Smart City: From the Metaphor of Urban Development to Innovative City Management

Daniyar Mukhametov

Financial University under the Government of the Russian Federation, Moscow, Russia

Abstract **– The article deals with the evolution of the concept of smart city. Smart city can be examined as the modern metaphor of urban development that is connected with the introduction of information technologies to address a wide range of governance issues. The innovation of the smart city is based on the increased role of human capital, inclusive institutions and cooperation of key participants within innovation ecosystem. The article proposes the use of a three-level model of urban benchmarking, which can contribute to the system self-organization. The future of the smart city projects will depend on ensuring cybersecurity, human and social capital, modern engineering ideas and competent project activities.**

Keywords **– Smart city, Digital technologies, City benchmarking, Human capital, Urban development, Innovation ecosystem.**

1. Introduction

Technological progress actualizes the implementation of digital technologies in management processes. In particular, extensive discussions are devoted to the possibility of their use in the context of urban management optimization: theoretical preconditions are reduced to the fact that modern information and communication technology can ensure efficient management.

DOI: 10.18421/TEM84-20
https://dx.doi.org/10.18421/TEM84-20

Corresponding author: Daniyar Mukhametov,
Financial University under the Government of the Russian Federation, Moscow, Russia
Email: *mukhametovdaniyar@gmail.com*

Received: 30 June 2019.
Revised: 25 October 2019.
Accepted: 03 November 2019.
Published: 30 November 2019.

Such formulation — the use of digital technologies for sustainable and efficient management of urban processes [1] - is the most general and concise characteristic of the concept of "Smart city". There are several reasons why interest in this concept is expected to increase.

Firstly, today the urban population is 55% of the total population of the planet, and by 2050 it is projected to grow to the level of 68% [2]. The constant growth of the urban population increases the burden on major urban systems (transport, education, health, safety, energy, construction, etc.) produce the need to find new tools to improve urban governance. The concept of "smart city" is capable to provide it.

Secondly, digital transformation marked the possibility to introduce cyber-physical systems in various spheres, including industrial production and social life in general. The use of the Internet of Things, the development of robotics and additive manufacturing, the emergence of the unmanned vehicles, the spread of the blockchain and other end-to-end technologies leads to cardinal changes in the life of society [3]. As a result, there is an opportunity to use them for innovative development of urban management [4].

Thirdly, the modern city is located at the intersection of many different flows associated with the process of globalization: migration, innovation, financial and economic flows, etc. [5]. It also causes the demand for sufficient flexibility and adaptability of urban management, which can be provided by implementation of the concept of "smart city" [6].

Despite these advantages of "Smart city" research, there are a number of gaps related to the study of the content of this concept. The purpose of this article is to trace the transition of the Smart city concept from the metaphor of urban development to the system of innovative management and to develop a model of urban benchmarking.

The review of the major metaphors of urban development is provided in Section 2. In Section 3 the factors of innovative development in smart cities are analyzed. Section 4 examines the urban benchmarking model using machine learning, digital technologies and self-organization mechanisms for system dynamics.

2. Metaphors Urban Development

The metaphor is the optimal way of pre-theoretical description of the concept. The metaphor consists of two components — the main and the additional, while the task of the additional component is to strengthen due to its value the main part [7], [8].

For metaphors of urban development the main component is the category "city", additional — the definition of the key direction of its transformation. At the end of XX century several key metaphors of cities of the future appeared: "networked city", "resilient city", "global city" and"attractive city". Each of these metaphors are focused on the individual factors of the urban environment, including economy, management, environment and social sphere (Table 1) [9], [10], [11].

