on health condition or genetic data. In certain situations other data may also be collected, e.g. sexuality, religious beliefs, biometric data. The catalogue of various types of personal information is open and specified in the regulations, e.g. in the GDPR [20]. Personal data will also include not only data held by the organisation as a controller, but also data that the organisation has to obtain from third parties [25]. This information may relate to patients, third parties nominated by the patient, employees of the healthcare provider, interns, trainees, volunteers, etc. The relationship between information and a person should be constantly monitored as not all information is of a personal nature. When evaluating data resources, attention should be paid not only to the traditional sources of data acquisition but also to the technology available at the time of data processing and, without doubt, anticipated technological progress should be considered. Therefore, the review of the resources should also refer to the data which are obliged to be acquired within a certain period of time on the basis of specific provisions, although physically the data has not been transferred yet and is not yet fixed in the resources.

3 Process-oriented management of personal data

All the entities also providing medical services, in order to fulfil their tasks under the existing conditions, implement specific processes and acquire specific resources, both tangible (e.g. raw materials, finances, buildings) and intangible (knowledge, information, organisational culture) [26]. Information in the organization is the basis for building knowledge of all people involved in the process of its acquisition and use. They shape the awareness of phenomena occurring in the company itself and its environment. They enable the organization to adapt to the changing reality and enable the transformation of this reality for the efficient functioning of the enterprise [27].

Organisations providing medical services are looking for effective ways of management. The process-oriented approach provides an opportunity to improve the internal processes of the organization, which may lead to improving its competitiveness [28]. Defining processes in the organization and resigning from the concentration of resources and competences in hierarchical, specialized functional departments of the organization ensures better use of material, financial, human, and information resources and increasing the dynamics of its functioning [29].

A critical element of the process-oriented approach is the process itself and its positioning in the organisation [30]. The idea of process-oriented management was initiated by K. Ishikawa [31], W.E. Deming [32], J.M. Juran [33]. Researchers define the term process as a set of activities requiring an input (input) and a result (output) having value for the contractor.

Process management in an organisation is seen as a system of interrelated processes making coordinated efforts to implement them aiming at mapping and improving them [34]. The main components of process management in an organisation are the designation of process owners, the establishment of a process measurement system and the identification of opportunities for improvement. In designing these new organisational elements, the structure adapts to the improved processes and changes to become process-oriented [35].

In the organisation of the health care sector we can distinguish, among others: basic processes related to the core activity of the organisation (provision of medical services), supporting processes (recruitment of employees, training) and, of course, processes related to management (leadership, rewarding). Hence, it is important to properly identify and manage processes, i.e. to distinguish [36] processes that add value for the customer.

In process-oriented organizations, each performed process is characterized by specific features, which include complexity, inclusiveness, integrability, structuring, measurability, susceptibility to improvement, purposefulness and customer orientation [37].

Personal data, being a specific information resource, is subject to specific rules of its use and therefore, while establishing the process of its management, it is necessary to:

- make an inventory of all information resources in the organisation and their location in the adequate data resources,
- dentify all data processing processes which shall be understood as an operation or a set of operations performed on data or sets of data in an automated or a non-automated way [20] (e.g. whether in the process of storing personal data recorded in a particular IT system the process of deleting this data or making it available is also performed)
- identify the required areas of data processing and the attribution of data categories, including identification of the purposes for which the data is processed within specific processes
- identify the level of participation of other subjects (persons) in the organization's tasks and identification of the level of the final customer's access to the information collected about him/her and other information and procedures related to the data processing [20].

It is necessary to emphasize that the above-mentioned activities should be carried out in such a way as to eliminate all the risks related to inappropriate processing of personal data during the implementation of management processes by the service provider. These processes in medical institutions are very diverse and concern both medical processes and management and administrative processes).

4 Model for personal data management

Personal data is part of an entity's information resource. It plays an important role in an enterprise's information systems. Due to the specificity of this resource and the synergy of processes related to the processing of personal data, as well as due to quantitative and qualitative changes related to the processes, it is necessary to form a separate model of personal data management. Such a model shall ensure efficient and effective management of personal data and effective functioning of the healthcare institution as a data controller. In order to achieve this goal, it will be necessary to analyse the processes, considering the expectations of patients as final stakeholders, also in legal terms. Such an analysis leads to an adjustment of roles, tasks and data flow between organisational units. The correct identification and restructuring of processes occurring in the organization providing medical services is crucial from the perspective of building the entire management strategy and examining areas where there are risks for the organization.

