Digital city: the characteristics of development indicators of new technologies

G I Kurcheeva¹, G A Klochkov²,5, T A Aletdinova³, A A Lapina⁴

¹ Novosibirsk State Technical University, 20, Karl Marx av., Novosibirsk, 630073, Russia
² Novosibirsk State University of Economics and Management, 52/1, Kamenskaya str., Novosibirsk, 630099, Russia
³ Limited Liability Company "Green Forest", 12, Nikolaev str., Novosibirsk, 630090, Russia
⁴ North–Caucasus Federal University, 2, Kulakov av., Stavropol, 355028, Russia
⁵ E-mail: klgeorge@yandex.ru

Abstract. There is a need in modern society for regular monitoring of changes in the quality of life of the population as an important criterion for the effective management. Monitoring today is one of the main parts of any project. The authors identify indicators that reflect the introduction of smart city technologies and the corresponding possible implementation of new technologies based on such concepts as inter-machine interaction (M2M) with a centralized management server and blockchain network organization. Monitoring, because of its focus on tracking a process, becomes the basis for making decisions in investment distribution. It makes recommendations that will allow one to move away from considering the static state of the processes and adjust the development of the "smart city" trends.

1. Introduction

We could define “smart cities” as systems that integrate various areas of activity within a single urban space. In modern society, in accordance with the tasks set by the federal authorities and the regional government, there is a need for regular statistical monitoring of changes in the indicators of the quality of life of the population, as this is the most important criterion of the effective management of any settlement, city, or region. Monitoring today is one of the main parts of any project, since tracking and evaluating results is just as important as the effect of implementation.

The term “monitoring” is defined as constant supervision of a process in order to make sure it meets its objectives or is compliant with initial assumptions. Nowadays monitoring has become a promising area of activity which covers absolutely all spheres of human life: ecology and biology, medicine, economics and business, industry and education. The information that researchers receive as a result of measurements should meet the monitoring objectives. This concept of monitoring seems to be quite understandable; however, the monitoring systems do often keep track both of necessary information and unnecessary or redundant information as well.

Objective of this study is to evaluate and identify the characteristics of indicators reflecting the implementation of smart city technologies and the corresponding possible implementation of new
technologies based on concepts such as machine-to-machine (M2M) interaction with a centralized management server and network organization blockchain.

We conduct our study based on the comparison of standards and indicators. The standard values for these concepts are considered by the authors as the maximum possible ones, while the indicators are looked upon as current values obtained by monitoring.

Standards, especially international ones, are created only on the basis of best practices and the possibility of their wide application for solving important problems. The introduction of smart city technologies is reflected in the international standard ISO 37120: 2015 “Sustainable development of communities - indicators for city services and quality of life”, updated in 2015 [1, 2] which was the first successful effort of experts to create integrated view for performance analysis of urban areas. The standard provides uniform definitions of measured values and methods of their use and introduces common basis for reporting, comparison and benchmarking.

The development of new technologies based on such concepts as machine-to-machine interaction (M2M) or the blockchain system is the reason for development of new standards and indicators.

2. **International experience in problem research**

Let us look at the internationally recommended key standards for smart cities developed by leading organizations and national standardization agencies.

Standards of Smart Cities of the International Organization for Standardization (ISO): ISO is the fundamental body that promotes and develops the protection of people’s rights in smart cities for economic and environmental sustainability. The ISO Strategic Advisory Group uses the following working definition: “Smart City” is a city that dramatically increases its social, economic and environmental outcomes, responding to challenges such as climate change, rapid population growth, and political / economic instability by fundamentally improving how it engages society, how it applies collaborative leadership methods, how it works across disciplines and city systems and how it uses data information and modern technologies in order to provide better services and quality of life to those who live in the city participate in its life now and in the foreseeable future, without an unfair disadvantage of others or degradation of the natural environment [3, 4].

International Telecommunications Union (ITU): ITU is another global body that develops standards for smart cities [5]. “A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve the quality of life, the efficiency of urban exploitation of services, while ensuring that they meet the needs of present and future generations of people, and with respect to economic, social, environmental as well as cultural aspect ” [6].

