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Organization and management of digital transformation of business structures in construction development

Abstract. This study is devoted to the problem of updating the administration system of a construction project based on the integration of the concepts of process-oriented and project-oriented management in the context of the implementation of the latest technologies and digital models of smart construction, building information modeling (BIM) and the Internet of Things (IoT). In accordance with this significant transformations are subject not only to the operating system of enterprise management, but also to the course of business processes in the management environment of an investment and construction project. The result of the study is a model of a digital design company for construction lifecycle management. Such a model for managing a virtual design enterprise will optimize and reduce the costs of existing operating systems for managing a construction enterprise. The concept of introducing a life cycle management system for construction objects using BIM in the areas of reconstruction projects is proposed. With further development and implementation, this industry-specific BIM platform management model can form an information technology integration framework for reorganizing the business processes of a construction enterprise. The basic structure of the BIM platform is described, consisting of four components. There are cloud computing, big data analytics, Internet of Things and Blockchain information technologies. The need for

the evolution of IoT information technologies from intelligent things to an intelligent planet is shown. In the future, it is planned to develop an integrated innovative structure of a holding type that supports the digital transformation of the operating system of enterprise management in the construction industry.

Keywords: project management, operational management system, construction company, digital transformation of administration systems, information modeling in construction.

The field of construction is one of the most important branches of the economy of most countries, which depends on the efficiency of the entire economic system, including the state of the environment, energy independence of the state, employment of the population, etc.

The construction industry creates a material and technical base for the development of industry and agriculture and is one of the main consumers of intermediate products (mineral construction raw materials, chemical products, electrical and electronic equipment, etc.) and related services. Funds invested in the development of the construction industry have a multiplier effect on interrelated processes, such as the production of building materials and related equipment, the engineering industry, transport, energy, etc.

Thus, the construction of an effective and competitive national economy in Ukraine requires a systemic comprehensive reform of the construction industry, one of the important components of which is its gradual digital transformation.

After all, European and world experience shows that the gradual digitalization of the construction industry significantly contributes to the sustainable development of the economy as a whole.

The development of the modern economy is determined by the high pace of economic and technological transformations, which is intensified by competition in industries and dynamic changes in the needs of the audience. However, the domestic business sphere shows signs of prolonged stagnation, overcoming which is a critically important task for the development of the Ukrainian economy at both the

macro and micro levels. Therefore, the choice of innovation as a driving force of progress simultaneously encourages positive shifts not only in scientific thought, but also qualitative changes in the entire system.

According to the liberal concept of the economy, there are special conditions for the activity of business entities, which are based on the processes of the macroeconomic situation with the provision of appropriate institutional changes and relate to freedom of choice, price policy, collaborative processes and information flows. At the same time, business, as a system as a whole, affects all the constituent structures of the organization, which violates their independence, affects the dynamics of development, inhibiting the progress of changes both at the level of the country and each organization separately. This especially applies to innovative business development in the context of digital transformations, which is a new dimension of reality with the definition of digital leadership.

Digital technologies in the modern world create fundamentally new opportunities for building interaction between the state, business and the population, eliminating long chains of intermediaries and speeding up various deals and operations. Such factors come to the fore due to the rapid development of information technologies and the globalization of the economy, which offer fundamentally new concepts of consumption and open up additional potential for the development of new markets and innovative developments.

But at present, the digitalization of the economy in Ukraine is actually narrowed down to the development of communication and information networks, since the digital infrastructure in Ukraine is not sufficiently developed. Thus, according to the data of the Speedtest.net resource, Ukraine's position in the world in terms of Internet connection quality indicators is quite low: 114th place in terms of mobile Internet quality and 45th in terms of broadband Internet quality1. In addition, if Ukrainian IT companies can afford state-of-the-art equipment, small and medium-sized businesses, potential buyers of their goods and services in Ukraine, are limited both in terms of technology and finances. This also applies to the average consumer, who, for the same reasons, does not have full access to modern digital advantages.

