

Trends and Prospects for the Development of "Smart Cities" in Russia*

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Abstract—The article deals with the research of approaches and best practices of application of the concept of "smart city", allowing to increase efficiency of various parts of city infrastructure, which in turn become the engine and the core of innovative technologies introduction. Conceptual and practical approaches to understanding the category of "smart city" and its interpretation in the modern world are presented. The paper describes the structure of the "smart city", its most important and inalienable elements, their functions. In the course of the research, world examples of the development of "smart cities", the introduction of "smart" technologies, as well as the most successful projects and smart solutions in Russian practice were analyzed. Key success factors, existing requirements and possible prospects of the development of the concept under consideration were identified. A conclusion was made about the advisability of introducing these technologies in Moscow and St. Petersburg. The preliminary rating of "smart cities" of Russia is considered, its strengths and weaknesses are highlighted. This case has studied in the context of international experience of different countries and economic systems, conclusions were drawn about the key ways to implement the concept of "smart city".

Keywords—*smart city; smart economy; information and communication technologies; Internet of things; city; world experience; rating; social and economic development; spatial organization*

I. INTRODUCTION

Historically, the outstanding role of cities in the spatial organization of the state is to create reference points for the spatial development of the economy. "Smart City" is a new kind of city that provides sustainable growth and stimulating high-tech economic activity, which reduces the burden on the environment and improves the quality of life of the population. To effectively modernize the Russian economy requires the concentration of resources and the formation of strong points of "smart" economic growth with a certain industry specialization throughout the country.

II. THE CONCEPT OF THE "SMART CITY" — THE ESSENCE, CONCEPT AND IMPLEMENTATION

Currently, population of the world is more than 7.5 billion people, half of them – 3.7 billion – live in cities, while 10 years ago the share of the urban population was 35-40%. The concept of "Smart city" (e-City) is becoming more and more widespread solving the problems of transport congestion communications, emergency and municipal services of cities and services to the needs of rapidly growing population of world cities [1] [2] [3] [4].

Traditionally, city is considered as a system with a big complex of interdependent connections within itself, which includes both the residence of the population and the dynamic production of person necessities [5] [6] [7]. "Smart city" is a modern concept of integration of information and communication technologies for urban property management. The main purpose of the "smart city" is to improve the quality of life of the population with the help of urban information technology. The target is to improve service efficiency and meet the needs of residents based on three types of basic networks: communications, Internet and "Internet of things" (Internet of Things, IoT) [8]. This technology allows the city authorities to interact directly with communities and urban infrastructure, to monitor what is happening in the city and the development of the urban environment, as well as to find new ways to improve the quality of life. Through the use of sensors integrated in real time, the accumulated data from urban residents and various devices are processed and analyzed. The information collected is a solving management inefficiencies key. It is also important to note that the development and approval of the concept of "smart city" must necessarily involve all residents or residents of the locality to which it is planned to apply a particular development strategy. Each locality has individual economic, social and geographical features, and the development of the strategy is a unique task for each locality.

The first developments of "smart" urban technologies appeared in Barcelona and Amsterdam [9]. These technologies quickly spread to other urban centers: Copenhagen, Dubai, Singapore, Hamburg, and Paris, and following the example, and American cities are also

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becoming "smarter" headed to San Francisco, Chicago, New York, Miami and San Antonio. Companies such as Cisco, IBM, Intel, Silver Spring, Build.io, GE Lighting and Siemens are successfully operating in the commercial market of development and support of smart technologies.

Among the current definitions of «smart city», leaders of the industry can identify several approaches. GE Lighting believes that a digital city is a downtown that can collect data efficiently and bring the statistic in a way that is appropriate to the user. This can increase the revenues of the city budget, or finally offer citizens new services that they have never used before. Cisco defines "smart city" as a city that uses digital technology or information and communication technologies (connected through an intelligent network) to find optimal solutions to the problems of different areas of urban life. These areas may include Parking, traffic, transportation, street lighting, water management and waste management, security, even the delivery of education and health services. Smart city is based on technological solutions that optimize the support and delivery of urban services, reduce resource consumption and constrain the growth of prices.

