The object of research is the concept of a smart city. The study considered the problem of interaction between local authorities and citizens in a smart city based on a platform approach. It was determined that the human-centric concept of a smart city involves representing the functions of the city government in the form of specific public services, the purpose of which is to satisfy the needs of citizens. Public participation and active citizenship are recognized as a key component of smart city development. The mechanisms of public participation in the smart city include information, consultations, discussions, public control of finances and joint funds. Multiple digital communication channels, including social networks, instant messengers, websites, e-mail, and various platforms for citizen appeals, could be used simultaneously to communicate through these mechanisms. This leads to a decrease in the effectiveness of interaction. As a result, information related to active public participation on official city websites is fragmented and often out of date. The scalable digital platform serves as a single environment for the exchange of information and resources between citizens and authorities and helps reduce the time and resources spent on organizing such communications. An example of the development of a digital service on the blockchain is given, implemented in the Bitbon decentralized information platform of Ukrainian origin. The practical application consists in ensuring broad citizen participation in filling funds and monitoring their financial transparency. The results of the implementation of platforms for the development of smart cities are organizing open data, encouraging stakeholders to participate in city management, developing innovative creativity and open dialog

Keywords: smart city, public participation, post-war reconstruction, digitalization, digital platform, blockchain, tokenization

DESIGNING A PLATFORM-BASED MODEL OF CIVIC PARTICIPATION WITHIN THE SMART-CITY CONCEPT FOR POST-WAR UKRAINIAN CITIES

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1. Introduction

Overcoming such challenges as the decline of basic and even traditional branches of the regional economy, unemployment, uncontrolled urbanization, increasing crime, environmental pollution and degradation, devaluation of local identity, is the basis of urban planning concepts. Improving the quality of life in cities and regions is reflected in the resolution of the UN General Assembly [1], which approved the goals and objectives of sustainable development until 2030. In particular, the sustainable development of cities and communities involves ensuring the openness, safety, vitality, and ecological sustainability of cities and settlements [1]. In the last ten years, a common approach to achieving this goal has been the urban planning concept of the smart city.

Industry 4.0 technologies such as information platforms and blockchain, the Internet of Things, smart devices, virtual reality, and artificial intelligence cover an ever-increasing area of people's lives and change their way of life. The devel-

opment of technologies gradually leads to the fact that the entire life of a person fits into a pocket, which is expected to reduce the burden on the environment and contributes to the development of a conscious attitude of a person to life. As a result of the combination of breakthrough digital technologies and ideas of sustainable urban development, the concept of a smart city emerged. It involves the use of information and communication technologies for the management of urban infrastructure in order to solve social problems within the framework of a multilateral partnership between citizens, businesses, and authorities. Accordingly, the goal of creating a smart city is to improve the quality of life of its residents with the help of digital transformation of the management of such areas of the city economy as transport, education, health care, housing and communal infrastructure, security, etc. Therefore, this transformation reflects fundamental technological changes in the urban infrastructure, ecosystem, services, systems and institutions of urban management, lifestyle.

The concept of a smart city does not imply replacing social development with technological re-equipment of urban space. A key feature of the concept is the direct participation of people in the processes of city governance and, in particular, urban development. Another feature of the concept is increased efficiency due to joint use of property, which has become the subject of business attention. The owners of successful startups are convinced that the main consumer in smart cities are citizens, whose needs include living in ecologically clean and safe neighborhoods, energy-efficient houses, and the use of affordable and fast transportation.

Therefore, studying the models that ensure the implementation of the concept of a smart city is a relevant task.

2. Literature review and problem statement

In work [1], the goal was to determine the expected changes in the process of forming smart cities in Poland by the method of conducting focus groups. As a result of the study, a SWOT analysis matrix was formed, which grouped the key favorable and unfavorable factors, advantages and disadvantages of the development of a smart city. In work [1] it is substantiated that the main directions of development of smart cities in Poland are the following: smart and sustainable buildings and infrastructure; smart mobility; intelligent energy. Innovative health care and sanitation systems, innovation, urban planning laboratory, research and development, renewable resources, urban planning and affordable housing are recognized as the main enabling factors. Lack of citizen involvement, high cost of urban infrastructure, scarcity of resources, lack of planning, lack of vision and strategy, and technological backwardness are recognized as the main hindering factors. The main characteristic of technological solutions that are implemented within the organizational units of smart cities is their reasonableness. Smartness at work is defined as the sum of various improvements in the functioning of municipal infrastructure, city resources, and public services. This definition is debatable because not every improvement can be considered reasonable. In addition, the term of improvement itself needs additional clarification. This may be related to the generalizations adopted in work [1].

In [2], the emergence of smart cities is associated with governance in terms of creating public value and achieving a high quality of life in urbanized spaces. Therefore, the aim of work [2] is an in-depth analysis of the experience of initiatives to involve citizens in smart cities in Europe. Based on the results of the research conducted in [2], it was established that smart cities are becoming a source of initiatives to involve citizens in governance. That is, electronic governance models are relevant not only in the field of public administration but also in the theory of democracy. Thus, an integral attribute of a democratic state is a participatory society, and information and communication technologies provide expanded opportunities for such interaction, communications and democratic participation of citizens. However, work [2] emphasizes that in European smart cities, more attention is paid to social initiatives such as smart people and smart life, which are more understandable for citizens. In addition, governance models implemented in most smart cities are based on open participation. Such participation within the smart city means not only the involvement of citizens in the processes of state policy and decision-making but also in the development of services and their provision. At the same time, both in theory and in practice of smart cities, electronic participation platforms are used for these purposes. In addition to platforms, in scientific studies such information and communication technologies as mobile applications, sensors and devices of the Internet of Things, as well as open data are called the main tools of engagement. While in practice, smart cities, along with platforms, often use offline and personal methods of citizen participation, including meetings, seminars/conversations, and social and cultural events. However, the drawback of work [2] is the case study method, which subjects the research results. In addition, the analysis of smart cities other than European ones was not conducted, which also narrows the conclusions of the study.

