

Stages of Formation of the Digital Environment of Modern Cities

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ABSTRACT

The purpose of this study is to structure the stages of digitalization of urban space. The research method is a systematic logical analysis of the various stages of digitalization and the development directions of modern cities. Four stages of urban development are distinguished, their significant differences in the context of digitalization of the urban environment are shown. The main difference between the post-industrial type of cities is the use of advanced digital technologies for the most efficient organization of economic activity. It is shown that the stages of digitalization of the urban environment are nested sets, each of which includes other technologies and socio-economic models of interactions. It is concluded that the development based on digital technologies is one of the most effective areas for solving the problems of modern cities.

Keywords: *industrial city, informational city, digital city, smart city, urban ecosystem, development stages*

1. INTRODUCTION

The development of industry that took place in a number of countries in the 18-19 centuries formed new principles for organizing socio-economic systems at various levels, starting the processes of rapid growth of industrial cities. The main result of the organization of production in the form of large factories was the relocation of the population from rural areas to newly created industrial cities, the transformation of agricultural into an industrial society. The main features of this period are considered the explosive growth of productive forces based on the formation of the machine industry, as well as the transformation of economic relations based on capitalist principles. Industrialization was not only the moment of introducing innovations into the production process, but also a change in the entire social structure. Such changes in the economic model of a number of states were accompanied by a sharp increase in working efficiency, rapid urbanization, and the beginning of rapid economic growth. Significant changes took place in territorial development, the industrial city became the main center of the economic and social sphere, as the most effective form of organizing the settlement of people of the industrial era. A new stage in the development of technology, the information and communication revolution that took place in the middle of the 20th century, gave a new impetus to the development of socio-economic systems, determining the development trends of most cities around the world. With the development of digital technology, real-world objects are becoming more intelligent, highly efficient and environmentally friendly. The use of digital technologies allows planning and forecasting, as well as the

management of socio-economic and technological systems at a higher level [1]. One of the promising areas for the use of digital solutions is their application in the framework of the development of the urban environment in order to form a single digital space of modern cities [2].

Based on innovative solutions in the field of digital technologies, modern cities are becoming more comfortable for living, and the urban community is more united in solving public problems. The technological drivers of this development are intelligent digital systems, such as cloud computing, data warehouses, social networks, which act as tools for creating balanced socio-economic systems. Modern cities are complex socio-economic systems that face increasing challenges in the social, economic and environmental fields. Sustainable development and quality of life are important tasks for modern cities. Residents of large cities are increasingly facing special needs in areas such as healthcare, education, quality infrastructure and a safe environment. These aspects of the urban environment are increasingly supported by modern digital solutions, specialized Internet applications, sensors and embedded intelligent systems, as well as infrastructure based on digital platforms [3]. In such conditions, modern cities are faced with a number of problems in maintaining and updating the necessary infrastructure and creating effective tools for implementing projects in the field of digitalization of the urban environment. In this context, cities represent an innovative environment that, on the one hand, generates demand for modern digital innovations, and on the other hand, offers modern digital experiments in an open and user-oriented environment. Therefore, an increasing number of cities are developing plans to create their own

digital environment, combining existing infrastructure, digital services, and other digital innovations [4]. Based on technological capabilities, cost and benefit estimates from the implementation of a project, cities must develop priorities for effective solutions that meet strategic goals related to economic and social development [5].

Despite the significant number of publications on digitalization of the urban environment, there are currently a number of issues that need to be studied. One of these issues is the identification of stages in the field of digitalization of the urban environment and their impact on urban development. Thus, the purpose of this study is to structure the stages of digitalization of urban area.

2. METHODS

The object of research in this article is the modern concept of digitalization of the urban environment in various manifestations of economic activity. The subject of this study is economic relations that are forming in various areas of the economic application of digital technologies in modern cities. The analyzed data are scientific studies reflected in the periodical press, as well as the author's results as part of the study of the digitalization processes of modern cities. The research method is a systematic logical analysis of the various stages of digitalization and the development directions of modern cities.

3. RESULTS

The experience of digitalization of the urban environment and the development of modern cities shows that this process is connected with the passage of a number of stages. In our study, we identified four stages of development of modern cities: industrial city, digital city, information city and smart city [6]. Let's consider them in more detail.