There are many examples worldwide of the introduction of various "smart" technologies in the life of cities. Thus, Barcelona (Spain) pays great attention to the protection of the environment. Copenhagen (Denmark) - specializes in energy saving through various events, initiatives and actions with the active participation of the city residents. Vancouver (Canada) is a center of the clean technology industry. Montreal (Canada) - developed a single map for the use of public transport, as in Moscow. Vienna (Austria) is one of the safest cities in the world. Brisbane (Australia) - development of the bicycles as a transport program. Los Angeles and New York (USA) - apply a large number of "smart" technologies in the city life, such as led street lighting, smart meters, "green" energy, electric vehicles, "smart" Parking, transport services MaaS (Mobility as a Service), communication technology V2X (Vehicle - to-Everything), "smart" garbage collection technology ("smart waste") and emergency communication systems using satellites. Singapore (Republic of Singapore) is the smartest road system. Bogota (Colombia) is one of the cleanest cities in South America. San Antonio (USA) is famous for street lights adapt to adverse weather conditions for improved visibility and reduce accidents. In Chicago (USA), the city manages a population of rodents with the help of predictive Analytics, which determines which garbage containers will be filled in the near future and will attract more rats. In San Francisco (USA), a special application helps smartphone users to search for free Parking spaces throughout the city [10] [11] [12].

III. ELEMENTS OF THE "SMART CITY" SYSTEM

The basic subsystems of "Smart City" include six elements [13]:

- Intelligent Transport System
- Geoinformation System

- E-police
- E-security
- E-education
- E-health

Intelligent transportation system (ITS) optimizes traffic by displaying the traffic situation on the street dashboards and smartphone users, tells them the best route, controls the operation of the traffic lights depending on congestion of intersections showing the location and arrival time on a stop of public transport, the estimated time spent on the road, and many other useful features.

Geographic information system (GIS) serves as a common "geographic substrate" for all smart city subsystems.

E-the police (ePolice) works at any call to the remote "electronic police", the GIS map instantly displays the location of the caller and on the monitor of the duty opens a window for registration of the message. It helps with subsequent processing and taking operational measures.

Subsystem security (Safe City) based on the interaction with the service e-police. However the Subsystem will involve also all the other emergency services: ambulance assistance, fire, gas and energy, why use a Single command, or situational, center, reminiscent of the MCC – the mission control center. Such centers can be specialized-for the needs of the police, emergency services, emergencies Ministry and other government organizations. The screens can display images from cameras, a map of the city with the necessary objects and their movements, and other necessary information.

The e-education subsystem (eEducation) includes much more functions than the usual "distance learning» and helps to realize the dream of any student-to "attend" lectures without leaving home [14]. Sitting at the computer, the student will also listen to the lecture and see the teacher and follow his notes on the electronic "white Board" in the classroom. The student can even virtually "raise his hand" from home and ask a question to the teacher. And after the lecture, you can immediately take an exam on the assimilation of the material. All recorded lectures are saved for later viewing and fixing the material.

E-health (eHealth). Many urban residents are already familiar with the system of electronic appointments to the doctor. However, eHealth is able to a lot more. The basis of the system is a single electronic database of patients – residents of the city. When contacting a medical institution, the doctor often has to start with long-term inquiries about the history, as the patient's cards from the district clinic in his hands may not be at a time of an appointment. In a single electronic database, the doctor (with a certificate of access) can immediately be acquainted with what complaints the patient had previously, what tests were made, what treatment was prescribed in other clinics. The video conferencing system with the effect of presence (Telepresence), will help to hold a consultation of specialists, to consider in detail the results of MRI and radiography, and even to perform an

operation under the remote guidance of a highly qualified surgeon.

"Smart City" can include many other subsystems. This can be, for example, a single database for insurance companies, real estate cadaster, feedback system for residents of the city, where they can indicate the existing shortcomings and breakdowns. Also such an important system as «Smart Grid» for effective management of electricity consumption, which leads to improved environmental urban environment.

Various IT devices (servers, data storage systems, etc.) require more and more electricity for their power supply, usually generated by burning mineral fuel. And most of it falls on the power supply of devices for storage and processing of information. This share can now be up to 10-20% of the energy consumption of a large city. Therefore, the reduction of this category of costs is especially important from the point of view of both the urban budget and the ecology of the urban environment [15].