Work [3] focuses on identifying the connection between e-governance and smart city initiatives by testing the hypothesis regarding their citizen orientation. It shows that electronic platforms serve to encourage citizens to participate in decision-making processes, improve the provision of information and services. This promotes transparency, accountability, and trust. Thirteen digital media platforms used in smart cities were investigated in [3]. At the same time, the smart city is defined as a tool for solving complex urban problems, such as increasing demand for resources, complexity of organization and management, traffic congestion, pollution and waste, poverty, unemployment, transport and crime. The approach that allows solving these problems within the concept of a smart city is the use of breakthrough information and communication technologies. They provide increased interactivity, quality and efficiency of city services by reducing costs and consumption of resources and improving relationships between government, citizens, and businesses. Based on the results of the research carried out in [3], it was confirmed that electronic platforms are an effective mechanism for increasing the involvement of citizens in governance processes. At the same time, it is shown that platforms provide two-way communication in this case. In addition, the platforms contribute to the accumulation of large volumes of information through engagement and interactive sharing, as well as improve urban planning. In addition, it is shown that platforms contribute to the development of personalized public services. The disadvantage of the work is the use of the case study method, which is explained by its review nature.

Article [4] examines the strategies of public involvement in the context of the development of smart cities on the example of Canada. It proves that local authorities use an approach that has developed historically and is based on limited interactions with city residents. At the same time, this article emphasizes that the concept of a smart city requires taking into account the opinions and feedback of the public through the use of innovative approaches. Accordingly, the cited article argues that governments should use technology to develop such more innovative approaches to public engagement in the context of smart city development. In particular, we are talking about digital technologies and a platform approach that allow developing a participatory system architecture. To analyze the levels of development of a smart city, the model "Spectrum of Public Participation" developed by the International Association of Public Participation (IAP2) was used in [4]. This model consists of five levels of involvement from the weakest civic influence to the strongest: information, consultation, involvement, cooperation, empowerment. The purpose of informing is to provide

the public with quality, balanced and objective information necessary for understanding problems, alternatives and/or ways to solve them. At the level of information, participation tools are web pages of authorities, open offices, and public reports. The consultation is conducted with the aim of obtaining feedback from citizens regarding alternatives and/or solutions. The tools of citizen participation at this level are focus groups, surveys, public meetings, and public discussions. At the engagement level, the goal is to work with citizens to ensure that suggestions and comments are taken into account in alternatives for final decisions. Engagement tools include workshops and advisory surveys. Cooperation as a level of public participation involves working together in partnership at each stage of decision-making when the authorities turn directly to the community for advice and new ideas for decision-making. The instruments of participation at this level are public advisory committees, consensus conferences, and participatory decision-making. Empowerment as a level of participation implies that the community directly makes the final decision, and the representatives of the authorities implement these decisions. The tools of participation at this level are a public jury, delegated decisions, ballots. The results of the analysis of Canada's smart cities based on the "Spectrum of Public Participation" model, obtained in [4], proved that public consultations mostly take place from top to bottom. Despite the citizen-oriented structure, the level of citizen involvement in the analyzed smart cities turned out to be lower than expected. Consequently, Canada's smart cities reflect a lower public impact according to the Spectrum of Public Participation model. The disadvantage of [4] is the limited range of smart cities, which narrows the results. Also, in [4], a model with vague criteria was chosen, which does not make it possible to formalize the obtained results.

In [5], it is noted that the city government is able to support and develop public-private partnership, involving public and private data custodians, citizens, and software developers. The partnership represents a departure from the hierarchical concept of smart cities and a growing interest in a horizontal governance model that defines the role of the city government as an administrator of data assets to achieve the city's strategic priorities. Therefore, paper [5] considers a platform approach to smart city management. The platform approach is represented in the work as an innovative way of city management, which involves the transformation of methods of interaction with external partners and citizens. The platform model of governance opens up the government mechanism to citizens, allowing the latter to collaborate with public officials to make effective decisions. In this way, openness and transparency of government work is ensured, replacing bureaucratic and centralized structures. At the same time, it is the government that must direct its efforts to overcome market failures and can set policy boundaries for promoting investment in services that correspond to the city's strategic priorities. Therefore, the innovativeness of the platform model of management is manifested through the rethinking of the role and structure of public institutions based on the digital transformation of public services. In work [5], the case study method was used to analyze the features of the platform application. As a result of the analysis, a typology of platforms for smart cities is proposed, which includes city information panels (info panels, dashboards), information showcases and information marketplaces. These platforms are called the supporting digital infrastructure of

smart city management. At the heart of this infrastructure is a series of socio-technical activities, cooperation forums, as well as technical and management issues that are discussed daily both within and outside city administrations. The shortcoming of [5] is its review nature, which may be related to the chosen research methods.

Similar in terms of issues is work [6], which examines the design of information panels as a tool for interaction between local authorities and citizens in the context of the principles of transparency and accountability. Information transparency through the use of information panels in smart city management is achieved by reducing information asymmetry, when one side of the relationship has more information than the other. Dashboards make it possible to visualize consolidated data sets for a specific purpose. As a result, users perceive information about the state of affairs in the city in a convenient format through the organs of sight or hearing, which allows the latter to make decisions and plan their actions. Thus, work [6] proves that information panels can be used by governments to support decision-making and policy processes or to communicate and interact with the public. On the other hand, information panels as a tool of interaction within the framework of a smart city have certain disadvantages. Among such problems, work [6] points to insufficient data quality, lack of understanding of data, poor analysis, misinterpretation, confusion about results and imposition of a predetermined view. These challenges can easily lead to misperceptions, poor decision-making, a blurred picture, resulting in less transparency and accountability, and ultimately even less trust in government. On this basis, the authors of [6] concluded that the principles of developing information panels for use in smart cities should be supplemented by mechanisms to support citizen involvement, data interpretation, and management. In general, work [6] has a practical nature and indicates problems in the functioning of information panels for traffic flow control in smart cities in Brazil. This is due to the limitations adopted in the study.

