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# РОЗВИТОК ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ У ЦИФРОВІЙ ЕКОНОМІЦІ

# DEVELOPMENT OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE DIGITAL ECONOMY

***Abstract.*** *The current trends of socio-economic development and progression of the digital economy in Ukraine and the world are described in the paper, the peculiarities of the economic development of the most dynamically developing countries in recent years are analyzed and established that they have focused on the development of informatics, mathematical and computer methods, software, network technologies, microprocessor systems, which 75% ensure the success of innovative entrepreneurship.*

*The role of information and communication technologies in the new economic relations is investigated and showed that the development of the digital economy is under the influence of the concept of the digital transformation of Industry 4.0, which involves the active integration of cyber-physics systems in production processes and the creation of smart enterprises and other intelligent objects of the digital economy on this basis.*

*The main trends of the development of information and communication technologies in the digital economy, in particular, Cloud computing, Cloud Technology, BigData, Self-service technology, Internet of Things, iPhone +1, Gamification, Socialization are considered and there was demonstrated in which way these technologies provide effective IT support for innovative entrepreneurship in the leading companies of the world on the basis of integrated and purposeful analysis of the environment and formation of knowledge about this environment in the form of objects: facts, concepts, knowledge and relations between objects and sets of objects in the digital economy; automated and automatic recognition of regular situations using classical methods, and freelance, through the use of images of specific production, economic, financial situations that occur in the enterprise.*

*The approaches to improving the activities of innovative enterprises based on the application of intellectual information technologies are analyzed, peculiarities of the development of intelligent objects of digital economy are determined, and conceptual provisions for the creation of intelligent enterprises in the digital economy and their IT support are proposed.*

***Key words:*** *digital economy, digital transformation, information and communication technology, information system, smart enterprise.*

***Анотація.*** *В роботі розглянуто сучасні тенденції суспільно-економічного розвитку та розбудови цифрової економіки в Україні та світі, проаналізовано особливості економічного розвитку країн, що най-*

*більш динамічно розвиваються в останні роки, та встановлено, що вони зробили акцент на розвитку інформатики, математичних і комп'ютерних методів, програмного забезпечення, мережевих технологій, мікропроцесорних систем, що на 75 % забезпечує успіх інноваційного підприємництва.*
*Досліджено роль інформаційно-комунікаційних технологій в нових економічних відносинах і показано, що розвиток цифрової економіки відбувається під впливом концепції цифрової трансформації Індустрії 4.0, що передбачає активну інтеграцію кіберфізічеських систем у виробничі процеси та створення на цій основі розумних підприємств і інших розумних об'єктів цифрової економіки.*
*Розглянуто провідні тренди розвитку інформаційно-комунікаційних технологій у цифровій економіці, зокрема хмарні обчислення, хмарні технології, BigData, технології самообслуговування, Інтернет речей, iPhone+1, гейміфікація, соціалізація та продемонстровано, як ці технології забезпечують ефективну IT-підтримку процесів інноваційного підприємництва в провідних компаніях світу на основі комплексного та цілеспрямованого аналізу навколишнього середовище та формування знань про це середовище у вигляді об'єктів: фактів, понять, знань і відносин між об'єктами і множинами об'єктів у цифровій економіці; автоматизованого та автоматичного розпізнавання штатних ситуацій за допомогою класичних методів, і позаштатних, за допомогою використання образів конкретних виробничих, економічних, фінансових ситуацій, що виникають на підприємстві.*
*Проаналізовано підходи до вдосконалення діяльності інноваційних підприємств на основі застосування інтелектуальних інформаційних технологій, визначено особливості розбудови розумних об'єктів цифрової економіки та запропоновано концептуальні положення щодо створення розумних підприємств у цифровій економіці та їх IT-підтримання.*
***Ключові слова:*** *цифрова економіка, цифрова трансформація, інформаційно-комунікаційні технології, інформаційна система, розумне підприємство.*

**Introduction.** The most important global trend in the formation of modern society is the transition from an industrial to a digital economy based on intellectual information resources and knowledge-intensive information technologies [1, 2].

Today, innovative sectors of the new economic structure play a decisive role in the economic development of almost all countries of the world, as evidenced by the growth of annual turnover in the world market of high technology and high technology products, which is several times higher than the turnover of the raw materials market, including oil, petroleum products and gas [1, 3].