Table 1. Metaphors of urban development

Metaphors	**Factors of urban development**			
	Economics	Management	Environment	Social sphere
Networked City	+	+	-	-
Resilient City	+	-	+	-
Attractive City	+	-	-	+
Global city	+	+	+	+

According to presented table, it is possible to give the following general characteristics of these metaphors:

- the networked city reflects the formation in the urban space of sustainable relationships that promote economic interaction and effective decision-making;
- the resilient city is based on economic stability and a favorable environment for urban development;
- the attractive city emphasizes the importance of economic sustainability and social development as key characteristics of a favorable urban space;
- the metaphor of the global city is connected with the influence of the city in the structure of the world economy, as well as with the attractiveness of the city for business.

However, the lack of the clear theoretical boundaries between these metaphors led them to merge into a single model that focused on the development of an attractive environment in urban space, optimization of management, use of modern technologies, environmental friendliness [12]. We can say that the metaphor "Smart city" is a reflection of the listed trends and includes the indicated elements. A key argument is the ability to implement information and communication technologies to ensure a safe and comfortable environment, as well as to optimize management. These properties form the basis for the definition of a smart city.

The first theoretical developments of «Smart city» dating back to the mid -1980s were characterized by abstractness and insufficient conceptualization. Despite this, they found support from different environmental protection movements, which justified the need to abandon noisy megacities in favor of quiet cities and switch to the use of renewable energy sources. In the future, the concept of "smart city" began to be used to describe the integration of technological innovations and urban life, which, however, was not embodied in practical projects.

3. Factors of Innovative Development

The implementation of the projects began after the financial crisis of 2007-2008: many municipalities lost significant support from the federal budget and were forced to make a transition to austerity regime. The introduction of information and communication technologies into the urban management system has made it possible to organize an effective savings policy and fulfill its obligations to the urban population. Moreover, the implementation of this concept has contributed to the development of innovative systems in these cities and to the attraction of talented scientific and technological intelligentsia from around the world, providing sustainable economic and social development [13]. The first experience of building smart cities is connected with these cities. It is important to emphasize that development of the smart city is linked with the inclusion of a wide range of actors in the processes of innovation exploitation and their collaboration, as well as with the growth of the values of knowledge and information culture. Based on this, following factors of innovative development can be considered.

Firstly, according to the paradigm, the majority of investments are directed to human capital, whose task is to create the necessary basis for the use of innovative technologies by the population. In some scientific papers this type of capital has received the name of "network capital" and is expressed in two interrelated aspects [14], [15]. The first is the access

of the population to information and communication technologies and modern means of communication, as well as their purposeful use in their activities. The second is the readiness of the population for a continuous learning process and acquisition of new skills to adapt to the introduction of digital technologies. Thus, the concept of human capital encompasses both access to modern infrastructure and the availability of relevant knowledge: together this ensures consistency of diffusion of innovation and adoption of new technologies by the population.

Secondly, technological development affects the production of inequality in society. This is the result of uneven distribution of resources, unequal access to technology and information, and differences in knowledge and skills among social groups. The introduction of inclusive institutions [16], [17] in smart cities in socially important areas (education, health care, social support, access to information and data) can be estimated as a strategy to prevent this problem. This allows, firstly, reducing social tension and avoiding perceptions of new technologies as a means of total control, and secondly, to establish institutional trust that promotes the preservation of solidarity and understanding between the authorities and the population. The objective of inclusive institutions is to ensure equal access and inclusion of people in various social and economic activities, thus avoiding resource allocation and growth deficiencies social polarization.

Thirdly, the cooperation of the city administration, the business community, research institutions and the population (civil society institutions) can be seen as the key to the successful implementation of the "smart city" project. This idea is based on a network model of resource exchange [18], which in the context of urban development is as follows. Material, institutional and intellectual resources are exchanged among the listed participants, which allow accumulating and mobilizing the maximum possible potential for implementation of the project. In an ideal typical design the described ecosystem will have the following form: 1) companies are the source of material resources and technical means, 2) research organizations provide formal models of development and ways of adaptation technology into life (innovation transfer and expertise), 3) the city administration acts as an institutional builder, and 4) the population renders loyality/disloyalty to the course. It is important to note that the inclusion in this network scheme the technology manufacturer, the expert community and the management agent represented by the city authorities allows to significantly reduce the risks of negative effects arising from the difference in scientific and technical knowledge among the listed participants (information asymmetry), which contributes to the selection of truly demanded effective technologies rather than their simulations [19]. To ensure the presented collaboration within the city boundaries, an innovative cluster can be created, which has financial and organizational support for the participants.