In order to develop a model of personal data management in medical institutions, it will be important to:

- -build a map of processes taking place in the organisation in relation to personal data processing, considering its structure,
- -determine existing databases and goals they are to serve in the organisation,
- -define relations between entities participating in information management processes,
- -determine the division of competences and accepting the responsibilities for achieving the accepted goals in connection with personal data processing.

The model for management of personal data processing is shown in Figure 1.

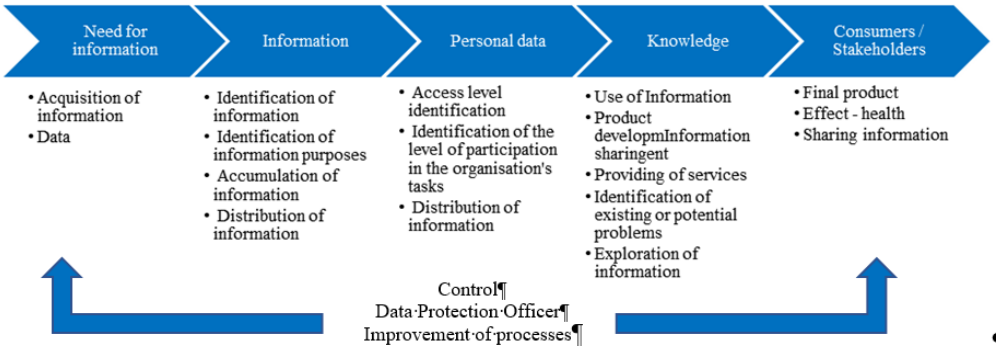

Fig. 1. Model of personal data management process. Own work.

It is important to remember that the very procedure of processing personal data in medical facilities is a complex and heterogeneous process. It is determined by many external and internal factors. The process of personal data management is influenced, among others, by the increasing amount of personal data collected from external sources and commonly available sources, as well as those generated inside the organisation, e.g. from the interview with the patient, conducting specialist examinations, etc.

We should consider the form of personal data processing (electronic, paper, oral), the structure of its localization (dispersed or centralized), possessed technological infrastructure (devices, systems by which it is handled) and the very structure. In addition to this spectrum of determinants, there are also legal factors, threats to information security from within and from the organisation's environment [38], as well as the shape of data resources as intangible resources or tangible resources (data as an object of economic

turnover). Determining with which management structure the data management processes are implemented will determine the adoption of specific roles in the organisation and will lead to the ordering of resources, eliminating incorrect and outdated data. For example, a task related to employment management will require a review of the processing of data related to recruitment in terms of the admissible area of data acquisition and the period of its retention. The maintenance of medical records will require an assessment of the quality of the collected data, considering the potential recipients of the data, as well as determining whether the resources contained in this area of management will also be used in other areas and whether this is reasonable and permissible under the law.

The institution providing medical services as a data controller should guarantee that within the framework for performance of particular processes, e.g. medical or administrative, only necessary and indispensable data is processed, eliminating at this stage the duplication of databases or competences connected with data management. The data shall be secured against unauthorised access, accidental loss, destruction and unlawful use. The controller has to demonstrate which solutions will be designed, developed and implemented to eliminate these risks. Appointing a Data Protection Officer within an organization is such an activity which minimizes the risk related to personal data management and the risk of inappropriate building of data protection system in the organization.

Appropriate formation of the information management model in the medical sector will therefore be of fundamental importance for the whole organisation from the perspective of its development and ensuring an increase in the quality of services. A properly constructed model of information management in the field of personal data influences the increase in the level of process security through the selection of adequate technological support elements, tested in terms of security, at the same time raising the standards of internal and external communication and increasing the level of competence and knowledge about threats.