Industrial city. From our point of view, the industrial city is the basis for the formation of a concept for digitalization of the urban environment, since on the basis of the infrastructure existing within such an economy, digital technologies are subsequently introduced into various spheres of the economic life of the urban system. Thus, the cities of the industrial era are the basis for most modern cities. The industrial revolution that has taken place in the leading states of the world and the processes of industrialization accompanying it have had a significant impact on the principles of functioning of urban households. One of the most characteristic features of the industrial era is that for the first time in the history of mankind it closely linked the introduction of technical innovations with economic efficiency.

Further events and technological, economic, social, and political transformations were not long in coming and fully reflected on the principles of urban structure. Among the most important features, the emergence of a factory system and the organization of urban space around large industrial

factories or factories, increased attention to innovations and their introduction into production, a high concentration of resources in a limited area, and an increase in the number of urban population can be noted. Industrialization processes directly affected the economic and spatial structure of cities. The main function of industrial cities becomes the industrial function, thereby transforming cities into industrial factories, concentrating for this in one place all the necessary production resources. Thus, the industrial stage of urban development can be characterized as a type of settlement of people, the development of which takes place in accordance with the basic socio-economic laws of industrial society, the economic basis for development is production, the mass introduction of machinery as a means of production, and production activity is aimed at creating technical - technological innovation. It is worth noting that the urban infrastructure formed at this stage, as well as the socio-economic characteristics of the urban environment, are an important factor in the transformation of urban space in the framework of the formation of modern society.

Information city. In the second half of the twentieth century, the world entered a new stage of its development, associated with qualitatively new phenomena not only in the production sphere, but also in the social sphere. Among the main characteristics of this stage of the development of mankind, one can single out such phenomena as the transformation of science and its product-knowledge into one of the factors of production; the acceleration of the use of new technologies in various fields of human activity, the growing demand for new technologies and their cost; the birth of the information revolution; changes in the structure of employment and improving the quality characteristics of the workforce. The third scientific and technological revolution created the conditions for the transition to a post-industrial society, where the main factors of social development were science in general and computer science in particular, as well as the growth of the services sector. The most important condition for the development of production in such conditions is a careful attitude to all types of resources, the organization of production is based on resource-saving technologies. Significant changes are taking place in the structure of employment in large cities. In the era of informatization, the number of people employed in traditional sectors of the industrial era is reduced and the share of people employed in high-tech industries is increasing. Among the main innovations of this stage, which significantly influenced the further development of society, were television, transistors, computers, integrated circuits, communication satellites and other communication technologies, microprocessors, significant distribution of the Internet. Such changes in the social and technological spheres could not but affect the development of cities. One of the most noticeable features of this stage of development, manifested within the limited space of cities, is the acceleration of economic processes and the increasing value of the time component in the face of increasing competition. Due to the fact that information and communication technologies are widely used as part

of the activities of economic agents, the speed of data exchange between them has significantly increased and the cost of their interactions has decreased. We can say that during this period, information and communication technologies became the basic technologies for the development of most areas of economic activity, influencing the social aspects of social structure, economic relations, production costs and other issues, becoming the object of socio-economic research and the emergence of such a scientific direction, like a digital economy.

At the end of the 20th century, the fundamental architecture of the global Internet was formed, the HTTP hypertext transfer protocol was developed, HTML syntax, the first web browser, URL-based global addressing was organized, the first web servers and first web pages began to appear. A little later, an institutional framework for the development of a global network was founded. The World Wide Web Consortium (W3C) was created to monitor Internet environments and develop web standards. By 1996, the global Internet network became a reality, and many economic agents felt the need for a presence on the network.

The first information cities based on the above technologies were static web pages providing information about the city in the form of text and graphic elements. Such information cities were a simplified model of the urban environment, the main task of which was to implement some of the functions of a real city via the Internet. At the first stages of the development of information cities, their main task was to inform about various events taking place in the city, about the services provided by city branches, and coverage of other aspects of urban space. The development of information cities resulted in the transformation of some urban activities leading to reconfiguration of the physical city, as well as the replacement of certain types of urban activities with new ways of functioning in the digital space based on the established information and communication infrastructure. The first generation of informational cities laid the foundation for the further development of the urban environment in the context of the formation of a digital society. By first providing information, and then laying opportunities for interaction between various stakeholders, information cities have formed a modern three-tier architecture of the digital space of modern cities, which includes technologies for integrating information, technologies for the participation of the population in interactions within the city's information space, and technologies supported by municipal authorities for interactions with citizens. In addition, at this stage, increased attention is paid to technologies that ensure information security, which becomes an important component of the information space of cities. The main idea, implemented as part of this stage, is to visualize and virtual simulate the physical objects of the urban economy. *Digital city.* A new stage in the development of information and communication technologies, an increase in the capacity of communication systems, and the development of open-source software products have significantly transformed the information landscape of