It seems that in the coming years the concept of "smart city" will continue to develop in the context of both human capital development and technological progress. Technological growth produces the emergence of new technologies, which are tested including in municipal government [20]. Other things being equal, there is a need for constantly updated knowledge of these technologies and the ability to use them on the part of the population to ensure that the management process itself is effective and not accompanied by the decline of trust in power and the growth of social protest from citizens — it is necessary to note that population is one of the key resources for many cities [21]. Technology is a tool, a means of realization of opportunities of the population and satisfaction of its needs.

Despite the identified advantages of the concept of "smart city", experts note that its superficial and ill-conceived implementation can lead to negative consequences. In particular, the translation of interactions into virtual space is able to neutralize the importance of actual physical contacts, which can lead to the self-isolation of individuals and the emergence of the phenomenon " split urbanism", in which public platforms for interaction do not work, social capital is lost, and the person is forced to rely purely on technology [22]. In addition, the widespread adoption of wireless sensors and other data collection and analysis tools can be done not so much to optimize the management process, but to increase the scale of control over the population and centralization of power, which can potentially provoke a conflict between the government and society [23]. Moreover, the implementation of the "smart city" project is inevitably connected with the involvement of various large technology companies [24], which can turn the whole process into corporate lobbying of interests. Thus, human isolation and the growth of centralization are assessed as the main risks of ill-conceived implementation of the concept of "smart city".

4. Model of City Benchmarking

Urban governance includes a number of subsystems: security, transport, health, housing, infrastructure, etc. [25]. Each of these areas uses its own indicators. When introducing digital technologies into the data of urban subsystems, it is possible to track changes and make adjustments without human participation, as indicated by their definition in as "smart" [26]. The concept of urban

benchmarking is the process of monitoring indicators in these subsystems and impact on them within the management process. As a result, in context of the digital transformation there are a number of options to improve urban benchmarking by accelerating both information analysis and responding to changes in indicators.

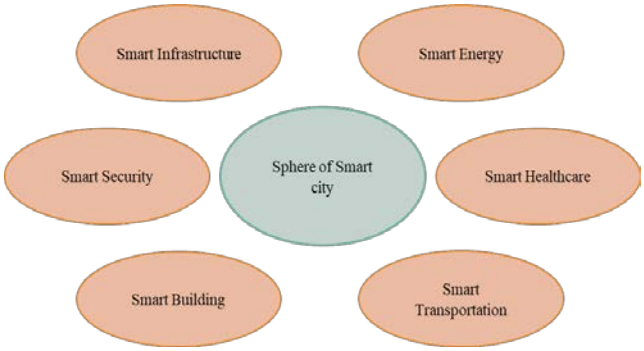

Figure 1. Smart City System

It is possible to propose the use of the three-level model of urban benchmarking. The first level consists of sensors, whose function is to collect data. The second level is machine learning algorithms, which determine behavior patterns and possible trajectories of the changes. The third level is the actuators, with the help of which the impact on the environment is carried out without human involvement. Due to the development of the Internet of Things and artificial intelligence technologies, this model can be implemented to collect and analyze data from various areas of urban economy, as well as to timely response and act to changes in the situation. Moreover, the use of this model of urban benchmarking contributes to the development of system dynamics — the study of behavior over time and depending on the structure of system elements and interaction between them [27]. In other words, the management system is not limited to "change-response" frames, but also receives intellectual resources for self-organization and predictive analytics.