There is the British Standards Institution in the UK. In addition to the organizations setting global standards, many countries are considering the development of their own standards aimed at the increase of intelligent cities around the world [7]. For example:

- UNE 178303 establishes requirements for the proper asset management of the city. This document is addressed to all types of local organizations (municipalities, associations of local governments, counties, etc.), regardless of their size, complexity, or technology they possess;
- UNE-ISO 37120 reflects the international indicators of the city sustainability, which have joined the already published ISO 37120.42 standard [8].

Germany is a member of the European Innovation Partnership (EIP). For smart cities and communities, DKE (German Commission for Electrical, Electronic and Information Technologies) and DIN (German Institute for Standardization) have developed a joint roadmap and recommendations for activities in Germany. Its goal is to highlight the need for standards and serve as a strategic template for
national and international standardization in smart city technologies. The “Standardization Road Map” shows the main activities required to create “smart cities”.

ISO, ITU and BSI are the most widely recognized standardization bodies for Smart Cities nowadays. However, national standard setting organization of several other countries like Spain, China, Germany, Singapore, etc. are in the process of developing smart cities standards for building safe and secure smart cities in their respective countries [9].

The indicators of smart sustainable cities developed by the UNECE were modified as follows: these indicators with the addition of new data could be divided into two subgroups of indicators: the main ones (relevant for Smart Cities and for transition type cities) and advanced ones (suitable only for “Smart Cities” and existing for their further evaluation at an advanced level).

Examples of indicators for economics, recreation and safety are shown in Table 1. More detailed information about ISO 37120 indicators can be found in ISO 37120.46: Core Indicators. The document also contains information about available sources of data for indicators assessment.

| Table 1. Examples of indicators of ISO 37120 [3] |
|-----------------------------------------------|
| Basic indicators by aspects | Core indicators | Supporting indicators |
| Education | The proportion of female school-aged population enrolled in schools | The proportion of male school-aged population enrolled in schools |
| | Primary education coverage: school-leaver rate | The proportion of school-age population enrolled in schools |
| | Secondary education coverage: school-leaver rate | Number of higher education graduates per 100,000 population |
| | Ratio of pupils and teachers in primary education | |
| Recreation and entertainment | Total area of public indoor recreation space per capita | Total area of public outdoor recreation space per capita |
| Security | Number of police officers per 100,000 inhabitants | Crimes against property per 100,000 inhabitants |
| | Number of homicides per 100,000 inhabitants | Police response time to primary call |
| | | The number of crimes against the person per 100,000 inhabitants |

ISO 37120 is important because it:
- stimulates and supports sustainability, effective management and provision of services;
- facilitates access to urban services, infrastructure, institutions (especially outsourcing ones);
- improves work environment in the city;
- increases transparency and accountability of public services;
- uses project financing with special emphasis on the impact of the city budget on the quality of life;
• transparency and open data for infrastructure development in the public and private sectors and investment attractiveness;
• makes possible various benchmarking options, goal setting and benchmark assessments in policy design and planning;
• helps to create core knowledge for city-level decision making and to provide benchmark assessments and global benchmarking;
• supports new open data and new application development.

Therefore, standards are indispensable to develop new indicators of the quality of life and to assess the current state of these indicators.

3. Monitoring of internet of things indicators
Means and methods of monitoring vary depending on the field of activity in which monitoring is carrying out. However, we could emphasize the most common ones, i.e., current observation, test situation method, survey method, testing, and others.

Successful implementation of smart city technologies depends on the following factors:
• accounting and monitoring of pre-developed and planned key performance indicators individually for each area of city life;
• ensuring timely, uninterrupted, fast data exchange between implemented information and communication technologies, taking into account compliance with all laws of the country (for example, the introduction of blockchain technologies with all basic properties such as transparency, speed, decentralization, etc.).

On the one hand, it is necessary to consider indicators for well-known foreign "Smart City" projects. On the other hand, one must to take into account indicators that have been developed and adopted for monitoring urban environment in Russia. There are more than 50 of such indicators for assessing the level of "development" of a city in accordance with GOST ISO 37120 - 2015, but all of them fully reflect the state of the urban environment with no relation to a "Smart City". These are the following groups of indicators:
• indicators for keeping a record of the introduced new technologies,
• indicators measuring the effectiveness and efficiency of the new technologies introduced,
• indicators of data exchange speed between implemented technologies in compliance with the country’s law, and so on [10].

Thus, we have attempted to form an array and a sample of new indicators for quality of life by interviewing and questioning the inhabitants of the city of Novosibirsk.