The term *digital economy* is used to determine the type of economy in which information technology, human capital and information resource play a decisive role.

The digital economy is the result of the transformational effects of new general-purpose technologies in the field of information and telecommunications. It affected all spheres of socio-economic activities, in particular the spheres of production, transport, trade, finance, public administration, education, healthcare, etc., which resulted in qualita-

tive transformations far beyond the field of information and communication technologies.

The digital economy is based on new methods for generating, processing, storing, transmitting data, and digital computer technology, and incorporating such concepts as the Internet of Things, Industry 4.0, the smart enterprise, the fifth communications network generation, engineering services, logging and others.

Intellectualization of the economy as a factor regulating industrial and social relations in society is connected with the development of institutions that provide the fields of production of knowledge (science), reproduction of knowledge (education), preservation of knowledge (culture) and the dissemination of knowledge (information). The indicated institutes should have the necessary support from the government and society and be focused on the possibility of participation in economic activities related to the production and consumption of products, satisfaction of the necessary material and spiritual needs of the person, etc.

The study of the regularities of modern socio-economic development and the development of the digital economy by leading researchers from Europe, the USA, Japan, Canada, China, South Korea and other successful developing countries contributed to the development of practical policy recommendations in the field of economic policy aimed at stimulating innovation activity on the macro- the micro-level, innovation management, the implementation of state structural and scientific and technical policy, the creation of special innovative institutes to ensure scientific and technological progress, which give competitive advantages for these states in various fields [3].

The countries that are most dynamically developing in recent years have focused on the development of information and communication technologies [4]. Due to this, only in recent years achievements in the fields of informatics, mathematical and computer methods, software, network technologies, microprocessor systems provide 75% of the success of innovation entrepreneurship [4].

However, the problem of ensuring high efficiency of management remains relevant, since solving the problem of effective management in the conditions of turbulence of economic development, incompleteness of information and risks, which is characterized by the modern business sphere, is difficult enough. To solve this problem, it is expedient to use modern information and communication technologies that will allow managers in real time to allocate and control knowledge for making decisions from the streams of large amounts of data of enterprises and organizations.

**The purpose of the article** is to study developing of information and communication technologies in the digital economy.

The achievement of this goal has necessitated the formulation and solution of the following tasks:

– analyze current trends of economic development,

–investigate the role of information and communication technologies in new economic relations,

–identify approaches to improving the activities of innovative enterprises through the use of intelligent information technology,

– develop conceptual provisions for the creation and IT support of smart enterprises in the digital economy.

**The main material.** Today, the development of the digital economy is influenced by the concept of digital transformation Industry 4.0, which implies the active integration of cyber-physical systems (CPS) into production processes and the creation on this basis of smart enterprises and other smart digital economy objects [5, 6].

CPS is essentially a comprehensive term used in conversations about the integration of small Internet-connected machines and human labor. Managers of enterprises not only rethink the principle of the assembly line, but also actively create a network of machines that will not only produce goods with a smaller number of errors, but also be able to autonomously change production templates in accordance with need, while remaining highly effective.

One of the most significant aspects of the fourth industrial revolution is the idea of *service-oriented design*. It can range from users using factory settings for manufacturing their own products, to companies that supply individual products to individual consumers. The potential of this type of production is quite huge. For example, the connection between the smart products of the Internet of Things and the smart machines that produce them, that is, this Industrial Internet, will mean that they will be able to produce themselves and determine the target production depending on the needs defined by them.

Experts attribute the leading trends of recent years and the future development of socio-economic relations with such types of technologies: Cloud computing, Cloud Technology, BigData, Self-service technology, Internet of Things, iPhone +1, Gamification, Socialization, etc.

However, 90% of the information that mankind has to date has been received over the past two years, and around 80% of this information is unstructured. This explosive information development with regard to customers, the environment and the interaction of people among themselves (as well as business entities) is accompanied by

some of the negative trends that were encountered by executives and top managers of enterprises:

– one of the three executives makes a decision based on information that it does not trust or simply does not,

– one of the two executives states that they do not have access to the necessary information,

– 83% of managers say they perceive business analytics as a competitive advantage,

– 60% of chairmen of the board of directors need to accelerate the processing of information in order to make balanced and optimal managerial decisions [7].