It is obvious that in such conditions, organizations, including commercial ones, need to intensify innovative and technological development, to be innovatively active in order not to lose global competitiveness and communication with their audience. The solution of this problem refers to the type of complex multi-criteria tasks, which actualizes scientific and economic research from the perspective of theoretical and methodological, as well as the institutional basis of business management, its innovative development in the conditions of the digital economy, and needs to be clarified, revised, supplemented and deepened.

For many years, a large society of domestic and foreign scientists has been addressing the problems of investment and innovation development of business. Foreign economic literature in the sphere of ensuring investment and innovation activity mainly pays attention to the history of formation and the current state of financial institutions, the peculiarities of their organizational and legal structure and functioning, the foreign authors of which are: S. Kaplan, J. M. Keynes, K. Christensen, R Nelson, M. Peters, M. Rogers, E. Toffler, S. Winter, R. Foster, F. Khizrich, J. Schumpeter, and many others.

Today, the key category of economic growth is innovations, the most important feature of which is the novelty of their consumer properties. Consequently, innovations are accompanied by radical and often permanent transformations, which are based on modern achievements in the field of science, engineering and technology, which quite often requires special knowledge, skills and creative energy in the field of their development and practical application, as well as an appropriate material and technical base, adequate to the management system.

Studies of the terminological apparatus prove that the concept of "innovative activity" today needs meaningful deepening and its transformation into the concept of "innovation", the essence of which in the conditions of the digital economy is much broader and is revealed through globalization and improvement of the information space, transformation of business models with the help of digitalization, implementation of advanced technologies, modification of the infrastructure of organizations, intellectualization of personnel. A new ideology of the process of

innovation is proposed as a prognostic idea of business development in the conditions of the digital economy at the macro- and micro-levels, which makes it possible to ensure an integral effect during the transformation of modern global socio-economic processes.

The emergence of new trends in conducting business, associated with the widespread use of the Internet and the use of various types of mobile devices, indicate a transition to a new level of economic development, the vector of which is digital economy. It has been proven that in modern philosophical and methodological research aimed at revealing the processes and mechanisms of the digital economy, it is important to focus attention on the problems of clarifying the conceptual apparatus - a new paradigm, the integrated influence of various management structures and forces on the development of the economic system, the adequacy of the methodological toolkit of the complexity and scale of the problem to be solved. problems Therefore, the main tenets regarding methodological approaches to the definition of the terminological apparatus of the digital economy (technological; based on types of activities; based on the system of relations; as a new type of economy), understanding of its nature, positive and negative consequences as a result of society's transition to the digital economy are considered. It is proposed to recognize the digital economy as a new type of economy, which includes a system of socio-economic relations based on the wide implementation and application in all spheres of economic activity of digital information and communication technologies, which is based on the concepts of informatization of management and business innovation, optimization of production, distribution, exchange , consumption and increasing the level of socio-economic development of the state in the conditions of globalization.

The success of business development in the conditions of digital transformation requires a clear understanding of the basic principles and mechanisms inherent in the digital economy. It is suggested that the methodological principles of the digital economy include the principles due to the systemic approach to the defined guiding ideas, namely: spatial, economic, technological, informational, intellectual, social,

innovative, virtual, and trust and security. The systematic of the recommended principles of the digital economy is of great importance, as it affects the understanding of its methodology, contributes to the solution of tasks, the determination of ways of its construction on both the macro and micro levels.

It is substantiated that, in addition to the principles, an important part of the methodology of the digital economy is its mechanisms, which are proposed to include the following: cloud computing, big data, artificial intelligence, the Internet of Things, outsourcing, quantum technologies, blockchain technologies, cyber-physical systems, etc. This approach contributes to the transformation of business priorities, leads to the introduction of process and productive innovations, the emergence of new markets, new business models.