cities [7]. A stack of technologies, including the PHP programming language, the Linux operating system with e Apache web server, and the MySQL database formed a new idea for developing an Internet environment called Web 2.0. The concept of Web 2.0 presented the prospect of cooperation and sharing of various benefits, both virtual and physical, laying the foundation for the formation of a sharing economy. In many ways, the concept of Web 2.0 can be seen as social rather than technological innovation. The network has become an environment in which users interact and collaborate, exchange information, join forces, create virtual communities. The transition to web-based, highly user-driven participation has begun to spread with the advent of wikis, blogs, social networking sites, media sharing, web applications, mashups, and other collaborative web applications. The most important transformation of the information environment of socio-economic systems, including cities, was that from a simple consumer of information, users became the creators of a huge amount of data in the form of content hosted by information resources implemented within the framework of the Web 2.0 concept. The increase in the number of data circulating in the information space has contributed to the formation of a new development paradigm. Such data in digital format began to be considered as a resource for socio-economic development, improving the quality of management of systems at various levels. Digital data has become the subject of economic relations, forming a digital economy.

Another feature of this stage is the development of digital platforms in various areas of public life [8]. The creation of more end-user-oriented digital products has simplified user participation in shaping the digital urban environment. Such areas as city-wide portals began to develop actively, where residents could coordinate efforts to solve significant problems, and social groups uniting residents of certain areas. In addition, services for the provision of municipal services in electronic form began to develop. In general, it can be noted that the development of such applications is an effective and inexpensive way to improve the quality of management and self-organization at the local level. This type of city better imitates the fundamental concept of the city as a social space of cooperation. Thanks to the development of digital infrastructure, the involvement of all interested parties in solving city-wide problems and joint work takes place in the digital, and not in the physical space. The key concepts for a digital city are crowdsourcing and outsourcing.

Crowdsourcing is an example of mobilizing people's resources through digital technologies in order to solve the problems facing business, the state and society as a whole [9]. Municipal authorities use these practices to attract intellectual resources to solve urban problems. Crowdsourcing can be applied in many different ways, including the development of goods and services; generating ideas and solutions; in marketing and advertising companies. The most common approach for involving the urban population in the development of management processes is to obtain feedback through social networks [10]. These are the main driving forces of

innovative development that determine the combined intelligence of the city as a community. One of the features of this stage of development of the urban environment was the organization of living labs and other forms of innovation, focused on people, which significantly expanded the rights and opportunities of users when developing new solutions [11].

Smart city. A new round in the development of digital technologies, intelligent systems and wireless communications has marked a new set of technologies for creating a digital space of cities [12]. Technological innovations that have emerged have made it possible to expand those areas of the urban economy where digital technologies have begun to be applied. In such conditions, a new infrastructure of the city's digital environment began to take shape. The first level includes various kinds of sensors, counters, allowing to accumulate data. The second level is a means of data transmission, network communication technology. At the third level, intelligent software products and applications are used to predict and model various situations for making more informed decisions. The development of modern cities through the introduction of intelligent digital technologies has formed into the concept of a smart city [13].

A smart city as a model of the digital eco-environment embedded in the physical space of cities is associated with a new set of technologies, devices and applications that provide universal access to data and the Internet. In this regard, smart cities are becoming part of future research in the field of digitalization and its impact on socio-economic systems in various aspects and manifestations. The most important characteristic of this stage of development of the

urban environment is the attention to the data that is generated as part of the functioning of urban systems. As part of the smart city concept, attention is shifting from technological aspects to the data area. The important data-related aspects are emerging, such as on-time delivery, real-time processing, and other aspects. A combining data with new technologies forms open innovative management models, solutions and services for citizens. The continuous evolution of web technologies from a static Internet to a social network, a real-time network, a semantic network, and, ultimately, an intelligent network, significantly expands the possibilities of building a digital space of cities [14]. An increasingly complex landscape of technologies, applications, data, business models and electronic services is emerging that far exceeds the managerial potential of municipal authorities. How to use the potential of digital technologies in improving the quality of urban environment management, how to preserve the value of investments within short innovation cycles, since each wave of web technologies ultimately makes previous digital solutions obsolete, and other issues related to digitalization of the urban environment are relevant in the process of forming a digital economy.

