Model of an IT Platform for Serving the Population of a Smart City

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Abstract

The rapidly remaining population generates many problems in urban areas. To solve problems of this type, Smart cities were created - where management takes place with the help of the latest advances in technology. For this reason, this article was written where various technologies related to the "smart city" were researched and analyzed, and the "smart city" platform was conceptualized. The definition of "smart cities" was investigated from a scientific, technological and economic point of view. In the second part of the article, the multilayer model of the smart city platform was discussed. The creation of such a logical structure will simplify the smart city platform and its actions.

Keywords

Smart City, Smart City Platform, Smart city Reference Model

1. Introduction

Rapid population growth is observed all over the world. According to scientists, by 2050 it will account for 70% of the world's population [1]. With the increase in the number of cities and megacities, there are many problems associated with high population density, urban traffic and efficient use of resources. For this reason, ambitious projects are being implemented in many countries to develop modern urban infrastructure based on the use of modern technologies – this concept has been called "Smart City". A smart city should be characterized by a highly efficient economy and management, a high standard of living, mobility and respect for the environment for long-term sustainable development. To solve the problems of modern cities, new generation IT systems are being developed and tested, using big data analytics, complex computer modeling, applying the results of the latest scientific research in the field of sociology and human behavior.

With the help of information and communication technologies (ICT), it is possible to solve various problems of sustainable development of the urban environment on the scale of the entire ecosystem and its environment. The number of smart cities projects in the world (planned or already implemented) has exceeded 400. Of these, most of the projects are focused on energy.

Using examples of three types of cities that differ both in the design of existing infrastructure systems and the initial level of development, the McKinsey Global Institute has calculated how about 60 modern smart city solutions affect various aspects of the quality of life. The use of these new tools gives a number of positive results: in particular, they can reduce mortality by 8-10%, increase the efficiency of emergency response by 20-35%, reduce the average time spent on work and back by 15-20%, reduce morbidity by 8-15%, and also reduce greenhouse gas emissions by 10-15% [2].

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Figure 1: Planned Smart City indicators of the European Union by 2030 [3]

2. Smart City

To ensure comfortable living conditions for a person in large cities and megacities, a deep understanding of the concept of a "smart city" is required. At the same time, the term itself is already used all over the world in various contexts and meanings. A number of variants of the frequently used term are formed by replacing the adjective smart with adjectives such as digital, connected or intelligent.

One recognizes the term ”Smart City" as a way to refer to a purely urban phenomenon, noting that the "smart city" marker is a concept and it is not always used consistently. Below are several working definitions that can be found in materials that have scientific goals and describe the concept from various points of view [3]. A brief concept of a "smart city".

2.1. Scientific view

A smart city is a safe, environmentally protected, efficient urban center with a developed infrastructure of sensors, electronics and networks, which ensures sustainable economic growth and a high quality of life" [4].

"The city will become smart when investments in human and social capital, as well as in traditional (transport) and modern (ICT) communication infrastructure will contribute to sustainable economic growth and a high quality of life." These investments should be supported by sound management of natural resources through the participation of the city administration"[5].

"This is a city that strategically builds and implements the development of the economy, human capital, city management system, mobility infrastructure, environmental protection and quality of life." This development is based on a reasonable combination of donations and the activities of citizens who consciously and freely make decisions"[6].

2.2. Economic view

"The smart city is an advanced and high-tech city that unites people, information and elements of urban infrastructure. It has a simple system of management and servicing of the municipal economy and uses new technologies for the sustainable formation of a green city (improving environmental protection), creating a competitive and innovative Trade and improve the quality of life "[7].

2.3. Information and Communication Technology view

With the help of intelligent computing technologies, it is possible to make urban infrastructure more intelligent and efficient." The components of the city service include the city administration, education, healthcare, public order, real estate, transport infrastructure, etc. [8].

A smart city is based on intelligent equipment and their exchange of information flowing between large subsystems. The city transforms the information flow into services for citizens and processes it for its ecosystem for more sustainable and cost-effective resources [9].