The ongoing digitalization of the global economy, the permanent trends that accompany its further transformation from the humanities into the precise sciences, the transformation of the innovation and information economy into the digital economy, allows us to assume that the importance and significance of the above issues and tasks will only increase. And one of the main tasks that arise in this regard lies at the crossroads of the three components that form the innovation and information policy of a modern enterprise: the information flow at the input, which is represented as a big data set (BigData), directly to the actual flow for transformation, formation, storage, analysis and further use of information (Business Analytics) and optimal and effective decision-making process (Decision-Making Process). At the same time, the possibility of transferring existing accents from the critical managerial level, the basis of intellectual resources, the human resource as the leading carrier of knowledge provide the multivariable enterprise development with supporting of information and communication technologies [8].

The development of information and communication technologies that will accompany the technological layout of 4+ requires some optimization, which includes some flexibility and dynamism, and also meets the time criteria for the fastest processing of input and process information and, as a result, the adoption of optimal and reliable managerial solution with the simultaneous reduction of the time lag from the beginning of the information cycle. But, at the same time, these features and principles have a contradictory character:

– *accessibility/openness* vs *security/fault tolerance,* in this way the information system must combine certain levels of access, flexibility and transparency, and at the same time provide guarantees of security and security by many criteria,

– *scalability and dynamism* vs *continuous optimization of the time interval of the corresponding reaction and adaptation of the infor-*

*mation system to urgent transformations*, which must be consistent with the global dimensions of the information system,

– *compatibility of globalization and privacy* vs *the observance of the optimal proportionality between the processing of personal queries while taking into account the global and large scale in the design of information systems of business entities*, since each company, in the ideal sense, is the subject and the bearer of world and national social, political and economic relations.

Taking into account the new features and actual principles of building information systems and enterprise management systems (especially for ERP-systems of the new generation), the next driver for information development of enterprises will be the use of artificial intelligence in their activities: from more serious developments, such as WATSON from IBM , outstanding works of robotics from Boston Dynamics and other manufacturers, autopilots from Google and Volvo, copiers from Amazon to deliver products, not to mention such fast-growing areas as BigData, bioinformatics and robotics.

Service-oriented designing of modern information systems is based on the application of intelligent information technologies supporting business processes of enterprises and organizations, which provides a flexible automation system with the presence of a wide range of functional blocks with distributed intelligence for IT support of high-performance functioning of modern innovative enterprises and organizations and the development of the digital economy.

The basis of distributed intelligence, including intelligent distributed technologies of different levels and purposes, are two interrelated concepts:

– *Ubiquitouscomputing/Pervasivecomputing* due to the total distribution of cheap miniature mobile devices, wireless networks, satellite navigation cloud computing and storage of information,

– *Ambient Intelligence (AMI)* which refers to the electronic computing information environment in which images of surrounding objects and processes are created that actively helps decision makers of innovative enterprises to take effective management decisions.

In the process of organizing support for the activities of enterprises and organizations, depending on the goals set for it, various situations arise and are resolved: production, logistic, informational, economic, financial, legal. The effectiveness of resolving these situations is directly related to the success and effectiveness of the enterprise in the digital economy.

The trend of today's development of the digital economy is the transition to smart enterprises. The transition to a smart enterprise in-

volves digital detailing the information that determines most of the elements of the enterprise's activities, and raising the level of enterprise management using mathematical models and algorithms. This allows you to perform technological processes as accurately and accurately as possible, use robotics and control, before individual operations, the performance of all work, eliminating the smallest discrepancies when performing individual operations specified in the technology. In addition, the comfort of work of the staff is increased, its problems are analyzed and taken into account, the degree of interaction between the enterprise and the staff is increased.

According to the definition given by the authors in [5], a *smart enterprise* (SE) is a flexible automation system with distributed intelligence of industrial automation, which in the complex causes effective functioning and life support of the enterprise.

In order to detail the view of the work of SE in the digital environment of the information community, we consider the main elements that determine the occurrence of certain situations related to the activities of the enterprise. Such detailing will allow moving from general definitions and representations to specific modeling, and then to algorithmic processes associated with the creation and operation of SE.

Production situations are directly related to *business processes* (BP) in an enterprise. BP includes the implementation of production operations defined by technologies that are implemented at the enterprise, management of resources that ensure these operations, the work of the staff and the provision of these personnel with the necessary resources — supporting the working conditions of the equipment and personnel, determining economic indicators, information calculation of the necessary indicators that form the enterprise model. For BP, performed with the interaction of various organizational structures of an enterprise, the logistical, organizational, economic and financial components that characterize the operation of the enterprise are essential.