Article [7] examines the power dynamics in the adoption of smart city initiatives in Taipei, Taiwan. In Taipei, initiatives related to smart technologies have been implemented since 1999, and the development of the smart city has gone through several stages. Therefore, the work examines the evolution of these initiatives in the context of the city power regime. The study shows that the use of similar strategies for the development of smart cities in different cities does not mean similar justifications and principles of their application. Using the example of Taipei, the strategy of building a smart city is considered in the environment of confrontation between a development program led by the local people and the still strong legacy of Taiwan's authoritarian model of state development. The results of the study also proved that the implementation of the smart city contributed to the redistribution of power through the reorganization of actors and interests, the reconfiguration of state institutions, the redistribution of resources and the promotion of legitimate governance. Thus, a technological neoliberal logic and an experimental citizen-oriented approach helps adapt the concept of a smart city to the specific geographical and historical conditions of the territory's development. Since the work deals with an authoritarian regime, the lack of analysis of the threats of the use of digital technologies is a significant drawback of the study.

In [8], an analysis of civic participation in the "Quayside" smart grid, implemented in Toronto, Canada, was carried

out. The analysis was conducted using heuristic methods based on the improvement of the civic participation scale developed to assess the levels of civic participation in smart city projects. The improvement concerns the definition of new civic roles and mechanisms of civic participation, as well as the definition of political dimensions as a new concept for the evaluation of civic participation. These dimensions include the formation of proposals, the choice of citizens, the form of involvement, the provision of information, discussion, debate and the implementation of proposals. Based on the established methodology, the level of civic involvement of the smart city "Quayside" is rated at 0 since the project is currently canceled and civic initiatives have not been implemented. The disadvantage of the method developed in the work is the lack of verification of its validity in other smart cities, as well as the development of a set of methods for collecting information regarding the assessment of each proposed dimension of civic participation.

Thus, the results of our review of scientific works [1–8] indicate that the consideration of the mechanisms of citizen participation is an unresolved issue in the research of smart city concepts. This allows us to state that it is appropriate to conduct a study to analyze the human-centric concept of a smart city.

3. The aim and objectives of the study

The purpose of this study is to develop a conceptual model of the interaction of local authorities with citizens in a smart city based on a platform approach. This will provide an opportunity to develop strategies and roadmaps for the digital transformation of city management based on the concept of a smart city.

To achieve the goal, the following tasks were set:
– to describe the concept of a smart city aimed at meeting the needs of local residents;
– to analyze the results of using participation tools;
– to build a descriptive model of a participatory platform for a smart city.

4. The study materials and methods

The object of our research is the concept of a smart city.

The main hypothesis of the study assumes that information platforms are a very promising and simple means of interaction between city authorities, businesses, and citizens, the use of which contributes to the achievement of the goals of the smart city concept and public trust in the city thanks to technology.

Assumptions adopted in the study:
– the city is considered as a territorial socio-economic system;
– citizens understand their needs, which explain the necessity of living in the city;
– citizens have an active civic position and are ready to consciously take an active part in the life of the city;
– citizens are ready to actively use innovative information and communication technologies to implement their behavior patterns;
– to participate in decision-making processes, knowledge and competences regarding digital technologies used in smart cities are necessary.

Sources of raw data are the Scopus scientometric database, analytical reports of interested local and international organizations on the development of smart cities.

A systematic approach was used to define the human-centric concept of a smart city. The classification of citizens' needs and levels of civic participation was carried out using the method of logical generalization. Characterization of the practice of using digital technologies for civic participation in cities is based on analysis and synthesis and relative indicators. The conceptual platform model of the interaction of the city government with business, citizens, and other city stakeholders was developed based on the functional decomposition approach. Functional decomposition consists in the fact that the city management system as a socio-technical system is divided into functional blocks or components. Each block performs a certain function and interacts with other blocks to achieve the purpose of functioning.

5. Results of investigating the concept of a smart city, taking into account the mechanisms of citizen participation

5. 1. Definition of the human-centric concept of a smart city

A city is a social community united by a territorial management system [9]. The development of the city in this way can be considered as the development of the territorial socio-economic system, the purpose of which is to improve the quality of life and comfortable living environment of the population [10, 11]. However, people have their own interests, which do not always coincide with the goal of the system as a whole. Therefore, in order to achieve common goals, it is necessary, as a rule, to agree among ourselves, limiting in a certain way personal interests, which acts as self-organization in society. Systemic self-organization of the city is based on the principles of local self-government.

Streamlining of the organization of local government is implemented in order to facilitate the decision-making process based on its transparency. Since decisions depend on information, and its availability depends on communications, the need to improve management efficiency requires an analysis of information needs and communication links. Information is the main resource of management because only after receiving information, its analysis and processing, the subject of management generates and makes decisions to influence the system. The adopted decision, in turn, changes the system in a certain way, about which information is also received. Therefore, the conditions and nature of the activity predetermine the information needs. In the city, a person interacts with information in various aspects: professional, consumer, cultural, and for personal communication. The information created by the local community thus acts as a product of the activities of some people or organizations for its use by other people and institutions. Therefore, information needs are determined by social relations regarding the exchange of information for purposeful activities.

Residents of developed cities make high demands on the quality of life. Therefore, the priorities in these cities are the implementation of innovative technologies, high quality of the environment, conservation of resources in the city economy, involvement of citizens in the processes of local governance, prevention of isolation of local communities.