2.4. Smart City Platform

The elements of the city platform are basic for the implementation of smart city services [10]. According to the latest data, the European Community has set three main goals:

- Speeding up the process of launching services;
- Adaptation of different solutions in the industry;
- Standardization - to bring decision-making up to the level of international standards.

As for the relationship with other components, the picture is quite transparent. At the lower level - interaction with sensors. These are the platforms and standards of the Internet of Things (IoT). A typical example of modern development that is directly related to the topic of smart cities is HyperCat [11]. Please note that another popular abbreviation - M2M (Machine to Machine) belongs to the same category as IoT. In principle, technically it is practically the same thing; the only difference is in the presence (absence) of user interfaces. These interfaces are present in IoT and are absent in M2M. In terms of platforms and standards, the picture in M2M is similar to IoT [12]. The urban platform is a higher level that uses IoT as a tool. Fig. 2:

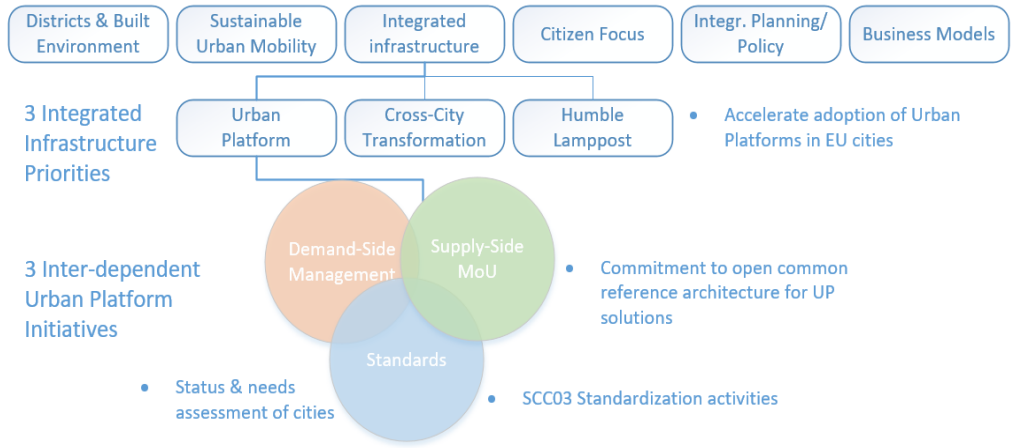

Figure 2: City Platform

European developments will solve the following tasks:

- Ensure interaction between elements of urban infrastructure.
- Ensure the transfer of solutions between different cities.
- Support for scaling processes with increasing load.
- Provide common programming interfaces (APIs) for developers and related tools (SDKs) to speed up the development process.

Initially, it is assumed that the architecture should contain (support) several levels. In particular, the following components are mentioned:

- Infrastructure.
- Data management, including semantics and ontologies.
- The level of open interfaces.

- Analytics.
- Creation and support of services.
- Security.
- System management.

In general, to build a city platform, a solution is needed in three main areas [13]:

2.4.1. Communication

The main problem in Smart cities is inefficiency, that is, duplication of communication channels. Data exchange should have the highest priority. At the same time, it is necessary to rely on heterogeneous interactions from the very beginning due to the availability of information exchange systems based on different network standards. A typical example is the same sensors of the Internet of Things.

2.4.2. Model of information representation

The reasons are the same as in communications. Weaknesses also exist. The final version of the Platform should also ensure the interaction of a wide variety of existing services.