Thus, any "Smart City" project is, as a rule, a deeply integrated system consisting of many subsystems, which include various functional components. Each one of them can be used simultaneously in many subsystems. There is no point in implementing such projects "partially", for example, to create an autonomous Information technology system (ITS), and then deploy separate video cameras and platforms for security systems. It is necessary to start working with the development of a General concept of "smart city", which will take into account both the current needs of various urban services and prospects, including demography, ecology, needs of residents and the needs of various organizations and businesses. Therefore, Smart City projects require an integrated approach, which is the main difficulty in realisation.

IV. WORLD EXPERIENCE OF "SMART CITIES" DEVELOPMENT

The smart city of Amsterdam is a project involving companies, authorities, research institutes and residents of the city. Large (Phillips, Cisco, IBM) and small companies work together to implement smart technologies. One of the projects is Climate Street, in which garbage is collected by non-polluting electric trucks, and bus stops, billboards and lights are powered by solar energy. Thousands of households and companies have been modified by their roofs with energy-efficient insulation, which reduces energy costs.

To achieve the goal of a carbon-neutral city by 2025, Copenhagen has accelerated its "smart" technological revolution. Several innovative companies have created an eco-friendly "smart" area with a population of 40,000 inhabitants, which is a sustainable development area. Street lights are turned off when there is no traffic on the streets. Air quality sensors are installed in lampposts to monitor trends in pollution. Copenhagen provided its database to innovators, which allowed to develop applications to find available Parking spaces throughout the city.

Vienna, a growing capital with more than 1.7 million inhabitants, aims to become the greenest city in the world. The largest biomass power plant in Europe provides heating for 75,000 residential and public buildings. The city plans to install 300,000 m² of solar panels by 2020. Public transport around Vienna has become more affordable and now more than 90% of the city's population has a convenient opportunity to use it. In the city of 1.3 million passengers every day using smartcard system that automatically detects the fee for any type of transport.

Stockholm was named the first green capital of Europe in 2010. The city combines world-class IT infrastructure, creative, well-educated citizens and well-developed cooperation between science, trade and industry and the public sector. The world's largest open fiber optic network has pioneered smart, green and innovative solutions in Stockholm. Stockholm was the first city in the world with 4G network and transmitting over wide 3D broadcasting via fiber optic cable.

San Francisco is regularly recognized as one of the best places to live in North America. In order to obtain this high status, the work on the implementation of the concept of "smart city" was carried out by the city authorities for many decades. More than 40% of San Francisco's energy is currently derived from renewable sources. An electric vehicle infrastructure is emerging that already includes 110 public charging stations (the highest number per capita in the world). The city has improved the public transport system, there are applications that show cyclists and pedestrians the best routes. The city has developed applications for the use of public transport for visually impaired citizens. To achieve zero waste by 2020, the waste recycling system is actively expanding. To assist in achieving the objectives of the development of "smart" technology, the city opened a data base to software developers.

Glasgow received a state subsidy of £24 million for the implementation of the smart city program. The activities of this program will include the development of services and applications for local residents, providing real-time information about the movement of buses and trains, combining the cameras of urban video surveillance in a single system with the Department of traffic management for better detection of traffic accidents. Analytical software and video surveillance cameras will be used to identify and prevent crime, as well as to find new ways to supply gas and electricity for poor areas.

TABLE I. IMPLEMENTATION OF THE "SMART CITY" CONCEPT IN RUSSIA

	Project	Smart decision
<i>Skolkovo Innovation Center</i>	Scientific and technological project of complex commercialization of new technologies.	The joint center of city management, virtual service provider, smart grid, energy-efficient technology of water-heat supplies, maintenance, utilities.
<i>Smart city of Kazan</i>	New urban space for the development of business, educational and research activities.	Online resource monitoring, storm water use, coordination and integration of traffic flows.
<i>Innopolis (Kazan)</i>	Innovation city for IT professionals and IT companies.	Extensive engineering, municipal and road-transport infrastructure, unified system of housing and communal services management based on energy-efficient technologies and process informatization.
<i>Smart city of Ulyanovsk</i>	Smart City Ulyanovsk is a smart aviation industry project	Best world practices in construction, energy saving and communications technologies.