It has been proven that the heads of enterprises must be ready for rapid transformational changes, namely, be able to change their own business strategy and the organization of existing business processes in time, because this will contribute to the emergence of new business models, goals and means of their achievement. It has been established that insufficient awareness of entrepreneurship regarding the possibilities of technology integration into its own business processes causes inhibition of the development of companies and the emergence of difficulties in the process of domestic business entering the international arena. That is why, along with statistical studies of the use of information and communication technologies in business and the formation of positions of companies in the process of digital development of the country, an important task is the creation of "road maps" of digital transformation and the provision of recommendations on the possibilities of using digital tools and improving the digital literacy of both entrepreneurs and population in general. Thus, the results of the calculation of the Index based on real data regarding the digital maturity of domestic business structures will serve as a driving force for further practical actions to increase their digital development. It was established that the phenomenon of digitalization is manifested not only in technical or technological characteristics, but also in the behavioral aspect of the object and subject of management. Achieving the goal of digitalization of business is possible if

a "road map" is developed, in which the main tasks, potential, opportunities, limitations and advantages of changes are prescribed, which will allow modernization action at the required scale and pace, taking into account available resources.

The digitization strategy is based on three basic parameters: focus on personnel; partnership formation; studying new technologies. A distinctive feature of the digitalization roadmap is the rejection of a step-by-step assessment of business areas in favor of real changes without excessive analysis. This approach is more effective in the conditions of the digital economy, since the constant study of business aspects allows you to get a comprehensive picture of it, however, such information quickly loses its relevance, and therefore does not have a positive impact on changes.

One of the main success factors of an organization's development in the digital economy is the effective use of its intellectual potential. Based on the theoretical justification of the existing methodological approaches to determining the structure of intellectual capital and taking into account the peculiarities of the activities of organizations in the conditions of the digital economy, its structure is proposed and it is proved that the relationship of the personnel of the organization with digital technologies is shifting from the field of self-development of technologies to the field of business improvement due to its intellectualization and new opportunities provided by technologies.

It is substantiated that psychological aspects play an important role during the generation and transformation of organizations. At the same time, the researchers note the clear advantages of the new concept of "design thinking", which, according to the author, is a tool of the digital economy and occupies a significant place in the work of management personnel. The design-thinking toolkit offers a fairly simple and understandable project model for the transformation of the work of management personnel using digital business technologies and dictates the need to find new and adapt existing management models, which are the basis of future competitiveness.

The main features of the formation of a new economy are the rapid growth of the value of information, which is an infinite resource. That is, in the conditions of

the digital economy, the information sphere acquires system-forming importance for the life of society, determining its political, socio-economic and cultural development. Information systems play an increasing role in achieving the strategic goals of organizations, because they not only provide information processing for departments and end users in the internal environment, but also directly generate products and services based on information and provide a competitive advantage in the market. Given the importance of the information infrastructure in the organization's management system for functioning and development, a model of its construction is proposed, which requires taking into account the properties and specifics of the organization, conditioned by the processes of digital modernization of the economy.

The results of the study made it possible to generalize the achievements of modern scientific principles regarding the construction of information management, taking into account practical recommendations for a formalized description of the information technology (IT) architecture of the organization, which serves as a detailed guide, defines the main, standard or typical elements of IT systems, their relationship, and as well as their management processes in the conditions of the digital economy.

Given the unconditional value of the scientific research of the domestic and foreign community of scientists, it was found that the need to develop theoretical-methodological recommendations and organizational provisions of composite management and to create a fundamentally new management system of the organization, developed with the help of the development and implementation of the Digital strategy, remains relevant today. The conducted studies of the works of scientists, economists, experts of various levels made it possible to generalize the main trends in the field of human resources management, which must be taken into account when forming the organization's Digital strategy, and to propose a concept of digitalization of business, which consists of the following main stages: modeling of the organization's architecture, modeling of the information infrastructure and development of Digital strategy.

It has been proved that the basic management technologies on which modern methodological approaches to the formation of the management system of organizations are based include the use of: balanced scorecard (BSC), business engineering technologies (BPR) of management and quality management system (TQM). All these methodological approaches to management are based on the process method, but have significant differences. The use and addition of digitalization features of these technologies makes it possible to improve the management system of organizations in the conditions of the digital economy, which is of significant importance, since high competition, complications of the consumption culture, as well as the presence of external risks lead to the fact that the preservation of medium-term efficiency will be subject to mobile, flexible and innovative developed organizations.