A smart city is a concept of urban management using digital technologies to create an integrated self-regulating

urban environment [12]. At the same time, adaptability is the main characteristic of management processes and contributes to the creation of public value, ensuring the digital transformation of urban space and social practices. The results of the analysis of different interpretations of the concept of a smart city, given in [13], show that it is based on the reduction of transaction costs and communication barriers associated with physical distance and the search for resources. It also directly follows from the technical purpose of digital technologies of Industry 4.0, which act as a tool for creating the physical and software infrastructure of smart cities.

The human-centric concept of a smart city involves representing the functions of the city government in the form of specific public services, the purpose of which is to satisfy the needs of citizens. This is a fundamental characteristic of achieving the goal of a smart city as a public space that promotes the health, happiness, and well-being of city residents, including individuals, business structures, and local authorities, as explicitly stated in the standard given in [14]. Therefore, the human-centric concept of a smart city takes into account the interests of a wide range of interested parties and partners based on constructive cooperation. Ideally, this completely eliminates the silo approach. A silo is a bunker closed to transparent interaction aimed at achieving strategic urban objectives. The silo is closed within itself, aimed at satisfying its own needs, as a result of which inter-functional connections are broken in the organizational structure of management. The lack of end-to-end processes, lack of interest in the final result blurs responsibility, increases opacity and leads to a decrease in manageability, increasing resistance to change and a decrease in efficiency.

The organizational structure of a smart city is thus designed to provide structural divisions with quality information, effective messages, effective tools and materials necessary for providing services to stakeholders – citizens and businesses.

In Table 1, the needs of city residents are compared with the components of the urban environment, which are objects of management in a smart city.

The classification of the needs of city residents, given in Table 1, is based on Maslow's theory of motivations, represented in [15]. The choice of this theory is explained by the fact that it allows applying a client-oriented marketing approach to the formation of a smart city development strategy. The results of the analysis given in Table 1 show that the information needs of a person from the point of view of spatial organization are determined by the laws of nature and the features of human consciousness. In this context, a smart city is a socio-technical system tuned to the specifics of people united by the boundaries of a certain urban area.

Table 1

Needs of citizens and relevant components of the urban environment

Human needs	The needs of city residents	Components of the urban environment
Physiological needs	Comfortable living conditions, such as provision of quality water, fresh air, tasty and quality food, warmth, convenient housing, availability of social services, comfortable working conditions, etc.	Energy infrastructure, trade infrastructure, transport infrastructure, health care infrastructure, housing and communal services
Security	Economic security, environmental security, emotional security, physical security, information security	Order protection system, emergency prevention and response system, environmental monitoring system
Affiliation	The possibility of creating a family, leisure with loved ones, the ability not to feel lonely, the presence of social roles, communication with community members, social interaction	Infrastructure for common leisure of citizens (parks, gardens, shopping centers, etc.)
Respect and recognition	Opportunities for professional recognition, obtaining a significant status, assessing contribution to public life	Infrastructure of participation, instruments of direct democracy, favorable conditions for doing business, a large number of enterprises
Cognitive needs	Opportunity to get education, improve skills, lifelong learning, the possibility of intellectual development)	Educational infrastructure, information and communication infrastructure
Aesthetic needs	Accessibility of culture, art, religion	Cultural and entertainment infrastructure, architectural and aesthetic component
Self-actualization	The possibility of creative manifestation	Creative industries

5. 2. Analysis of mechanisms for citizen engagement

One of the subsystems of a smart city is smart management, when information and communication technologies are used for the functioning of the communication system between citizens and local authorities, which involves active public participation. That is, the city administration adapts to the needs of citizens, the latter become not just consumers of certain information about the state of affairs in the city, initiators of changes in city planning. A smart city with developed mechanisms of public participation has a high level of human capital development and is distinguished by long-term cooperation between local authorities, scientific institutions, business and the population. Partnerships between these stakeholders make it possible to accumulate intellectual, financial, and technological resources, and at the same time ensure a high level of alignment of the interests of various parties.

Table 2 gives different levels of public participation of local stakeholders within the concept of a smart city.

As can be seen from Table 2, several digital communication channels can be used for different public participation tools, which can be used simultaneously. In this case, it is necessary to have time to process large amounts of information and pay attention to filling all selected channels with quality information. At the same time, the development of a smart city as a scalable digital platform, which acts as a single environment for the exchange of information and resources between citizens and authorities, will contribute to reducing the time and resources spent on organizing such communications.

The analysis of the mechanisms of involvement of citizens within the city was carried out by analyzing information from the websites of Ukrainian city councils for cities of Ukraine with a population of more than 100,000 people.

The list of cities is given in Table 3.

Table 2

Mechanisms of public participation in a smart city

Mecha-nism name	Characteristic	Digital communication channel	Direction of communication	The purpose of communi-cation
Informing	Information alert or clarification	Social networks, instant messengers, websites, email, platforms for citizens' appeals	One-way	Open access to information
Consulta-tions	Survey, relation-ship detection	Social networks, instant messengers, e-mail, platforms for citizens' appeals, platforms for holding conferences	Bilateral	Getting information about citizens' needs, opinions or awareness
Discus-sion	Group discussions, conferences, work-shops to discuss problems	Social networks, instant messengers, email, confer-encing platforms	Multilateral	Obtaining expert evaluation of projects from citizens
Partner-ship	Making decisions through joint par-ticipation in this process	Social networks, instant messengers, email, digital platforms for conferences	Multilateral	Joint equal work at each stage of decision-making, developing alternatives and identifying the best solutions
Delega-tion of authority	Citizens' deci-sion-making	Digital conferencing plat-forms	Bilateral	The community makes deci-sions, and local authorities implement it

Note: developed by some author based on [16−22]