Foreign countries take an active part in the implementation of the concept of "smart city" on the territory of Russia [16]. In December 2016, the Ministry of construction of Russia and the Ministry of national lands, infrastructure, transport and tourism of Japan signed a Memorandum of cooperation in the field of improving the urban environment. Voronezh and Vladivostok were selected as pilot project territories. In particular, it is planned to develop the territory of the international airport in Voronezh. Other projects include the construction of a waste recycling plant, a "smart and healthy home" and the fight against traffic jams with the help of "smart" traffic lights. The basis of the work of the latter will lay the Japanese technology, which allows you to adjust the movement in the online mode based on the analysis of the current traffic flow. Special attention will be paid to the development of innovative urban

planning. To solve the problems of planning dense and high-rise urban development, as close as possible to major transport hubs, specialists of the world-famous architectural Bureau Nikken Sekkei are involved. With this approach, users of public transport will be able to quickly get to the objects they need.

Huawei (engaged in the development of smart economy in major cities of China with a population of more than 15 million people – Shanghai, Guangzhou, Karamai – and other cities of the world) took part in the project "Safe city" in St. Petersburg, providing a solution for cloud storage and analysis of video files with 12 thousand cameras of outdoor intelligent The system provides high efficiency of security measures.

V. RUSSIAN "SMART" CITIES" RATING

The Institute for Internet development (IRI), PJSC Rostelecom and the national Association of industrial Internet presented in December 2016 the methodology and evaluation criteria that will form the basis for the formation of the "smart cities of Russia" Rating. The project "Russian smart cities Rating" assesses the level of readiness of the pilot environment and its infrastructure for the use of intelligent technologies within the framework of the smart city concept – in terms of housing, energy, transport, e-government and industry. The study will be based on a field survey (representatives of municipalities, Federal agencies, etc.), as well as expert evaluation of the decisions and approaches used in the cities under consideration. The project will be a driver of the theme of digitalization of cities in Russia, creating a single center for collecting the best domestic solutions in this area. The preliminary rating of "smart" cities of Russia is presented in "Table II".

TABLE II. THE RATING OF THE POTENTIAL OF "SMART" DEVELOPMENT OF CITIES OF RUSSIA

	Economic potential (production)	Economic potential (population)	Housing potential	Innovative potential	Human resources	Social potential	Ecological potential	Assessment of the potential of "smart" development	Population 2010
<i>Moscow</i>	0.81	0.81	0.55	0.87	0.82	0.63	0.97	0.78	11514.13
<i>Saint-Petersburg</i>	0.51	0.51	0.49	0.75	0.74	0.55	0.97	0.58	4848.7
<i>Podolsk</i>	0.22	0.44	0.83	0.43	0.39	0.59	1	0.49	188
<i>Tomsk</i>	0.08	0.34	0.35	0.65	0.71	0.54	0.98	0.48	544.3
<i>Krasnogorsk</i>	0.10	0.44	0.72	0.53	0.36	0.58	1	0.47	116.7
<i>Zhukovsky</i>	0.11	0.44	0.59	0.41	0.42	0.63	1	0.46	102.7
<i>Khimki</i>	0.15	0.5	0.54	0.47	0.37	0.56	1	0.46	207.1
<i>Novosibirsk</i>	0.12	0.31	0.48	0.63	0.58	0.44	0.95	0.46	1473.7
<i>Lyubertsy</i>	0.07	0.39	0.8	0.45	0.36	0.51	1	0.45	172
<i>Novy Urengoi</i>	0.35	0.53	0.42	0.07	0.61	0.59	1	0.45	104.1
<i>Korolyov</i>	0.09	0.45	0.49	0.54	0.39	0.53	1	0.45	183.5
<i>Shchelkovo</i>	0.06	0.41	0.64	0.42	0.42	0.56	1	0.45	110.4
<i>Yekaterinburg</i>	0.11	0.38	0.49	0.45	0.56	0.48	0.99	0.45	1383.4
<i>Odintsovo</i>	0.06	0.41	0.72	0.48	0.26	0.58	1	0.44	139
<i>Almetyevsk</i>	0.09	0.38	0.49	0.26	0.59	0.62	0.99	0.44	146.3
<i>Pushkino</i>	0.07	0.39	0.79	0.36	0.37	0.46	1	0.44	102.8
<i>Balashikha</i>	0.12	0.4	0.72	0.31	0.39	0.5	1	0.43	215.4
<i>Voronezh</i>	0.08	0.27	0.46	0.38	0.49	0.66	0.99	0.43	975.7