The considered characteristics of various types of cities allows us to highlight some features that must be taken into account in the management of modern cities (table 1).

Table 1 Some stages of urban development

Type of city	Description
Industrial	The main element is the conveyor type factory production, industrial production prevails, around which cities are often formed. An important role begins to play scientific activity as a factor in increasing the efficiency of production activities. The management system is dominated by administrative management methods.
Informational	Information is one of the most important resources of socio-economic development, the use of this resource by means of information technology is an important factor in competitiveness. Vertically integrated structures in such conditions are replaced by horizontal network structures. In the urban economy, a tendency is being formed to automate production and implement information technologies in various processes, traditional industrial production is being replaced by the service sector. The Internet is the most important technological innovation that forms the information space of cities.
Digital	Digital technologies penetrate deeper and deeper into various socio-economic spheres, education, medicine, management and other areas. Agent interactions are moving from the physical environment to the virtual space based on social networks, digital platforms, virtual environments. Digital data from various sources in an unstructured form is becoming a critical resource for development. Qualitative development in the field of data processing and transmission technologies has become the driver of the development of digital cities. PHP programming language, Apache web server, MySQL database, as well as data transfer systems have expanded the possibilities of using resources in urban development.
Smart	Social interactions are often replaced by the interaction of devices and mechanisms, excluding human participation. Decision making systems are based on the analysis of data on the means of machine learning, neural networks. Most urban operations are automated and do not require human intervention. A new stage in the development of digital and communication technologies has allowed us to form a technological basis for the interaction of devices. The main technological innovations of this stage are associated with the development of artificial intelligence, neural networks, and cloud technologies.

4. DISCUSSION

The development of a strategic view of the digital environment of modern cities may give some answers to the choice of investment projects and technologies. Currently, there are three main principles for managing the introduction of digital technologies in the urban environment as part of the development of the concept of smart cities.

The first principle is related to the development of a culture of exchange and cooperation. This approach involves the use of free open source software and collaboration with the community of developers focused on the development of free software. Open source applications are most effective for use in the digital space of modern cities, since they do not require development costs. Significant savings are also achieved through the use of modern cloud technologies, which represent significant advantages in cost and service. In addition, sharing cloud solutions and data is much simpler and more efficient.

The second principle concerns the digitalization strategy of urban space. In the rapidly changing conditions of the modern world, socio-economic and technological changes, it is necessary to more clearly analyze the prospects and track changes in the digital urban environment. Tools such as benchmarking, analysis of the activities of other communities and cities, the study of the factors of their success and failure can significantly contribute to reducing risks in the process of implementing projects to digitalize the urban environment and create a digital society. The value is represented by studies of a long period of time that can track certain trends and patterns of digitalization processes, as well as evaluate alternative business models to increase its effectiveness.

The third principle of creating a digital environment of urban space is that low-cost solutions should act as the basis for digitalization to minimize investment and thereby provide a more secure strategy for the introduction of digital technologies. The main areas in this case include the use of existing software in cases where it is possible, as well as implement complex solutions in stages, acting in small steps and minimize costs. Developing applications from scratch in such conditions is the last resort and applies only in cases where there is no other solution. One of the important tools for the development of the digital environment is the development of standards in this area that will accelerate the diffusion of technologies, facilitate their large-scale implementation, and reduce barriers to training in the field of digital technologies. Sharing software products, using existing and proven solutions, accessing open source code and using cloud technologies, standardizing digitalization processes are the basis for solving the problem of creating a digital space of cities.

5. CONCLUSIONS

In this study, with the aim of identifying the main stages of the transformation of the urban environment in the context of the digital society, the following results are obtained.

Firstly, the work shows that one of the most important factors in transforming the urban environment is digital technology that affects various aspects of the socio-economic activities of people.

Secondly, the main stages of the development of the urban environment in the context of the formation of the modern theory of digital society are considered. The main stages of urban development such as an industrial city, an information city, a digital city, a smart city are highlighted. Thirdly, the essence of these stages of development is shown. The main difference between the post-industrial type of cities is the use of advanced digital technologies for the most efficient organization of economic activity.

Fourth, it is shown that the stages of digitalization of the urban environment are nested sets, each of which includes other technologies.

The identification of the stages of the application of digital technologies in the framework of the development of the urban environment provides an opportunity for researchers to formulate future focused research in the field of the economy of the digital society.

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