The results of the study made it possible to conceptually outline the directions of transformation of the components of the organization management system in digital business and to propose an addition to the above management technologies, a specific block, which is defined as "instrumental methodology of the digital economy" between the scientific base of theoretical knowledge and the practice of activity, which conditions the coordination of existing management methods with design and engineering technologies and leads to the combination of innovative ideas with real measures of their practical implementation in the conditions of the digital economy. It was determined that for this it is appropriate to take into account the following main trends in the methodology of managing innovative business development: visual commerce, personalization, trust and privacy, design, unified commerce, thing of commerce, customer analytics, artificial intelligence, etc.

The concept of implementation of construction information modeling technologies (BIM-technologies) in Ukraine (hereinafter referred to as the Concept) defines the guiding principles, ways and terms of the formation and implementation of state policy aimed at reforming, modernizing and digital transformation of the construction industry of Ukraine.

Thus, the developed concept of lifecycle of strategic tasks of the innovative model of surveying company describes with the help of dynamic programming tools the process of balancing the "task portfolio", in which the lifecycles of strategic tasks are balanced by the stages of the "cycle of serving" and expected profits.

The use of such a model will help to achieve a balance between the tasks and will facilitate the process of strategic decision-making in the management of real estate management company REMC.

Figure 1 presents a visualization of the implemented set of application programs – a subsystem of application of target indicators of quality of operational activity of REMC for the choice of the final alternative of the annual program of activity in the market of surveying services

	A	B	C	D	E	F	G	H	I
160									
161	Target indicators of quality of a choice of a variant of a cycle of operas. activities of the REMC								
162	FQI_1	FQI_2	FQI_3	FQI_4	FQI_5	FQI_6	FQI_7	FQI_8	FQI_9
163	maximum profit REMC	maximum turnover REMC	minimum own sources of investment of CREO from REMC	maximum profitability of operating activities REMC	the minimum capacity of the payback duration of the project in the total	minimum cycle risk for REMC (in semantic-banal units)	maximum net current assets of REMC	maximum maneuverability	maximum management autonomy
164	Specific contributions of target indicators of FQI in the general model of operational-production and administrative-management cycle								
165	Θ_1	Θ_2	Θ_3	Θ_4	Θ_5	Θ_6	Θ_7	Θ_8	Θ_9
166	0,24189	0,167	0,0506	0,0437	0,0763	0,059	0,197	0,112	0,05251

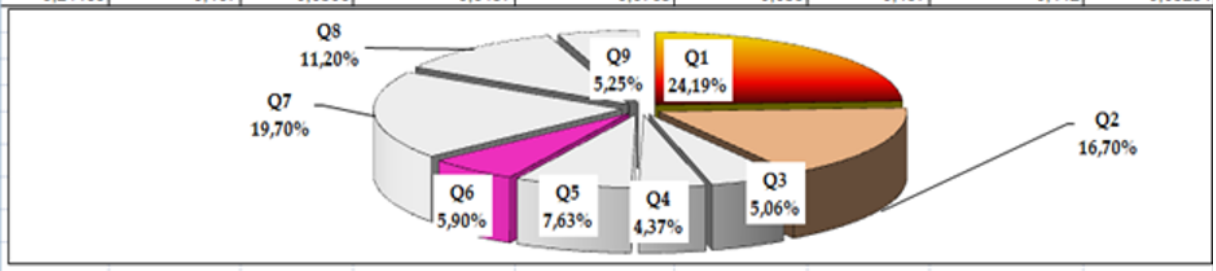

Fig. 1: Complex of application programs: application of target indicators of quality of operational activity of REMC for a choice of final alternative of the annual program of activity in the market of surveyingservices

Integrating BIM with real-time data from IoT devices is a powerful paradigm for applications that improve construction and operational efficiency. Numerous applications enable real-time data streams from the rapidly expanding set of IoTs for high-fidelity BIMs. However, research on the integration of BIM and IoT is still at an

early stage, it is necessary to understand the current situation of the integration of BIM and IoT devices [20].