Table 3

Cities of Ukraine with a population of more than 100 thousand people

City name	Population as of January 1, 2022, persons	City administration website
Pavlograd	101430	https://pavlogradmrada.dp.gov.ua/
Slavyansk	105141	https://www.slavrada.gov.ua/
Nikopol	105160	https://www.nikopol-mrada.dp.gov.ua/
Brovary	109806	https://brovary-rada.gov.ua/
Uzhhorod	115449	https://rada-uzhgorod.gov.ua/
Kramatorsk	147145	https://krm.gov.ua/
Bila Tserkva	207273	https://bc-rada.gov.ua/
Kremenchuk	215271	https://kremen.gov.ua/
Lutsk	215986	https://www.lutskrada.gov.ua
Kropyvnytskyi	219676	https://kr-rada.gov.ua/
Ternopil	225004	https://ternopilcity.gov.ua/
Kamianske	226845	https://kam.gov.ua/
Ivano-Frankivsk	238196	https://www.mvk.if.ua/
Rivne	243873	https://rivnerada.gov.ua/
Sumy	256474	https://smr.gov.ua/
Zhytomyr	261624	https://zt-rada.gov.ua
Chernivtsi	264298	https://city.cv.ua
Cherkasy	269836	http://chmr.gov.ua/ua/
Khmelnytskyi	274452	https://khm.gov.ua/
Kherson	279131	https://miskrada.kherson.ua/
Poltava	279593	https://www.rada-poltava.gov.ua/
Chernihiv	282747	https://www.chernigiv-rada.gov.ua/
Vinnytsia	369739	https://www.vmr.gov.ua
Mykolaiv	470011	https://mkrada.gov.ua/
Kryvyi Rih	603904	https://kr.gov.ua/
Zaporozhye	710052	https://zp.gov.ua
Lviv	717273	https://city-adm.lviv.ua/
Dnipro	968502	https://dniprorada.gov.ua
Odesa	1010537	https://omr.gov.ua/
Kharkiv	1421125	https://www.city.kharkiv.ua/
Kyiv	2952301	https://kmr.gov.ua

Note: compiled by authors based on data from [23]

According to the results of the analysis of information from the websites of Ukrainian cities, indicated in Table 3, the main mechanisms of public participation in Ukrainian cities were identified. These include electronic petitions (present on 77 % of portals), oppor-tunities for citizen appeals, presented contact centers and electronic forms for citizen appeals (present on 97 % of portals), public par-ticipation budget (present on 81 % of portals). 10 % of city portals have a link to a chatbot, another 52 % of city administration web-sites have information about public hearings, and 29 % of websites have implemented the possibility of conducting electronic consultations in the form of surveys. Mecha-nisms such as public exper-tise and general meetings can be found on only 6 % of websites of Ukrainian cities. Overall, it should be noted that only 29 % of websites have a separate section on public participation. Elec-tronic petitions, public par-ticipation budget, electronic consultations, contact center and electronic application forms provide an opportuni-ty for stakeholders to provide feedback to local authorities, as well as inform about the results of communication. All other named mechanisms are represented in the form of documented interaction results published on the web-site. In addition, almost half of these informational ma-terials have either not been updated for a long time or are missing altogether. From the point of view of completeness of information, its presenta-tion in a separate section and updates, the reference is the website of Vinnytsia City Council (Ukraine).

5. 3. Descriptive form of a platform model of citizen engagement for a smart city

The main trend in the development of the urban

environment at present is the active use of information and telecommunication technologies in infrastructure initiatives. That is, digital technologies become the core of a smart city, generating large arrays of data on various aspects of the functioning of the city system. These data are used for further analysis and decision-making regarding the solution of strategic management tasks at the local government level.

The intelligence of urban management systems within the concept of a smart city is a qualitative characteristic that means the ability of the system to make reasonable and adequate decisions regarding the sustainable development of the city based on the results of data processing in automatic mode. At the same time, urban management systems are digital systems built using such technologies as the Internet of Things, cloud computing, big data, and artificial intelligence.

Urban management systems within the human-centric concept of a smart city belong to complex socio-technical systems because they must include not only technical components but also modeling the behavior of local social groups along with their values and interests. The specificity of these management systems is the need to take into account the following components:

– an organizational component to ensure the distribution of roles and interaction between citizens;

– a motivational component to encourage citizens to create social value;

– an infrastructural component for creating a unified interaction interface and accumulation of collective knowledge and ideas;

– an evaluation component for the creation of guarantees for consideration of civil initiatives.

Thus, the smart city as a socio-technical management system monitors and evaluates the functioning of the urban environment and, on this basis, optimizes it in relation to the goals of sustainable development. The heterogeneity of the social urban space makes the human-centric concept of a smart city a priority. The involvement of citizens in the processes of managing the development of urban territories through the creation of communication and feedback channels with local authorities can reduce information asymmetry, as well as the level of distrust of citizens in smart city technologies. This fully corresponds to the platform model of involving citizens in solving urban problems.

The development of the city as a platform means that the digital platform is the environment in which communications and feedback between citizens and authorities take place, along with the exchange of information and resources. The structure of the platform model of engagement for a smart city is schematically depicted in Fig. 1.