For ease of analysis and search for the appropriate solution, the economic and financial components included in different BPs are separated from these BPs and combined into single situations that use additional methods of analysis and search for solutions in their management. Thus, these components are analyzed and used at two levels, the BP level and at the situational level of the enterprise.

We have a similar situation when considering the logistics component of BP, which is considered at the *BP level* — providing resources to individual departments of the enterprise, and at the *enterprise level* — providing resources, selling and selling products manufactured at

the enterprise. The logistic situation also includes marketing activities related to the sale and supply of products.

The *information situation* is defined by arrays and storage of all data collected at the enterprise, simultaneously with external data provided by global networks and the Internet, the operation of hardware and software, computer networks, cloud storages, knowledge bases. The informational situation also includes: its analytical component, determined by the intellectual analysis of data, the forecasting component, on the basis of which the predicted performance indicators are determined.

Under the influence of digital transformation of enterprises, the solution of production situations is constructed as follows:

– business processes developed for product launch are automated based on the universal use of digital and imaginative information technologies in relation to all the components of these processes — personnel, equipment, resources used to support processes,

– the organization of work maintains a constant viable state of the enterprise (repair, modernization, customer and supplier orientation, technological compliance, technical support, innovative state, information model) as functional units of the enterprise that support production processes,

– support of the production process by the results of the work of interrelated auxiliary processes: accounting, analytics, management, relations with resource suppliers and consumers of products within SE,

– providing technology support (equipment, personnel, information, management) of their means of implementation, analysis of risks associated with the operation of equipment,

– embedding links between design, technology and production units in relevant business processes.

Similarly for SE, all other possible types of situations characterizing this enterprise and arising in the course of its operation are considered. The situations themselves are not independent, since they are interrelated and have a significant impact on each other.

The resolution of *logistic situations* in the SE is as follows. The main logistic components are distinguished. These are procurement and sales logistics, transport and warehouse logistics. There is information logistics, but for a smart enterprise it relates to a general information situation and is considered in this context.

For purchasing and sales logistics, a significant role is played the fact what type of enterprises does the SE interact. If these are ordinary enterprises, then logistics is considered in the usual form, and addi-

tional functions arise only at the level of transport and warehouse logistics. If the SE must coordinate its actions with other smart enterprises, then problems arise in the interaction of the information models of these enterprises. So, these tasks are closer to the corporate level.

The transport and warehouse logistics of the SE form part of the logistic situation in which:

– using individual observation of incoming material resources, algorithms are created for optimal distribution, storage and use of resources in all business processes carried out at the enterprise,

– the warehouse logistics of the SE allows for the active use of robots to support the operation of warehouse complexes,

– due to the individual informational presentation of the necessary parts, components and resources, the processes of accumulation, support and use of reserves to ensure BP change; mass gives way to individuality,

– the transport links can fit directly into BP, and transport logistics can be integrated with the manufacturing process.

Therefore, we can talk about intelligent logistics, which is part of the overall operation of the SE.

The basic intellectual role in the work of the SE is played by the informational situation, which ensures the transition from a regular enterprise to a smart one. Information technology creates the necessary additional resource that increases the level of intelligence that controls the processes embedded in the SE. Collecting, coordinating, describing, analyzing and using the information component of SE (providing processes for solving information situations as an internal and external basis of SE) is the basis for building a model of a smart enterprise. The information component, including technical and software, serves as a tool that forms a new information view, both on the enterprise itself and on the processes occurring in it. And the processing of information by this component determines the method of influence on the material structure of the SE.

The formation of the information model of the SE is determined by the collection and processing of information that the SE receives from all the components of the structure constituting the SE (information elements):

– personnel (current status and performance indicators),

– production equipment (condition, use, possible risks of failure, the need for modernization, repair),

– availability of all necessary resources for technical equipment (electricity, water, materials, components, personnel, management computers, network communications),

– component of the plan for ensuring the loading of work personnel and equipment,

– analysis of the state of the SE, analysis of possible risks, analysis of the backup capabilities of the SE at the moment,

– analysis of the quality of resources used and their compliance with new technologies,

– forecasting expected deviations and malfunctions associated with changes in the external and internal conditions of the SE,

– inclusion of trainee components in the information model as an integral part of the development of the enterprise's intelligence,

– assessment of the effectiveness of the SE and the reduction of material costs of production, in the context of the modernization of the enterprise, the use of new technologies, changes in the conditions of production of SE,

– assessment of product compliance with state requirements and standards,

– a program for the psychological mood of the workshop staff and its preparation for possible permanent changes at the technological and social level. This program is carried out on the basis of an analysis of the current state of the personnel and embeds a "smart enterprise" into the modern conditions of constant changes in materials, resources, technologies, equipment, and the development of requirements for the qualitative characteristics of modern products.