	Economic potential (production)	Economic potential (population)	Housing potential	Innovative potential	Human resources	Social potential	Ecological potential	Assessment of the potential of "smart" development	Population 2010
<i>Petropavlovsk-Kamchatsky</i>	0.19	0.32	0.32	0.37	0.67	0.45	0.99	0.43	179.5
<i>Nizhny Novgorod</i>	0.11	0.27	0.4	0.54	0.57	0.42	0.98	0.43	1259.7
<i>Arzamas</i>	0.06	0.23	0.5	0.51	0.58	0.41	1	0.43	106.4
<i>Murmansk</i>	0.1	0.37	0.36	0.39	0.56	0.53	0.98	0.43	307.7

The proposed rating will allow to identify and identify leaders in the use of technical and innovative potential in urban management for the purpose of promoting best practices in the implementation of "smart" technologies. The final version of the rating is planned to be presented based on the results of the work with the regions in autumn 2017. However, according to the preliminary version of the rating, the authors of the article are very debatable about the inclusion of the production component in the integrated assessment of the potential of "smart" development. Economic potential is rather a condition and source of development of all other elements of the "smart city". In addition, the innovative sector of the economy with high-performance industry, knowledge industry and high-quality and innovative services should come to the first place in the post-industrial society [17]. In this regard, innovation, human and environmental potentials are absolutely clearly consistent with the essence and structure of the concept of "smart city".

VI. EXPERIENCE IN APPLYING THE "SMART CITY" CONCEPT IN THE FORMER USSR

The experience of using the innovative environment "Smart city" of some of Russia's closest neighbors, who until recently were in the unified political and economic system of the USSR and similar to Russia in some aspects of public administration, is of interest.

Astana (Kazakhstan) – in the near future will become the center of smart lighting. It is expected that about 90% of the lighting in Astana will be replaced by 25 thousand modern energy-efficient lamps, which can reduce energy consumption by more than 60 percent. Akimat of the Aktobe Region also falls under the program of development of Kazakhstan. On February 2, 2017, ROSTEC Corporation announced the signing of a Memorandum on strategic cooperation between Rusinformexport and the Akimat of the Aktobe Region for the development of a target model of a Smart city.

Baku (Azerbaijan) – the Smart city project is being implemented in Baku by Huawei and the Ministry of Transport, communications and high technologies of Azerbaijan. Azerbaijan has developed the Concept of "Azerbaijan 2020: a look into the future" and a strategic roadmap for the development of telecommunications and information technologies. Thus, the project "Public Wi-Fi" launched in the capital of Azerbaijan the process of digitalisation. It is also planned to implement the system of "Smart transport", "Smart port", and "Smart trade".

Batumi (Georgia) – it is planned to introduce a system of "smart city", which will explore the climate in the city and give recommendations in cases of worsening weather conditions. Batumi will be one of the first "smart cities" in the world, where with the help of climate monitoring system it will be possible to plan the architectural development of the city, to predict the risk of natural disasters, to improve the tourist infrastructure of the city, to inform drivers about changes in the road situation due to weather conditions, as well as to develop the agro-industrial sector. Seven SYNOPTIC automatic control centers have already been installed in Batumi and its surroundings. They will accumulate the entire range of weather data and generate various forecasts, as well as through a specially developed warning system for services and district administrations to inform about the approaching meteorological danger.

VII. CONCLUSION

According to the study, the main approaches can be identified. It can be used to enhance the intellectual capabilities of cities.

The first approach involves the introduction of a key application in the urban device to solve the most acute problem, such as congestion, and then adding other applications over time.

The second approach is to create the basic infrastructure, a platform needed to support a wide range of intelligent applications and services.

In the third approach, several applications are implemented in the framework of pilot projects to assess their effectiveness before making decisions on a long-term use.

The transformation of a simple city into a "smart" is a complicated task. Technologies and business models are developing rapidly, and this leads to uncertainty in many aspects. Standards of formation and development of "smart city" are already beginning to appear, but their creation is still very far from completion. There is no easy way to provide intellectual opportunities for the development of a particular city [18]. However, there are several conditions that must be observed – to take into account all possible factors of functioning and development of the city, to maintain realistic expectations and learn from the experience of others. These may be other cities solving the same problems, although in a different context [19][20] [21] [22]. These may be suppliers who have already gained some experience in the implementation of "smart" technologies. It can be young companies, which are often excellent

innovators. And first of all, it is the citizens themselves – faithful helpers along the way.

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