5 Conclusion

In modern management of an organisation providing medical services, process-oriented management should be considered. In view of the changes taking place, it is necessary to identify and classify the areas that should be improved in order to introduce adequate management support mechanisms. Determining the most optimal way for a healthcare organisation to function as a controller in the area of data management will bring significant benefits to the organisation. In order for the organisation to adapt faster to the changes and to make rational choices in the performance of its tasks, certain standards of data protection and personal data management should be created and introduced.

The identification of the elements of personal data management in medical institutions will be the basis for designing appropriate information and decision-making structures and management functions. The introduction of a model of personal data management is also necessary to reduce the risks related to the processing of personal data, strengthening security in this area and at the same time transferring to a higher level the sense of patient's trust towards the whole organisation. As a consequence, it allows to build a proper course and relationship between processes affecting the level of achievement of organizational goals and financial benefits.

References

1. Olszak C.M., Batko K., The use of business intelligence systems in healthcare organizations in Poland, Preprints of the Federated Conference on Computer Science and Information Systems, p. 997–1004.
2. Kaplan B., How should health data be used?. Privacy, secondary use, and big data sales, ISPS-BIOETHICS WORKING PAPER, 2014, p. 2-4.
3. Identity Theft Resource Center. ITRC's 2021 Q3 Data Breach Analysi. https://notified.idtheftcenter.org/s/2021-q3-data-breach-analysis?utm_source=pressrelease100621&utm_medium=web&utm_campaign=Q3BreachAnalysis. (access on, 14.10.2021r.).
4. Pangrazio L., Selwyn N., Personal data literacies': A critical literacies approach to enhancing understandings of personal digital data, New Media & Society, Vol. 21, issue: 2, 2018, p. 419-437.
5. Quinn E.R., Bright D., Faerman S. R., Thompson M. P., McGrath M. R., Becoming a Master Manager: The Competing Values Approach to Management, 5th ed., John Wiley, New York, 2011, p. 20-7,
6. Porter M., The contributions of industrial organization to strategic management, Academy of Management Revie 11: 6, 1981, p. 609-620.
7. Barney J., Firm resources and sustained competitive advantage, Journal of Management, 17(1), Thousand Oaks, California, 1991.
8. Krajewski K, Wójtowicz M. (red.), Procesy przekształceń w ochronie zdrowia – szanse i zagrożenia. Zarządzanie ochroną zdrowia, Instytut Przedsiębiorczości i Samorządności, Warszawa, 2001, p. 90.
9. Penc J., Myślenie strategiczne w organizacji XXI wieku. [w:] Grudzewski W.M., Hajduk I.K. (red.): Przedsiębiorstwo przyszłości - wizja strategiczna, Wydawnictwo Difin, Warszawa, 2002, p. 42-65.
10. Eaton J.J., Bawden D., What kind of resource is information?, International Journal of Information Management, Vol. 11, issue 2, 1991, p. 156-165.
11. Best D.P., The future of information management. International Journal of Information Management, Vol. 8, issuse 1, p. 13–24.
12. Bebber R.J., reating Information as a Strategic Resource to Win the "Information War", Orbis Vol. 61, Issue 3, 2017, p. 394-403.
13. Materska K., Informacja w organizacjach społeczeństwa wiedzy, Wydawnictwo Stowarzyszenia Bibliotekarzy Polskich, Warszawa, 2007, p. 97.
14. Olaisen J., Information versus information technology as a strategic resource. International Journal of Information Management, Vol. 10, issue 3, 1990, p. 192-214.
15. Stefanowicz B., Informacja jako zasób strategiczny, Ekonomika i Organizacja Przedsiębiorstwa nr 7, Instytutu Organizacji i Zarządzania w Przemyśle ORGMASZ, Warszawa, 2004, p. 11-21.
16. Ackoff R.L, From data to wisdom, Journal of Applied Systems Analysis 16(3), 1989, p. 3.
17. Sopińska A., Wiedza jako strategiczny zasób przedsiębiorstwa: analiza i pomiar kapitału intelektualnego przedsiębiorstwa, Szkoła Główna Handlowa, Warszawa, 2008.
18. Michalczuk G., Zasoby niematerialne jako czynnik wartości przedsiębiorstwa: luka informacyjna sprawozdawczości finansowej, Wydawnictwo Uniwersytetu w Białymstoku, Białystok, 2013.
19. Murawska M., Zarządzanie strategiczne niematerialnymi zasobami przedsiębiorstwa, Fundacja Promocji i Akredytacji Kierunków Ekonomicznych, Warszawa 2008, Oficyna Wydawnicza, Warszawa, 2010,
20. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free