For technical support of the information situation of SE, the following is required:

– sensors of various types, which are installed on all information elements and are combined into local networks,

– analyzers, routers, computers,

– networking hardware, including network cards for computers,

– wired and wireless network equipment,

– sensors for the structure of the workshop (including technological equipment — machines, cranes, presses; auxiliary equipment — electric vehicles, loaders, platforms, means of moving products; computers and network equipment; robots and robots; premises),

– sensors for personnel (workers, employees, managers, support staff),

– sensors for process components (blanks, parts, components, consumables, including processing tools used in technological processes),

– sensors for the logistics component, along with the internet of the necessary resources,

– technical information equipment of power supply and equipment, intrashop transport,

– technical information equipment of warehouses and storerooms, their maintenance facilities,

– sensors for security and monitoring of the status of the SE.

The various divisions of the SE are equipped with local area networks that accumulate and process information related to these divisions. If necessary, this information can be stored in cloud structures. It depends on the amount of information and its forms.

*Economic, financial, legal situations* for SE basically coincide with similar situations for ordinary enterprises with the difference that economic and financial information can additionally be used to train an analytical intellectual system that analyzes the specific nature of this information and its relevance to the goals and objectives that are placed in front of the SE.

In addition, a new level of control, which is associated with the use of robotics and the availability of measuring equipment at all stages of the technological process, allows us to improve the quality of the manufactured product and its competitiveness. And the increase in quality is reflected in the economic indicators of products and its prices. There is a concept of a brand with additional value, which, when sold on the market, adds to the cost of production. An example of this is Apple Inc. products for which prices are significantly inflated compared to the cost of the product itself [9].

The economic and financial analysis of the SE should confirm the strategy and tactics that the SE management has chosen to achieve its goals. For analysis, you can, for example, use software tools that Microsoft SQL Server offers for data mining. Although the problem here is related to the choice of information that must be processed by analytical programs. The problem of the choice of information from the Big Data information model obtained in the information model and the desired directions for analyzing this data generally applies to the entire SE. Here is an additional resource for increasing the efficiency of the SE.

Consequently,the process of digital transformation of enterprises, the creation and development of smart enterprises in the digital economy involves creating a detailed SE model for the manufacturing industry, defining the requirements for production information and information and communication technologies to support production processes, as well as developing appropriate models and algorithms for processing and information analysis. Such a model can serve as a basis for creating technology for the subsequent transition from existing enterprises to smart enterprises in the digital economy and increasing their productivity through the use of modern information and communication technologies.

**Conclusion.** For the purposes of joint development of information and communication technologies in the context of the development of the digital economy, subjects of economic activity seek to share knowledge, exchange experts, jointly develop and apply innovative digital technologies that contribute to digital transformation in the world transborder economic space.

The leading trends in the development of information and communication technologies in the digital economy are Cloud computing, Cloud Technology, BigData, Self-service technology, Internet of Things, iPhone +1, Gamification, Socialization, etc. These technologies allow to provide effective IT support to the processes of innovative entrepreneurship on the basis of integrated and purposeful analysis of the environment and the formation of knowledge about the environment in the form of objects: facts, concepts, knowledge and relations between objects and sets of objects in the digital economy. ; automated and automatic recognition of regular situations using classical methods, and freelance, using images of specific production, economic, financial situations that arise at the enterprise, etc.

The development of information and communication technologies to support enterprises and the development of smart enterprises in the digital economy is aimed at improving the ability to automatically recognize the images of specific production, economic, financial situations in the defined processes, and based on this, to make effective decisions and improve quality. work with incomplete information in conditions of uncertainty for finding optimal managerial decisions.

Thus, information and communication technologies are the most important component of the development of the digital economy, which requires the active development of this area of research.

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