As shown in Fig. 1, the structure of the platform model assumes several socio-technical subsystems depending on the functionality of the roles of the participants of the smart city. The front office includes units of local authorities and technical means that directly collect information about the functioning of city infrastructure and interact with inter-

ested parties – consumers of smart city services – on the basis of a «single window». Accordingly, the middle office includes divisions and technical means that are responsible for working with unstructured data, performing the functions of their verification and processing, as well as technical support for service applications. The back office ensures compliance with the accepted standards, implementation of relevant accounting and control procedures, as well as decision-making.
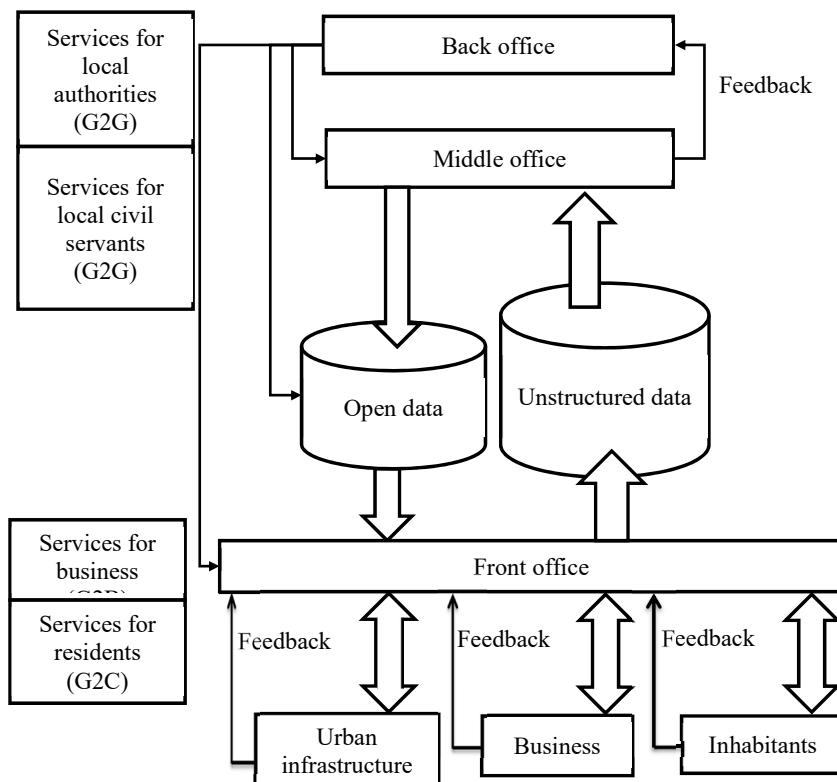

Fig. 1. The structure of the platform model of interaction with feedback within the smart city

As for the architecture of a smart city as a socio-technical system built on the basis of a platform model, it consists of the following components. Digital infrastructure is located at the physical level, i.e., telecommunications systems and networks, data centers, systems of devices for collecting and analyzing information about the state of urban infrastructure, information security systems, and warning systems. This component is the technical component of the front office.

At the intermediate level of the architecture, it is advisable to place the data, including both the databases themselves and the analytical systems for working with them. This component is a technical component of the middle office. It should be noted that third-party service developers are involved in the middle office.

Service applications should be placed at the level of data users. Depending on the role of the user, the following groups of applications are distinguished: applications for city residents (G2C), applications for business (G2B), applications for interaction with state bodies (G2G), applications for local government employees (government employees) (G2C). The involvement of citizens in the process of creating value in the platform model shown in Fig. 1 can be implemented in two ways:

– as a separate service, specially designed for collecting information about civic initiatives to improve city infrastructure. This can be done in a centralized government platform (like the Ukrainian «Diya») or in a decentralized blockchain platform (like the Ukrainian «Bitbon System») [24];

– as an evaluation module within the scope of providing other services.

From a technological point of view, the implementation of such an interactive function of the new platform of citizen engagement can be carried out:

– through the system of Internet appeals, pop-up messages, crowdsourcing [25]. At the same time, it is important to ensure information security and confidentiality of personal data of platform users for third parties. If you follow this path, only the format and principle of centralized information (digital) platforms are used;

– through the tokenization of legal relations, for example, between a citizen and the city council or between communities of people. The key tools are smart contracts on the blockchain and prescribed tokenization procedures.

So, the modern concept of a smart city involves the use of blockchain technology and tokenization of legal relations, which allows for more efficient management of the city and attraction of the population. The positive results of implementing blockchain and tokenization for city management are as follows:

– blockchain ensures transparency and authenticity of data related to citizen participation in smart cities, and smart contracts can guarantee compliance with agreements and ensure trust between participants;

– tokenization allows the creation of digital tokens that can be used to give citizens a voice in the decision-making process. Citizens can receive tokens for their activity, participation in surveys or providing valuable data about the city;

– with the help of tokenization, physical and digital assets can be represented in the form of tokens on the blockchain. This may include the right to vote, participate in decisions, or even own certain assets. The population can use such tokens to express their preferences and opinions on various aspects of smart city management;

– blockchain platforms can be used to attract financing for smart city projects through contributing to real projects. This allows attracting investments from a wide audience of people who are interested in the development of smart cities;

– tokenization and blockchain can contribute to the development of the ecosystem in smart cities. Citizens can use tokens to access various services, such as transportation, energy, education, and healthcare, as well as exchange services and resources among themselves;

– blockchain can help ensure data security and protect citizens' personal information. Smart contracts and anonymity mechanisms can be implemented to ensure confidentiality during data collection and processing;

– blockchain can be used to provide transparent access to city data such as budgets, energy consumption, transport networks and other important parameters. This will allow the population to be better informed and make informed decisions about improving the urban environment.

All this is important to know because blockchain governance can only exist within decentralized platforms and the corresponding ecosystems of services, which are currently actively developing and offering themselves to public authorities and corporations.

A tokenization mechanism for local self-government and direct democracy can provide simple and cheap solutions for operational support. At the same time, trust between participants increases because it is practically impossible to falsify the information stored in the blockchain registry [21]. But for the mass spread of tokenization of rights and legal relations, at the moment, in 2023, it is necessary to solve the issues of compliance with regulatory requirements, regulation, and storage. For this, both countries and organizations need to take steps to better understand the tokenization of assets and their value, as well as the potential of tokenization for asset ownership. This will allow people of any income level to increase their wealth and financial literacy. It also causes the reconfiguration of institutions and rules of operation of the market infrastructure. If the states and private providers of such services are jointly ready to establish the accounting of tokenized assets, a low threshold for entry into the world's investment asset markets will be established already at the level of institutions.