In essence, construction is project management. With digitalization, it turns into control based on data obtained automatically at the point of their origin from IoT devices and sensors, connected machines, platforms and equipment, which allow creating information and mathematical models and algorithms, and realizing more and more autonomous production and business processes having the property of adaptability.

That is, the basis for digitalization of construction is informational and mathematical modeling of end-to-end processes, which allows to optimize work in terms of cost, timing, business sustainability and minimization of negative environmental impact, and any other specified characteristics, based on high quality data (in terms of parameters – relevance, accuracy and completeness).

So, for almost 40 years of the existence of the IoT, according to a number of experts, 4 evolutionary stages have passed. Let's present them in the Table 1.

Table 1 Evolution of the Internet of Things

Stage	Stage characteristics	Example
Stage I– Smart Things	Identification of each object is carried out separately. One fact remains unchanged - a person is needed to connect all objects. It was at this stage of development that the idea of effective interaction between all objects appeared.	Indoor humidity data over a period of time; information about insufficient amount of washing powder in the machine.
Stage II – Smart Building	A system of connected devices and objects that have the ability to communicate. The ability to delegate a significant part of your daily routine to the Internet of Things.	Everything in the house, from the refrigerator to the curtains, is connected to each other, the level of illumination and temperature is regulated thanks to sensors and smart watches. The devices are able to make independent diagnostics, as well as inform about the need for repair work.
Stage III – Smart City	Collective image. It shows a situation where every house will become smart. In other words, the prototype can be implemented if IoT technologies become available to everyone. The collection of individual nodes will create an infrastructure in which all objects will	All residential areas are under the control of a general analysis of the data that comes from things. Thanks to this feature, electricity consumption is regulated; various breakdowns are recorded and eliminated as quickly as possible. A smart city is an ecosystem

	communicate with each other. Provides for the collection and processing of all information related to the inhabitants of the settlement, as well as individual districts, quarters and houses.	in which everything from urban transport to the regulation of commodity and retail relations is shaped by the collection of data. Ultimately, the standard of living rises.
Stage IV – Smart Planet	Sensory planet. Acts according to the example of the third level, but already on the territory of the entire planet. When humans can create an ecosystem of smart things, it's time to shift their focus to Earth. With the help of a system of sensors, humanity will be able to control absolutely all natural processes. It will be possible to avoid the consequences of natural disasters; a base will be formed to track the health of the planet and the possibility of improving it; people will be able to effectively track, control and use resources.	All cities and countries, all populated and uninhabited areas of the planet are under the control of a general data analysis that comes from things. Thanks to this opportunity, the consumption of natural resources is regulated, the negative consequences of dangerous natural phenomena are recorded and eliminated as quickly as possible, and possible disasters are prevented.

Practical applications of IoT in the construction industry range from smart thing to smart home. The implementation of IoT in construction is complicated, among other things, by the need to take into account the impact on the environment, close ties with housing and communal services, energy and consumer electronics. Based on this, it is possible to determine the current areas of application of the IoT in this area.A serious advantage of the integration of BIM and IoT is that the Internet of Things is being introduced not only during the operation of the building, but also directly in the design and the stage of construction work.

Conclusion. Thus, we can conclude that information modeling technologies are an extremely promising topic. The topic of “relevance of BIM technologies” is raised at all kinds of forums and exhibitions. Due to the high interest of the state in the implementation of BIM technologies in the construction industry, construction organizations that are making the transition to the use of information modeling technologies can seriously count on state preferences. Today, some of the tasks set by the state for construction organizations seem to be impossible, however, as the experience of many countries shows, the solution of these tasks is just a matter of time.