2.4.3. Open service development environment

Smart City projects cannot be implemented without developers. Here we emphasize the need for software interfaces that will cover all measurement areas [14]. The reason is that most of the interesting services fall into the category where different applications use data from multiple sources. For this reason, the combination of data gives the most interesting results. Fig. 3 shows the general structure of the City Platform:

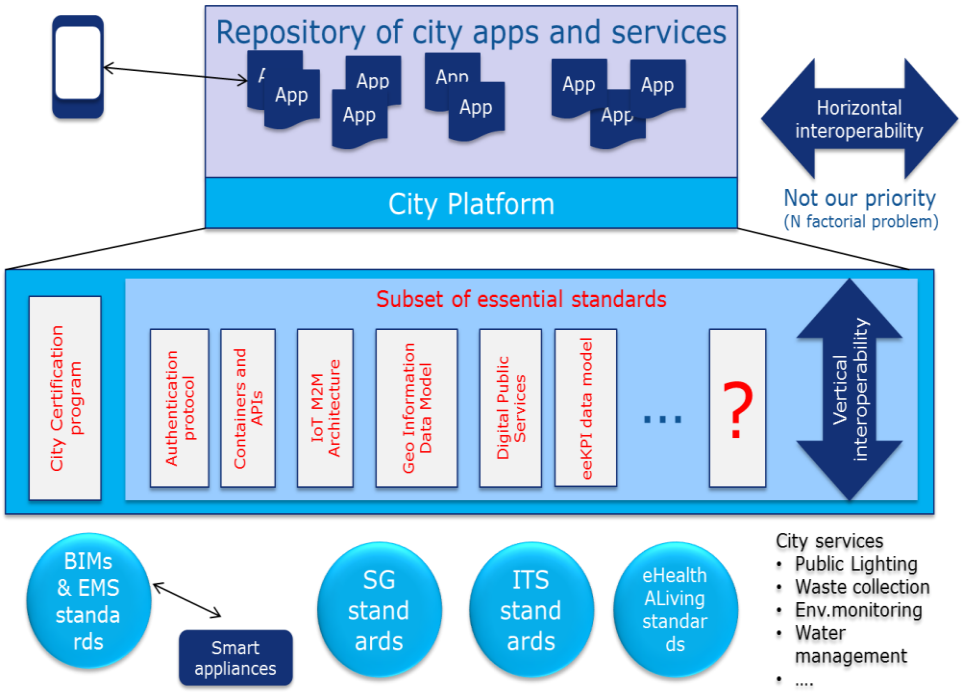

Figure 3: Smart City Convergence Platform Reference Model

Naturally, this European initiative, headed by the Fraunhofer Focus [15], is not the only one. Here you can mention, for example, TCS Intelligent Urban Exchange (IUX) [16], Hitachi develops its own platform and already has examples of use [17]. Social Glass [17] is a typical example of the City Platform project designed to integrate and visualize heterogeneous data sources [15-18].

3. Multilayered Smart City Model

In the literature review, having made an analysis for various platforms [19], we have proposed the architecture for the future smart city platform, as shown in Fig. 4.

