

THE SMART CITY: TECHNOLOGY, FUNCTIONALITY AND CHALLENGES

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ABSTRACT

There has been a constant trend of urban population growth in the world, putting pressure on existing infrastructure, resources, governance, public health and ecosystems. The city management is becoming very big challenge. Smart city implies an intelligent city management that uses information and communication technologies (ICT) to create a more sustainable, humane and efficient environment. This paper considers concept of smart city, its technologies, functionalities and challenges.

Key words: smart city, infrastructure, intelligent city management.

INTRODUCTION

During the past centuries, there are a constant trend of world urban population growth, i.e. the process of urbanization. The United Nations predicts that nearly 70% of the population in the world will live in cities by 2050 (United Nations, 2019). This constant growth in urban population makes pressure on existing infrastructure, resources, governance, public health and ecosystems. Traditional models of urban governance are becoming unsustainable under the burden of energy crises, water consumption, inefficient waste management, traffic congestion and air pollution.

The solution is the concept of a smart city (Albino et al., 2015). In general, smart city uses different technologies (Big Data, Cloud Computing, Machine Learning & Artificial Intelligence, Internet of Things) to improve the infrastructure management, optimization of city functions, quality of life of its citizens, intelligent governance and fostering economic growth. The essence of a smart city is not in the technology itself, but in its application to create an efficient, sustainable and humane environment.

The population in the cities mainly lives from industry, trade and services, unlike villages where the majority of the population lives from agriculture. The increase in the number of inhabitants in cities has had its great advantages (quality education, availability of cultural content, exchange of goods and ideas, accessibility of markets, cheaper and more efficient transport, hydrotechnical and telecommunication systems, high-quality energy, etc.), but also disadvantages (pollution, higher cost of living, smaller living space, increased crime, increased mortality, increased stress, etc.) (Caragliu et al., 2011). In this context, the smart city represents a possible solution to create an efficient, friendly and safe environment for people by alleviating the current shortcomings. The main goal of a smart city is to improve the lives of its residents through the application of information and communication technologies and intelligent decision-making based on the analysis of large amounts of data.

In the big cities, management of critical infrastructure presents a challenge of the future (Rinaldi et al, 2001) (Lewis, 2014). The term infrastructure consists of two parts, both of which originate from the Latin language - the first part "infra" means below, lower or under, and the second part "structure" means construction, masonry or building. The translation of the word infrastructure would be "under buildings", which does not correspond to the real circumstances, because a significant part of the

infrastructure is not in the ground, i.e. under buildings. Based on this, we distinguish between underground and aboveground infrastructure. Of particular importance is the so-called critical infrastructure, whose disruptions cause serious consequences for the population - they can endanger people's lives and health, and they can threaten the security and economic stability of the state and its citizens.

THE TECHNOLOGICAL ARCHITECTURE

To make a city “smart”, it is necessary to establish a multi-layered technological architecture that allows for the collection, transmission, analysis and decision-making based on real-time data. This complex architecture generally consists of the four key technology layers:

- 1) The physical layer that includes sensors and devices (Internet of Things - IoT). Sensors constantly collect data about the city, and devices implement smart decisions. This layer consists of billions of connected sensors and devices (smart water and electricity meters, air quality and noise level sensors, traffic surveillance cameras and sensors in waste containers, devices that smartly manage city infrastructure, etc.).
- 2) The communication layer, which is based on the data transmission network. Data collected from sensors must be quickly and securely transmitted to central systems where they are processed and analyzed. A key role here is played by next-generation networks (e.g. 5G networks), which enable mass data exchange.
- 3) Data and analytics layer that includes data storage and processing. Raw and unstructured data has no value without analysis. Through cloud platforms (Cloud Computing) and the application of machine learning (ML) and artificial intelligence (AI) algorithms, city systems analyze data, recognize patterns and predict events (e.g. predicting traffic congestion, early detection of failures in the electricity distribution network or water supply network, etc.).
- 4) Application layer includes platforms for managing the city and its infrastructure, as well as applications for citizens (e.g. applications for public surveys, reporting utility problems, finding parking spaces, paying for services, submitting requests, etc.).

THE SMART CITY FUNCTIONALITY

The effect of a smart city can be observed at the level of its individual functions, but also at the level where the same individual functions are integrated into a harmonious whole. This section will discuss functions of a smart city through various examples from common urban life.

Smart traffic systems

It is well known that traditional traffic systems in large cities are one of the biggest sources of congestion, stress and pollution with a bad effect on people's health. Smart traffic lights adjust cycle times to the current flow of vehicles and significantly reduce congestion and stress. In addition, smart traffic lights force the green light for the passage of public transport and emergency vehicles. Smart parking systems presents the number of free parking spaces in real time and optimally direct drivers, in order to reduce unnecessary congestion. Mobile applications of the public transport allow citizens to optimally plan their trips through the city. The use of electric and autonomous public transport vehicles is becoming increasingly common in the numerous cities.