6. Discussion of results of investigating the concept of a smart city taking into account the mechanisms of civil participation

A smart city is a concept of city management based on innovative information and communication technologies. In technological terms, a smart city is an integrated digital self-regulating urban environment. The digital transformation of urban space and social practices ensures the adaptability of management processes to create public value. Representing the functions of the city government as specific public services to meet the needs of citizens is the basis for the human-centric concept of a smart city. Taking into account the interests of individual citizens, business structures and local authorities requires transparent mechanisms of interaction. The needs of city residents determine the structure of the urban environment (Table 1). In contrast to [1–6] the approach given in Table 1 reveals the essence of the human-centric concept of a smart city.

The human-centric concept of a smart city, integrating various subsystems of the city as a territorial socio-economic system, also meets the goals of sustainable development. At the same time, public participation acts as a driving force for improving the quality of life, as well as caring for future generations. Partnership relations, a conscious approach to participation in the development of the city by both authorities and business structures, and individual citizens create a constructive basis for their interaction. This will make it possible to accumulate and develop intellectual, financial, and technological resources. Described in Table 2, the mechanisms of public participation are implemented in a smart city through digital communication channels, in contrast to [16–18]. As a result, it is possible to analyze the practice of public participation. Thus, the practice of using electronic petitions, public participation budgets, electronic consultations, citizen appeals in Ukrainian cities shows the following problems:

– lack of a common mechanism for information exchange between city citizens and local authorities;

– diversity in communication channels;

– lack of joint participation of all stakeholders of civil participation in establishing strategic directions for sustainable development of cities [23]. Electronic contact centers, electronic petitions, and public participation budgets were the most developed options for interaction in Ukrainian cit-

ies, and the most common problems that needed to be solved were the state of local infrastructure and improvements. This is caused by such communication barriers as mistrust and stereotypes, low awareness of citizens in the system of city management and the involvement of residents, prejudice, previous negative experience of cooperation, unsystematic interaction, selective attitude of city authorities to civil society. Among the main barriers to engagement are also not knowing who to turn to in order to establish interaction; as well as previous negative experience of citizens and businesses in solving their problems, indifference and formal attitude of officials. In the process of interaction, both parties have to go through traumatic conflict situations. An important barrier is also the lack of practices of early involvement of residents in the city administration.

Also, a significant barrier to participation and an impeding factor in the development of smart cities is corruption. The main negative consequences of corruption in the researched area are insufficient transparency and openness, unjustified costs, restrictions on access to information, lack of effective control, and unfair distribution of resources. Thus, corruption leads to insufficient transparency and openness in city governance, including decision-making processes and resource allocation. This can lead to the development of smart cities being controlled by a few individuals or groups who can use it for their own selfish purposes. Corruption can lead to overestimation of the cost of implementing smart city projects due to unscrupulous agreements and distribution of financial resources. This leads to a loss of confidence in projects and an increase in budget holes. Corruption creates restrictions on public access to information about smart city projects and decision-making processes. This complicates the participation of citizens in solving local development issues and leads to mistrust and alienation of the public. The lack of effective control and supervision over the implementation of smart city projects causes insufficient quality and efficiency of project implementation, as well as loss of trust in state and municipal bodies. The inequitable distribution of resources for the development of smart cities means that certain areas or cities receive more investment and support, while others are left behind.

To overcome communication barriers and fight corruption in the field of smart city development, transparency, openness and participation of citizens in city management processes, strengthening of anti-corruption mechanisms are key. Under such conditions, a platform model of interaction between citizens and authorities is acceptable in a smart city, the organizational structure of which is shown in Fig. 1. The platform model for the smart city concept with feedback is a development of the so-called "open data platform" but is not limited to it. At the same time, the open data platform ensures centralized (within the city) storage of sets of structured data on the functioning of city services, organizations, and residents themselves, and provides the possibility of their multiple use. This platform performs the function of integrating disparate data and ensures interoperability of various systems to serve internal and external consumers of relevant information within the city. An open data platform allows different actors to reduce time spent searching for the necessary information about services and city resources by coordinating their actions. As a result, there is a decrease in transaction costs and a corresponding increase in productivity. Adding to the functionality of the open data platform mechanisms for engaging citizens and

businesses allows for public control of various aspects of urban development [20, 21]. An open data platform with feedback allows for real-time coordination of the activities of city services and interaction of local authorities with citizens and businesses. Feedback support provides a collective decision-making system and creates a local environment for urban innovation. As a result, the city becomes a system capable of self-organization. The expected results from the implementation of engagement platforms for the development of smart cities are the organization of open data and the encouragement of stakeholders to participate in city management [26]. Such interactive participation in urban planning and resource allocation will contribute to the development of innovative creativity of citizens and the development of an open dialog and exchange of information with local authorities.

It is proposed to use a digital platform for the needs of public control by citizens (local residents, donors, and benefactors) of funds that are collected and intended for specific humanitarian purposes or reconstruction in post-war Ukraine. At this time, the issue of trust in society and access to limited resources from abroad will be acute. Technologically, this can be implemented on the basis of already existing blockchain tools of Ukrainian origin. The main idea is to spread among citizens and global philanthropists a digital tool that would help strengthen their trust in the volunteer movement and donations that are intended for specific humanitarian projects. This software solution will tokenize (i.e., replace physical and legal assets with tokens on the blockchain) the legal relationship between benefactors (donors) and beneficiaries (recipients of aid) through the mediation of a specific volunteer. As such a solution, the decentralized social network of economic relations "Bitbon System" (https://www.bitbon.space/en) of Ukrainian origin is proposed, which is based on blockchain technology – smart contracts and prescribed tokenization procedures. Such a software solution allows users of the platform – any donors, volunteers, and legal administrators of donations:

– to have reliable information about those who need help, when, and how, about initiated or promising social projects, etc.;

– to provide and manage the most targeted and accountable financial assistance by transferring funds to specific projects through a standard banking service – "escrow account";

– to provide confidence in the implementation by the volunteer (local charity foundation, local council or Rotary club, aid recipient) of humanitarian project in any country of the world.