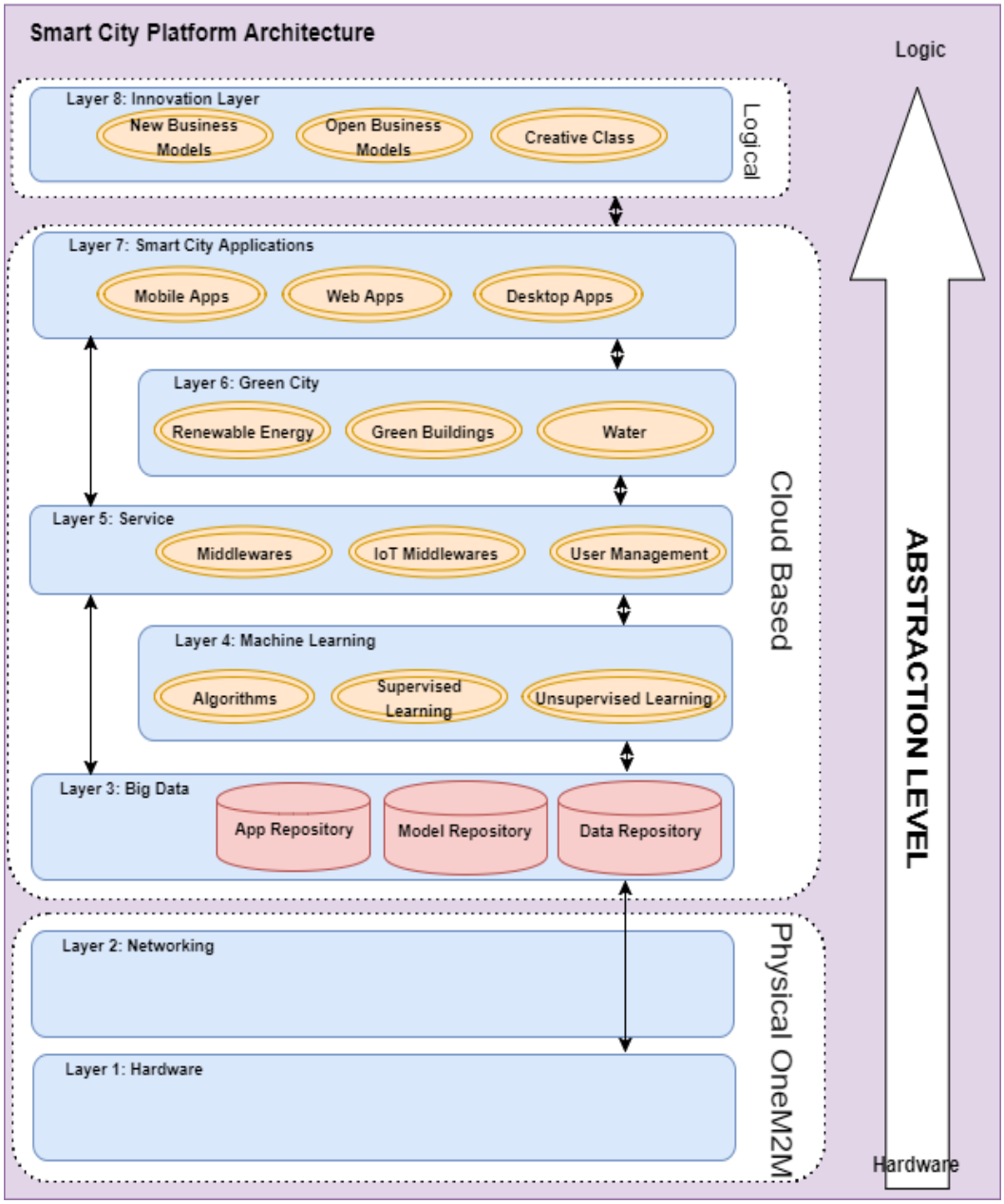

Figure 4: Smart City Convergence Platform Reference Model

3.1. Layer 1 – Hardware Layer

Cities require real-time system response. They include connection points like radio frequency transmitters, traffic light signals, streets, meters and infrastructure sensors, as well as motion sensors [20]. Real-time data is the actual element of smart cities connecting data with information data [21]. It is expected that the Internet of Things, as the implementation of digital technologies in the physical world, will make a significant contribution to solving today's urban problems [22]. The next generation of Internet technologies will be able to interact with devices connected to almost all objects created by man [23].

3.2. Layer 2 – Networking Layer

The lowest level of the Smart City architecture is the "Network" level, which is responsible for process management identification of all infrastructure components, devices and application systems connected to the platform, including sensors, actuators, agents, controllers, servers, terminals, mobile devices, etc. In the Smart City concept, the network layer can guarantee the following properties [23]:

- Supports extensible management;
- Sustained failures to maintain uptime;
- Has a guarantee in performance.

Provides low latency.

3.3. Layer 3 – Big Data Management Layer

Big Data manages all the data on the platform collected from the city, users, devices and data, this layer has three storages:

- Application storage for storing applications, including source code, images, videos and documents related to the application;
- Model storage models for storing urban models such as traffic patterns, sensor network models, data models, city maps and energy distribution models;
- Data storage for storing data collected from sensors, citizens and applications.