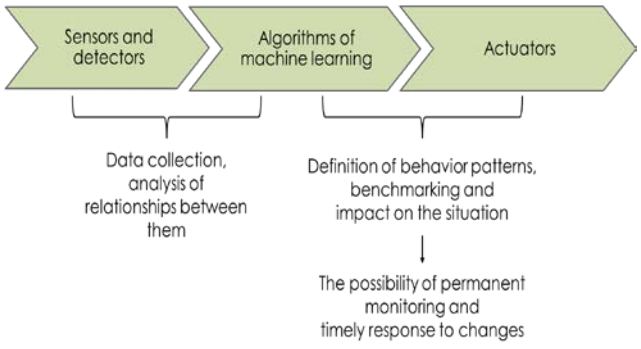

Figure 2. City Benchmarking Model

Definitely, this model of information collection and management carries risks of growth of centralized control and manipulation. To prevent this, it is necessary to develop information culture, social capital and democratic institutions that generate confidence in innovation and limit potential manipulation and uncontrolled handling of data.

Summarizing the presented material, we can say that the content of the concept of "smart city" is reduced to several elements. First, to implement the active use of modern IT technologies and Big Data to optimize the management of urban processes. New technologies allow to organize real-time monitoring through "urban benchmarking" — comparison of specific indicators and indicators [28]. Secondly, «smart city» can be also characterized by the introduction of "green technologies" in the broadest sense of the term — from building materials and public transport to renewable energy sources. Thirdly, transparency of processes and active dialogue between authorities and citizens: the involvement of the population minimizes the risks of resistance to data collection and systematization. Fourth, the acquisition by population of the city to gain the necessary knowledge and skills on the use of modern technologies for effective interaction with municipal management. However, there are a number of obstacles to practical implementation of the concept: lack of professional staff, increased threat of information attacks, choice of appropriate technologies, etc. the solution of these problems and the proper targeting of urban policies makes it possible to implement the concept.

5. Conclusion

Thus, "smart city" can be defined as a modern concept of urban development, characterized by the use of digital technology and the significant role of the intellectual capital. Today Barcelona, Stockholm, Amsterdam, Songdo [29] and a number of other cities are estimated as the successful examples of smart cities, which is largely due to the high level of their technical and social base and information culture of the population.

However, the practical implementation of the concept faces objective problems, including technical problems (lack of professional personnel, threats of information security, competent selection technologies) and political issues (mistrust on the part of the population, threat of expansion of state control, risks of lobbying). Their solution is linked to the introduction of inclusive institutions in the social sphere and investment in human capital. Experience in implementing smart city projects (Montreal, Hannover, Boston, Toronto, Taipei, Rio de Janeiro, Masdar, etc.) demonstrates that building a decision-

making system based on modern technologies monitoring and analysis of data is possible today.

In addition, one of the main technical risks is that the smart city system is extremely vulnerable to cyberattacks and energy accidents: information failure of the system or problems within energy system can lead to the collapse of the entire system of the city. These risks stimulate the development of "ethical hacking" and "white hats" activities [30]: there is a growing need for regular professional checks of existing systems for malfunctions and damage in order to detect and eliminate them in a timely manner.

Urban governance will face many challenges in the near future, including a constantly growing urban population, the need to attract additional funding, improvement of monitoring systems and data analysis mechanisms, etc. All this requires a qualitatively new approach to the management process in order to optimize it. The concept of "smart city" emphasizes the importance of innovation and the introduction of modern technologies in urban life.

References

[1]. Kitchin, R., & Perng, S-Y. (2016). Code and the City. London: Routledge.

[2]. United Nations (2018). 2018 Revision of World Urbanization Prospects. Retrived from: https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html, [accessed: 06 April 2019].

[3]. Schwab, K. (2016). The Fourth Industrial Revolution. Crown Business.