Among the main elements of such a project are:

– «announcement service», which is used for the register of volunteers or benefactors and is linked to the list of projects and their estimates. The owner of the service can be a volunteer foundation, a Rotary club, or a charitable foundation;

– a standard bank "escrow service" that allows the use of tokenized funds contributed as charitable aid with the possibility of their programming (smart contracts), which, thereby, ensures their intended use without fraud. At the same time, the owner of the escrow account is a specific Rotary club or charitable foundation. Beneficiaries in the escrow service are volunteers from the registry, local communities-recipients of aid, etc., who are interested in increasing aid and a confirmed good reputation. The condition for receiving funds is confirmation of the implemented/planned

stage of a specific volunteer project (essentially – digital reporting within a digital platform);

– a network of regional operators of the "Bitbon System", which exist (will be formed) in the form of non-profit legal entities (according to national legislation). They resolve all legal issues of compliance with national legislation.

The use of blockchain technology will facilitate the fact that all financial transactions will be easily accessible for verification. This can help build trust in the volunteer movement and strengthen a culture of integrity. Tokenization will allow money to be used for exactly the purposes for which it was allocated/donated. This excludes the possibility of misuse of funds in a private manner. The standard bank service of the escrow account guarantees that the money will be transferred to the volunteer only after the successful implementation of the project (stage of the project), etc. This encourages volunteers to fulfill their duties responsibly and provides additional confidence to donors. In addition, the platform allows donors to choose the projects to which they would like to donate funds, ensuring a direct connection between donors and recipients of aid.

There are also interesting prospects for the use of tokenized assets in smart city management through:

a) decentralized resource exchange: Tokens can be a means of resource exchange between city residents. For example, residents can exchange tokens for services such as using public transportation, renting city real estate, or energy resources. This contributes to the development of an economic system within the city, based on interaction and mutual assistance between local residents;

b) accounting and transparency: Tokens can be used for transparent accounting and tracking of the use of city resources. Residents will be able to see how the funds raised from the token sale are being used and control which projects receive funding and which decisions are made in their city.

Thus, rethinking the role and place of mechanisms of public participation and their deep digitalization towards direct democracy within the concept of a smart city will help solve the problems of sustainable urban development.

The limitation of this study is the adequacy of the obtained results within the analyzed situation. The described concept of a smart city and mechanisms of public participation are analyzed on the example of Ukraine.

The disadvantage of this study is the impossibility of checking practical expectations without their real application in the practice of the functioning of cities.

The development of this study consists in conducting experimental studies on the perception of the proposed technological infrastructure by potential users.

7. Conclusions

1. It was determined that the basis of the smart city concept is the reduction of transaction costs and communication barriers associated with physical distance and the search for resources. The tool for creating smart city infrastructure is digital technologies, the key ones of which are the Internet of Things, big data, cloud computing, artificial intelligence, virtual reality, blockchain. The human-centric concept of a smart city involves representing the functions of the city government in the form of specific public services, the purpose of which is to satisfy the needs of citizens. In such an interpretation, it is possible to take into account the interests of a wide range of interested parties and partners based on constructive cooperation.

As a socio-technical system, a smart city acquires properties depending on the specifics of people united by the boundaries of a certain urban area. Therefore, the human-centric concept of a smart city contributes to the increase of social capital and the development of human resources.

2. Public participation and active citizenship are recognized as a key component of the development of a smart city as a socio-technical system. Partnership relations as a constructive interaction between local authorities, scientific institutions, business and the population make it possible to accumulate intellectual, financial and technological resources, and at the same time ensure a high level of coordination of interests of various parties. The mechanisms of public participation in the smart city include informing, consultation, discussion, partnership, and delegation of powers. Several digital communication channels, including social networks, instant messengers, websites, e-mail, and various platforms for citizen appeals, may be used simultaneously to communicate through these mechanisms. This can lead to a decrease in the effectiveness of the interaction. The use of digital communication channels for civic participation in Ukrainian cities with a population of more than 100,000 people indicates just such a situation. As a result, information related to active public participation provided on the official websites of Ukrainian cities is scattered and often outdated.

3. The heterogeneity of the social urban space makes the human-centric concept of a smart city a priority. The involvement of citizens in the processes of managing the development of urban territories through the creation of communication and feedback channels with local authorities can reduce information asymmetry, as well as the level of distrust of citizens in smart city technologies. This fully corresponds to the platform model of involving citizens in solving urban problems. In addition, a scalable digital platform, which acts as a single environment for the exchange of information and resources between citizens and authorities, will contribute to reducing the time and resources spent on organizing such communications. An open data platform with feedback allows for real-time coordination of the activities of city services and interaction of local authorities with citizens and businesses. Feedback support provides a collective decision-making system and creates a local environment for urban innovation. As a result, the city becomes a system capable of self-organization. In terms of technology, the implementation of the interactive functionality of the citizen engagement platform can be done through a system of Internet appeals, pop-up messages, and crowdsourcing. At the same time, it is important to ensure information security and confidentiality of personal data of platform users for third parties. Therefore, the expected results from the implementation of engagement platforms for the development of smart cities are the organization of open data and the encouragement of stakeholders to participate in city management. Such interactive participation in urban planning and resource allocation will contribute to the development of innovative creativity of citizens and the development of an open dialog and exchange of information with local authorities.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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The study was conducted without financial support.	All data are available in the main text of the manuscript.

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