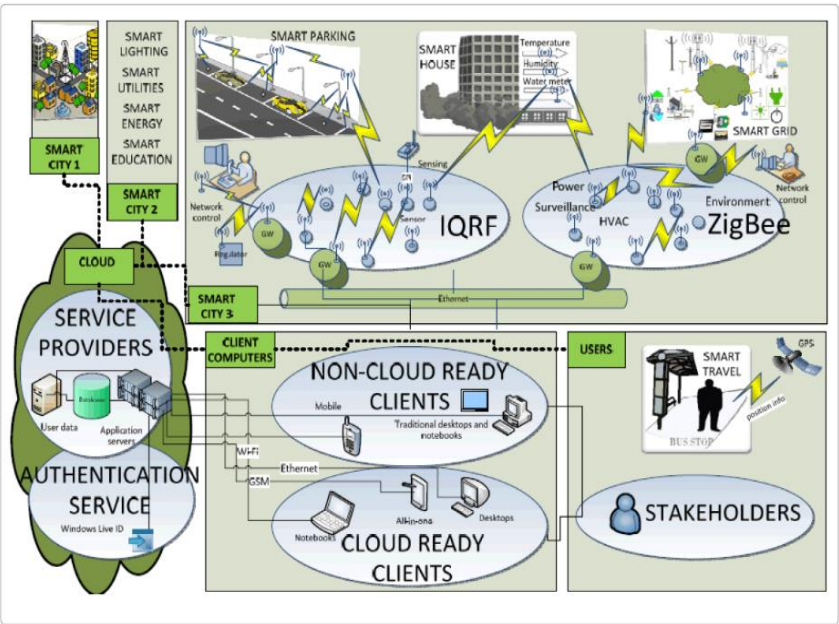

Figure 5: Planned Smart City indicators of the European Union by 2030 [4]

In addition, the big data processing module is also responsible for processing urban data. There are two types of data processing: streaming processing and analytics for performing real-time analytics; and batch processing (HPC) for analyzing large datasets. In addition, this module should be able to perform useful preprocessing tasks such as data filtering, normalization, and transformation.

Data visualization is an important component, along with a data cleanup component to remove data that is no longer needed and archive old data in slower, high-capacity storage. Figure 5 shows the level of Big data management that has a relationship with all other levels of the platform.

3.4. Layer 4 – AI and Machine Learning Layer

The next level is the machine learning level, in which various equipment in the system are trained using various algorithms to facilitate the life of the city by automatically constructing various models and predicting urban phenomena. Since a smart city will produce huge amounts of data, this training will make the work much easier.

Cities are a collection of many complex and interdependent problems and solutions. Machine learning solves various ei tasks by optimizing and integrating urban services to obtain single results that were not used in specific services in the past. For example, machine learning can track waste levels in dumpsters and individual data collection services based on waste forecasts. It could also give an idea of the variable recycling rates.

To improve forecasting and model accuracy, we use smart algorithms that understand patterns and learn from them. Based on smart algorithms, machines learn from their own experience. Experiences are samples of labeled data transmitted by people to machines. The system observes the pattern from different training samples and improves itself. The use of neural networks improves this result. The interconnected weights from one level to another can be better studied only with the help of a deep neural network to generate a final prediction of the event. Another reason why we need to use a deep neural network to solve the problems of the Internet of Things is the complex relationships between disjoint datasets that make up structured and unstructured data. It is very difficult for other algorithms to work in such a complex system involving huge datasets.

3.5. Layer 5 – Service Layer

The next level is the “Service Level", which includes the Internet of Things and service software components. At this level, the provision of the Internet of Things provides and is responsible for managing the smart city Internet of Things network and effective communication between the platform and various devices, which include sensors, various actuators, controllers, mobile devices, etc. And also the Service Middleware is responsible for the management of various services, in which the platform provides applications with various operations such as publishing, implementing, monitoring, compiling and synchronizing various services to provide better services to citizens. However, to ensure confidentiality, this data must be protected, and permission to store it must be acquired from the user of the right to use it [24]. Moreover, since there will be many applications on the city platform, it may be useful to offer a single registration mechanism.