[4]. Caragliu, A., Del Bo, C., Kourtit, K., & Nijkamp, P. (2015). The winner takes it all: forward-looking cities and urban innovation, *The Annals of Regional Science*, *56*(3), 34–51.

[5]. Zinkina, Y. V., Shulgin, S. G., & Korotaev, A.V. (2016). Evolution of global networks: regularities, trends, models. Moscow: URSS.

[6]. Komninos, N. (2008). *Intelligent cities and globalisation of innovation networks.* Routledge.

[7]. Black, M. (1962). Models and metaphors: Studies in language and philosophy. Ithaca: Cornell University Press.

[8]. Lakoff, J. (1987). Women, Fire, and Dangerous Things: What Categories Reveal About the Mind. University of Chicago Press.

[9]. Jabareen, Y. R. (2006). Sustainable urban forms, *Journal of Planning Education and Research*, *26*(1), 38-52.

[10]. Hatuka, T., Rosen-Zvi, I., Birnhack, M., Toch, E., & Zur, H. (2018). The political premises of contemporary urban concepts: The global city, the sustainable city, the resilient city, the creative city, and the smart city. *Planning Theory & Practice*, *19*(2), 160-179.

[11]. Moir, E., Moonen, T., & Clark, C. (2014). What are future cities – origins, meaning and uses. Foresight Future of Cities Project and Future Cities Catapult.

[12]. Verrest, H., & Pfeffer, K. (2019). Elaborating the urbanism in smart urbanism: distilling relevant dimensions for a comprehensive analysis of Smart City approaches. *Information, Communication & Society*, *22*(9), 1328-1342.

[13]. Komninos, N. (2009). Intelligent cities: towards interactive and global innovation environments, *International Journal of Innovation and Regional Development*, *4*(1), 337–355.

[14]. Kaufmann, V. (2002). Re-thinking Mobility. Contemporary Sociology. Aldershot: Ashgate.

[15]. Urry, J. (2012). Mobilities. Moscow: Praxis.

[16]. Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Books.

[17]. Khalil, E. (2013). Lock-in institutions and efficiency, *Journal of Economic Behavior and Organization*, *88*(3), 27-36.

[18]. Jackson, M. (2010). Social and Economic Networks. Princeton University Press.

[19]. Akerlof, G. (1970). The Market for «Lemons»: Quality Uncertainty and the Market Mechanism, *The Quarterly Journal of Economics*, *84*(3), 488-500.

[20]. Goodspeed, R. (2014). Smart cities: moving beyond urban cybernetics to tackle wicked problems. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 79-92.

[21]. Glaeser, E. (2011). Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier. Penguin.

[22]. Graham, S., & Marvin, S. (2002). *Splintering urbanism: networked infrastructures, technological mobilities and the urban condition*. Routledge..

[23]. Greenfield, A. (2013). Against the Smart City. New York: In Projects.

[24]. Wiig, A. (2015). IBM's smart city as techno-utopian policy mobility. *City*, *19*(2), 1-23.

[25]. Mohanty, S. (2016). Everything You wanted to Know about Smart Cities, *IEEE Consumer Electronics Magazine*, *6*(3), 60-70.

[26]. Ratti, C., & Claudel, M. (2016). The city of tomorrow: Sensors, networks, hackers, and the future of urban life. Yale University Press.

[27]. Randers J. (2019). The great challenge for system dynamics on the path forward: implementation and real impact, *System Dynamics Review*, *35*(1), 19-24.

[28]. Kitchin, R., Lauriault, T., & McArdle, G. (2012). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards, *Regional Studies, Regional Science*, *2*(1), 6-28.

[29]. Joss, S., Sengers, F., Schraven, D., Caprotti, F., & Dayot, Y. (2019). The Smart City as Global Discourse: Storylines and Critical Junctures across 27 Cities, *Journal Of Urban Technologies*, *26*(1), 3-34.

[30]. Engebretson, P. (2011). The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made Easy. Elsevier.