movement of such data, and repealing Directive 95/46/EC (Journal of Laws UE L 119 z 4.5.2016), art. 4, pkt. 2, 7-15, art. 6, art. 9, 13, 14, 15, 28, , motyw 63
21. Jost TS. Readings in Comparative Health Law and Bioethics. 2 ed. Durham, NC: Carolina Academic Press, 2007.
22. Samarati P., Di Vimercati S., Data protection in outsourcing scenarios: Issues and directions, ACM Symposium on Information, Computer and Communications Security, 2010, p. 1–14.
23. Ustawa z dnia z dnia 6 listopada 2008 r. o ochronie praw pacjenta i Rzeczniku Praw Pacjenta (Journal of Laws 2017 poz. 1318 consolidated text).
24. The Constitution of Poland from 2nd April 1997 r. (Journal of Laws 1997 nr 78 poz. 483 consolidated text).
25. Court of Justice of the European Union: Case C-101/01 (decision of 6 November 2003).
26. Penc J., Leksykon biznesu. Agencja Wydawnicza "Placet", Warszawa, 1997, p. 591 .
27. Grabowski M., Zając A., Dane, informacja, wiedza - próba definicji, Zeszyty Naukowe nr 798 Uniwersytetu Ekonomicznego w Krakowie, nr 798, Kraków, 2009, p. 99-116.
28. Olszak C.M, K. Batko K,, Szpitalne systemy informatyczne w zarządzaniu procesowym organizacją medyczną, Roczniki Kolegium Analiz Ekonomicznych nr 29, Szkoła Główna Handlowa w Warszawie, Warszawa, 2013, p. 704.
29. Olszak C.M., Billewicz G., Ziemba E., Systemy informatyczne w zarządzaniu procesowym w organizacjach opartych na wiedzy, w: Kierunki rozwoju społeczeństwa informacyjnego i gospodarki opartej na wiedzy w świetle śląskich uwarunkowań regionalnych, red. Olszak C.M., Ziemba F., Wydawnictwo Uniwersytetu Ekonomicznego, Katowice 2010, p. 317–336.
30. Nosowski A., Systemy informatyczne w zarządzaniu procesami biznesowymi, w: Informatyka gospodarcza, t. 3, red. J. Zawiła-Niedźwiedzki, K. Rostek, A. Gąsiorkiewicz, Wydawnictwo C. H. Beck, Warszawa, 2010.
31. Ishikawa K., What is total quality control? The Japanese way,Englewood Cliils, Englewood Cliffs, New York, 1985.
32. Deming E.W., Out of the crisis: quality, productivity and competitive position., Cambridge Univesity Press., Cambridge, 1988.
33. Juran J.M., Juran on leadership for quality: an executive handbook, Free Press, New York, 1989.
34. Benner M.J., Tushman M.L., Exploitation, Exploratation and the proces managment. THE Productivity dilemma revisited. Academy of Management Review, 28(2), 2003, p. 238–256.
35. Hellström A., Eriksson H. Are you viewing, mapping or managing your processes?, The TQM Journal, Vol. 20, isusse 2, 2008, p. 166-174.
36. Grajewski P, Organizacja procesowa, Wydawnictwo PWE, Warszawa, 2007, p. 62-63.
37. Nowicki M., Szymańska K., Organizacja w ujęciu procesowym od koordynacji funkcjonalnej do procesowej, w: Nauka o organizacji. Ujęcie dynamiczne, A. Adamik (red.), Oficyna wydawnicza Wolters Kluwer business, Warszawa, 2013, p. 344.
38. Bączek P., Zagrożenia informacyjne a bezpieczeństwo państwa polskiego, Wydawnictwo Adam Marszałek, Toruń, 2006, p. 30.

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