3.6. Layer 6 – Green City Layer

The growth rate of cities in the last ten years is very developed in developing countries. By carefully planning transport networks, land use and energy efficiency standards, it is possible to avoid economic models that cause great damage to resource savings.

The concept of a green city is inspired by new theories of urbanization, and initiatives of the Energy and Environmental Development Guide (LEED) [25]. Green cities are becoming integral playgrounds for smart

cities for sustainable development. At this level, the Green City creates a favorable environment in which broadband networks, sensors and actuators, energy management agents, smart grids and smart technologies can have a great impact on the environment. The transition from traditional urban planning to "green" urban planning requires "green" management in which a "green" ecosystem is developed, including "green" transport, energy-efficient specifications of "green" buildings, "smart grids" and the use of alternative energy sources.

Thus, the green trend of a smart city will be the maximum reduction of energy consumption and minimization of human impact on the environment. The green city will be able to generate more than 70% of the energy for its needs from renewable energy sources [26].

3.7. Layer 7 –Applications Layer

Smart cities are developing in real time as a system with systems. Cities are also endowed with the latest technologies on which they are based, as well as being instrumental and interconnected. The system includes infrastructure such as broadband network, smart grid and creation of new mobility systems based on distributed networks, as well as interconnected and instrumental real-time operators with various data and provide data using several forms of ICT applications, such as intelligent energy networks, intelligent transport, electronic traffic, electronic payments and electronic government [27].

The developed web technologies facilitate the development of innovative applications on the Internet, where their users become producers and consumers of content and services.

Smart planners develop policies and measures to increase exposure and disseminate information in urban areas. Such as emergency forecasting, awareness of the situation, traffic jams, etc.

The platform should also provide a set of tools that use application development, including tools such as an integrated development environment (IDE), libraries and frameworks, as well as a smart city simulator for experimenting with applications before actual deployment. Finally, a number of non-functional properties, in particular security and confidentiality, must be maintained at all levels.

3.8. Layer 8 – Innovation Layer

The next level is the Innovation Level, which is responsible for the further progress of the "Smart City". It translates all the processes of the lower layer into real life processes. This level provides the activity of developed technologies to services for government organizations to introduce new applications for the "smart city" into real life through urban planning, where it allows any qualified company to build urban infrastructure for urban services.

To actualize various processes in a smart city, developers must constantly improve and innovate their services for stakeholders.

A smart city is not just a one-time event, a smart city is a constantly evolving process that adapts to new developed technologies every time and at the same time is constantly evolving.

For this reason, a complex network of interactions between enterprises that create and manage the systems that make up the smart city ecosystem can be represented as another level of interconnected components that use physical and economic resources or the real world, along with components of the lower 7 levels to stimulate development and the spread of "smart city" technologies in various spheres of urban life.

4. Conclusion

Based on the research, in this article we have given a clear definition and discussion of the "smart city", as well as all the actions of a smart city and their functioning on the platform. For reliability and full functioning to all actions, a smart city should be versatile and always ready for new resources and actions

from developers who supply the city with different actions. It must be maintainable, scalable and successful for standardization and careful architecture planning.

Careful design and correct operation of the adaptable structure of the "smart city" will create the basis of a "smart city" – with a living and developing system consisting of thousands of actions and components that can function independently and are interconnected with the help of modern information technologies and telecommunications.

The next step is to standardize all actions. Standardization in compliance with a single standard is important not only for performing certain functions, but also for new components, applications and services that are used for maintenance and scalability. Currently, there are many proposals that have been created for various standards and structures aimed at certain actions. The use of digital technologies will be invested in the next stages of the development of a smart city, such as the Internet of Things, artificial intelligence, distributed registries, big data, machine learning, and artificial neural networks. These technologies give and will contribute to the development of a smart city in the future. The emergence of new standards will lead to the growth and development of smart cities in independent actions, where, in general, they will give a certain qualitative result for the residents of the city.

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