An original scheme of systems engineering for digital modeling of creative activity is proposed. The scheme describes seven levels of digital modeling, corresponding to six levels of link aggregation: “plan-goal”, “object-project”, “process-time”, “technology-economy”, “system-resource”, and “convergence complex”. All levels of digital models of the presented system engineering of creative activity are connected by object, by object and by the logic of digital models proper is arbitrarily.

The urgent need to rethink the goals of BIM technologies in the direction of long-term economic models and life cycle management of capital construction objects was realized. From these positions, the production concept is promising a virtual design enterprise on a single industry BIM platform, combining digital tools that correspond to the specifics of information flows of the full life cycle of a project in construction.

The virtual design enterprise as a management model optimizes and reduces the costs of the existing management systems. With further development and implementation, this management model on the industry BIM platform can form the information technology basis for a new work organization and interaction between project participants – employees and companies. At the same time, a virtual project enterprise is proposed as a production concept and an organizational basis for the transition to full cycle BIM, to the management of the full project life cycle and the reengineering of the corresponding information flows.

Finally, the authors believe that integrated BIM, Cloud Computing, Internet of Things, Big data and Blockchain information technologies create an innovative framework supporting digital transformation in the construction industry.

REFERENCES

[1] J. K. W. Wong, and J. Zhou, “Enhancing environmental sustainability over building life cycles through green BIM: A review”, Automation in Construction, vol. 57, pp. 156–165, 2015.

[2] A. H. Alavi, and A. H. Gandomi, “Big data in civil engineering. Automation in Construction”, vol. 79, pp. 1–2, 2017.

[3] M. Bilal, et al., “Big Data in the construction industry: A review of present status, opportunities, and future trends”, Advanced engineering informatics, vol. 30(3), pp. 500–521, 2016.

[4] A. Gandomi, and M. Haider, “Beyond the hype: Big data concepts, methods, and analytics”, International Journal of Information Management, vol. 35(2), pp. 137–144, 2015.

[5] Y. Yuan, and Z. Jin, “Life cycle assessment of building energy in big-data era: theory and framework”, In Network and Information Systems for Computers (ICNISC), pp. 601–605, January 2015.

[6] M. Arslan, Z. Riaz, and S. Munawar, “Building Information Modeling (BIM) Enabled Facilities Management Using Hadoop Architecture”, 2017 Proceedings of PICMET '17: Technology Management for Interconnected World, Portland, USA, 2017.

[7] H. M. Chen, K. C. Chang, and T. H. Lin, “A cloud-based system framework for performing online viewing, storage, and analysis on big data of massive BIMs”, Automation in Construction, vol. 71, pp. 34–48, 2016.

[8] K. Gopalakrishnan, A. Agrawal, and A. Choudhary, “Big Data in Building Information Modeling Research: Survey and Exploratory Text Mining”, MOJ Civil Eng, vol. 3(6), 2017.

[9] A. A. Volkov.“Cybernetics of construction systems. Cyber-physical construction systems”, in Promyshlennoeigrazhdanskoestroitel'stvo, 2017, no. 9, pp. 4–7. (In Russian)

[10] T.W. Huang, “Application Case of Big Data Analysis on Dynamic BIMs with Parameters for Use Scenarios” [Master’s Thesis], National Taiwan University of Science and Technology, Taiwan, 2016.

[11] S. Sagiroglu, and D. Sinanc, “Big data: A review”, in Collaboration Technologies and Systems (CTS), 2013 International Conference, pp. 42–47, May 2013.

[12] V. Mihaylenko, T. Honcharenko, K. Chupryna, T. Liazschenko: “Integrated processing of spatial information based on multidimensional data models for general planning tasks”, in International Journal of Computing, vol. 20 (1), 5562, 2021. https://doi.org/10.47839/ijc.20.1.2092

[13] T. Honcharenko, G. Ryzhakova, Ye. Borodavka, D. Ryzhakov, V. Savenko, O. Polosenko. “Method for representing spatial informationof topological relations based on a multidimensional data model”, in ARPN Journal of Engineering and Applied Sciences, vol. 16, Issue 7, 2021, pp. 802–809, http://www.arpnjournals.org/jeas/research_papers/rp_2021/jeas_0421_8555.pdf.