Smart traffic systems are based on a network of cameras, sensors and devices, which collect data in real time. By analyzing this data, city services can quickly respond to traffic jams and accidents, as well as risky weather conditions. These systems also encourage the use of bicycles and other sustainable modes of transport through the development of smart bike lanes and bike-sharing systems.

Such systems reduce fuel consumption and the negative impact of traffic on the environment, while improving the quality of life of citizens.

Smart energy consumption and sustainability

Smart grids are modern power grids that enable the two-way flow of electricity and information, thereby ensuring more efficient management of energy production, distribution and consumption. They enable easier integration of renewable energy sources (e.g. solar panels, wind turbines, etc.), contributing to greater energy efficiency, system reliability and reduced negative environmental impact. An increasing number of cities are implementing smart street lighting with LED technology that dims when there are no pedestrians or vehicles, achieving significant energy savings.

Smart meters play a fundamental role in smart energy management, since they enable accurate measurement of electricity, gas and water consumption. Users can monitor their consumption in real time via mobile applications or web platforms, which helps them more easily identify unnecessary costs and use resources more rationally. In addition, many residential and commercial buildings are installing smart flow meters and thermostatic radiator valves. These devices automatically regulate the amount of thermal energy in each room depending on the temperature and the presence of the user, thus avoiding unnecessary heating of the space and achieving additional energy savings. In winter, heating and in summer, cooling of empty rooms are reduced, and based on the detection of user arrival, it is increased, thus achieving significant savings.

By applying these technologies, smart cities reduce energy consumption, maintenance costs and emissions of harmful gases, while contributing to sustainable development and environmental protection.

Smart water supply and sewage management

Smart water and sewerage infrastructure enables the application of modern information and communication technologies for the efficient management of water supply and wastewater disposal. The integration of sensors, devices and systems for remote monitoring and real-time data analysis enables continuous monitoring of the condition of the water and sewerage network, water quality, pressure levels and flow. Such systems enable rapid detection of leaks, failures and other anomalies, thereby reducing water losses, maintenance costs and the risk of supply interruptions. In addition, smart sewage infrastructure enables significantly more efficient management of wastewater and its quality, monitoring of network load, and timely response in the event of failure, flooding or congestion. In this way, the reliability, resilience and sustainability of critical municipal infrastructure are increased, while at the same time improving the quality of services for citizens and protecting the environment.

E-government in smart cities

E-government improves the accessibility, efficiency and transparency of public administration by using information and communication technologies. The digitalization of administrative procedures and public services for individuals and legal entities enables easier access to administrative procedures, while reducing time and financial costs. Various software applications are used that enable electronic communication between individuals and legal entities and public administration. For example, submission of requests for the issuance of documents, payment of taxes, fees and utility services, scheduling of appointments in state institutions, reporting of utility problems (breakdowns, illegal landfills, road damage, etc.), participation of citizens in decision-making through surveys and public hearings, monitoring of the status of requests and receiving notifications in real time, etc. The integration of e-government into the smart city concept contributes to the optimization of urban resource management, the improvement of the quality of public services and the strengthening of citizen participation in decision-making processes. In this way, e-government is not only a

technological innovation, but also an instrument of public sector modernization that fosters sustainable, inclusive and data-driven urban development.

Security in smart cities

Given that the functionality of a smart city is based on the application of information and communication technologies, security is one of the key aspects of the smart city concept, as it encompasses the protection of citizens, infrastructure, data and information systems. Smart cities use sensor networks, video surveillance systems, big data analytics and artificial intelligence for the timely identification of potential security risks, with a quick and efficient response by the competent services. The integration of various data sources enables continuous monitoring of the urban environment, improving emergency management and increasing the city's resilience to natural disasters, traffic incidents and other risks. At the same time, the development of such systems imposes the need for high standards of cybersecurity and protection of citizens' privacy, in order to ensure the safe and responsible use of collected data.

CONCLUSIONS

The smart city concept is based on the applications of information and communication technologies (ICT) to improve the management of urban resources and services, with the goal to improve the quality of life of numerous citizens and achieve sustainable development. This paper presented smart city through an analysis of its technologies, functionalities and challenges.

REFERENCES

- United Nations: Department of Economic and Social Affairs, Population Division. (2019). *World Urbanization Prospects: The 2018 Revision*. New York: United Nations.
- Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, 22(1), 3–21. <https://doi.org/10.1080/10630732.2014.942092>
- Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart Cities in Europe. *Journal of Urban Technology*, 18(2), 65–82. <https://doi.org/10.1080/10630732.2011.601117>
- Stephen M. Rinaldi, James P. Peerenboom, & Terrence K. Kelly (2001). Identifying, Understanding, and Analyzing Critical Infrastructure Interdependencies. *IEEE Control Systems Magazine*, 21(6), 11–25.
- Lewis, T. G. (2014). *Critical Infrastructure Protection in Homeland Security: Defending a Networked Nation* (3rd ed.). Wiley.