4. Development of new indicators for quality of life in the context of the “smart environment” section
Analysis of the information array shows that the respondents prioritize the following “smart city” aspects: “smart environment” – 24 indicators, “smart infrastructure” – 25 indicators, “smart transport” – 21 indicators, “smart medicine” – 27 indicators, “smart education” – 28 indicators, “smart economy” – 22 indicators, “smart management” – 24 indicators, “smart technologies” – 27 indicators.

Thus, two thirds of the residents of the Novosibirsk region (67%) prioritized the following indicators, noting their importance for well-being improvement (Table 2).

Sample interviews and selective surveys show that residents of the region choose indicators for the aspects of “smart city” development that are vital for improving the environment quality. It should be noted that current standards developed within the “smart city” program in Russia do not sufficiently reflect the progress already made in the development of new technologies.
The function of monitoring as tracking of real processes is actively manifested in various fields of science. Attempts are being made to classify monitoring studies depending on the strands of scientific research as well as on the purpose, spatial and temporal parameters, scale and level of implementation.

Table 2. Examples of the development of new quality of life indicators (developed by the authors)

| Key indicators                                      | Specification                                                                                                                                 |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Share of ecological transport                       | The ratio of people who use eco-friendly, non-polluting transport to the total number of people with cars. Calculated in manual way (manual calculation of the percentage share) |
| Growth/Reduction of wastewater discharges into the basins of rivers and lakes | Shows a change for waste generated by various types of economic activity. Calculated as a difference between the last two periods. |
| Ratio of residential waste recycling                | The ratio of recycled residential waste to total waste                                                                                      |
| Ratio of naturally and artificially restored forest areas in the country | The ratio of the total restored forest area and artificially restored forest areas is calculated in percentage terms |
| Number of waste collection points                   | Shows the total number of collection points in the city and suburbs. Calculated in quantitative terms from zero.                             |
| Average indicator of air quality in the city        | The presence of harmful impurities in the air                                                                                               |
| Renewable energy consumption and production         | The number of renewable energy sources and the number of renewable energy consumers                                                        |
| Number of waste recycling plants in a city boundary | Shows the number of industrial waste-recycling enterprises. Calculated in quantitative terms from zero using the maps of geographic information systems |
| Number of enterprises / organizations using alternative energy sources | Shows the number of enterprises switched to green energy solutions. Calculated in quantitative terms from zero |

However, unlike statistics and sociological surveys, monitoring cannot be reduced to collection of ascertaining data. Monitoring, by virtue of its focus on process tracking, appears to be more effective, pertain directly to identifying new opportunities, providing the conditions for their implementation, and even to strategies. After all, the “power of fact” and the data obtained can form a framework for the recommendations, which enables one to do without snapshot analysis, to play a constructive role and to implement a new rational action.

The authors believe that the development of new quality of life indicators and data mining for their evaluation are necessary to develop a monitoring system for the large cities and other urban areas in the Novosibirsk region. Selection of the performance estimates for the technologies organized in the blockchain and machine-to-machine communication structures is a necessary step to single out the characteristics of the indicators developed for “smart city” aspects. It is known that the Bitcoin protocol is built on the blockchain technology. Third generation blockchain platforms are already available now with the throughput reaching tens of thousands of transactions per second, which is exactly what is necessary for all the physical sensors that form the backbone of the “smart city”, namely, for timely exchange of information and real-time reflection of the situation in the city instead of data accumulation and their sending once a day/ an hour, as it is happening now.
Although there are several startups offering blockchain solutions, none of them has yet achieved widespread recognition as they face the competition of existing, well proven technologies. Therefore, to facilitate the implementation of the blockchain technology and to demonstrate its real benefits for the users it is necessary to find additional, ubiquitous applications for this technology, which, however, may be regarded as a novel technology with a potential for improvement as regards the efficiency and technical capabilities.

The review of the developments in this field shows that the blockchain technology has various characteristics that are further analyzed with regard to practical applications, selection of key characteristics and development of functions such as medical records digitizing, execution of documents such as wills and legal contracts, financial management and others. As a result, we could form new indicators

5. Conclusion
The function of monitoring indicators of the development of the city allows you to track the real transformation processes on the way to creating a digital city. Directly for a smart city, you need to determine the minimum allowable values for each of the indicators in order to consider it as such. Own ICT initiatives can potentially effectively increase the level of technology development and the level of indicators of the quality of life of the population.

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