[14] P. Kulikov, G. Ryzhakova, T. Honcharenko, D. Ryzhakov, O. Malykhina. “OLAP-Tools for the Formation of Connected and Diversified Production and Project Management Systems”, in International Journal of Advanced Trends in Computer Science and Engineering, 8(10), October 2020, pp. 7337–7343, https://doi.org/10.30534/ijeter/2020/1108102020.

[15] M. Dyomin, A. Dmytrenko, D. Chernyshev, O. Ivashko, “Big Cities Industrial Territories Revitalization Problems and Ways of Their Solution” in Lecture Notes in Civil Engineering, vol. 73, pp. 365–373, 2020.

[16] S. Azhar, A. Behringer, “A BIM-based approach for communicating and implementing a construction site safety plan” in 49th ASC Annual International Conference Proceedings, Associated Schools of Construction, 2013. https://ascpro0.ascweb.org/archives/cd/2013/paper/CPRT43002013.pdf

[17] Y. Tan, Y. Fang, T. Zhou, V.J.L. Gan, J.C.P. Cheng, “BIM-supported 4D acoustics simulation approach to mitigating noise impact on maintenance workers on offshore oil and gas platforms” in Automation In Construction, vol. 100, 1–10, 2019. https://doi.org/10.1016/j.autcon.2018.12.019

[18] T. Honcharenko, V. Mihaylenko, Y. Borodavka, E. Dolya, V. Savenko, “Information tools for project management of the building territory at the stage of urban planning”, in CEUR Workshop Proceedings, 2851, 2021, pp. 22–33.

[19] D. Singh, and C. K. Reddy, “A survey on platforms for big data analytics”, Journal of Big Data, vol. 2(1), pp. 8, 2015.

[20] Koo Bonsang, La Sunmin, Cho Nam-Wook, Yu Youngsu. Using support vector machines to classify building elements for checking the semantic integrity of building information models // Automation in Construction. 2019. Vol. 98. Pp. 183–194. DOI: 10.1016/j.autcon.2018.11.015

[21] Y. Mehmood, F. Ahmad, I. Yaqoob, A. Adnane, M. Imran, S. Guizani. (2017) "Internet-of-Things-based smart cities: recent advances and challenges", IEEE Communications Magazine, 55(9): 16–24.

[22] S. Parween, S. Z. Hussain, M. A. Hussain, "A Survey on Issues and Possible Solutions of Cross-Layer Design in Internet of Things", in International Journal of Computer Networks and Applications (IJCNA), 8(4), pp. 311-333, 2021, DOI: 10.22247/ijcna/2021/209699.

[23] P.T. Kasthuribai, "Optimized Support Vector Machine Based Congestion Control in Wireless Sensor Network Based Internet of Things", in International Journal of Computer Networks and Applications (IJCNA), 8(4), pp. 444-454, 2021, DOI: 10.22247/ijcna/2021/209710.

[24] P. Joshi, A. S. Raghuvanshi, "Hybrid Approaches to Address Various Challenges in Wireless Sensor Network for IoTApplications: Opportunities and Open Problems", in International Journal of Computer Networks and Applications (IJCNA), 8(3), pp. 151-187, 2021, DOI:10.22247/ijcna/2021/209186.

[25] S.A.A.B. Hmaid, V. Vasanthi, "Fractional Gaussian firefly algorithm and darwinian chicken swarm optimization for IoT multipath fault-tolerant routing", in International Journal of Computer Networks and Applications (IJCNA), 7(6), pp. 167-177, 2020, DOI:10.22247/ijcna/2020/ 205318.

[26] T. Honcharenko, Y. Chupryna, I. Ivakhnenko, M. Zinchenco, T. Tsyfra. "Reengineering of the Construction Companies Based on BIM-technology", in International Journal of Emerging Trends in Engineering Research, 8(8), August 2020, pp. 4166-4172 https://doi.org/10.30534/ijeter/2020/22882020. 2,33