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CRITICAL OVERVIEW OF THE CLOUD-BASED INTERNET OF THINGS PILOT PLATFORMS FOR SMART CITIES

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ABSTRACT

The Internet of Things (IoT) has started to appear everywhere in many shapes and forms. But security is one of the crucial topics that could trip up the growth of the IoT. Following security principles used in enterprise computing can help clear that issue. Already there are more connected devices than people on the planet, according to leading researchers in this area. By 2020, there will be 50 billion connected devices, outnumbering people by more than 6 to 1. Most of these devices will be controllable over the Internet, and they will increasingly be responsible for collecting and transmitting sensitive data. Today consumers might own an app that collects information on their exercise routine. In a few years, those same people might have an Internet-enabled medical device that continually delivers data to their doctor. In the wrong hands, data from home management systems could be used to assess user's whereabouts. Likewise, businesses could be vulnerable when they connect things like HVAC, irrigation, or commercial appliances.

KEY WORDS

IoT, smart cities, smart grid, cloud platform

CLASSIFICATION

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INTRODUCTION

The introduction of steam engines, industrialization and computers have arrived in West Balkan with a delay, as an echo of the major changes in the world. The previous three industrial revolutions have established their winners – Great Britain, the United States, and Japan – countries that have dominated the world economy in the decades since the changes occurred. Serbia, burdened with its history, geopolitical context, loss of population, low level of education, finances, was not among those winners. The fourth industrial revolution, or digitization, as it is often called, refers to the application of various technologies that enable the fusion of the real and digital world [1, 2].

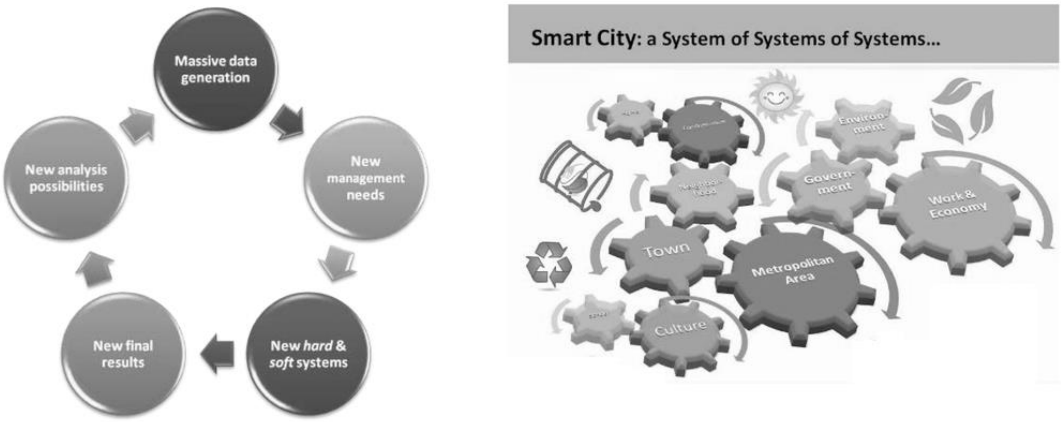

Figure 1. Smart city approach.

Digitization is not only reflected in programming, using an online form, instead of going to the counter or by connecting different databases. IT, artificial intelligence, robotics, Internet stuff, 3D printing, nanotechnology are just some of today's mature technologies that have the potential to change the world from which we live [3]. One of the sectors of great significance for West Balkan, traditionally perceived as a branch with a low potential for digitization, is agriculture. However, digitization can bring enormous positive changes in that area. Worldwide, agriculture faces a huge challenge: in order to feed humanity, 2050 will have to produce almost two times more food than it is today. Unused agricultural land is almost no longer available, and existing agro-technical measures cannot provide the necessary growth. West Balkan is facing economic non-sustainability of agricultural production, which particularly affects small producers. Digitization is the only solution today enough to respond to these challenges. It is only the first step in the exciting life of a single data and a basic prerequisite for new technologies as great data to provide their real contribution [4]. Different sensors that produce data placed on plants and animals, into land, to droplets, robots or satellites, allow us to see complex processes in agriculture. For example, to understand why even the best producers in West Balkan today in some parts of their plots have a yield difference of several times, even though they apply all agro-technical measures - and that we change it. Or to recommend what sort of sowing on which plot so that without any additional cash investments simultaneously increase the yield and reduce the risk to farmers. Or that we do not provide up to date data to support the banking and insurance sectors so that their products become available to farmers. Serbian Institute BioSens is recognized today as one of the leading scientific institutions in the world dealing with agriculture 4.0. The digital agriculture of West Balkan has already come to life through the AgroSens platform, which in just a couple of months of existence has gathered over 5 000 users who can access various data related to their production plot without any compensation and with the help of satellite images to monitor progress and identify problems, even via mobile phones . However, the digitization of agriculture, or any other economic branch, is not a task that can be solved by only one institution [5, 6]. The domestic IT sector is solid and has already proved ready to contribute to this process. The transition from, today, the prevailing, outsourcing model of IT companies to the development of their own products can ensure that significant added value remains in West Balkan [7].

SMART CITIES

Today 3,5 billion people live in cities, which makes up about 50 % of the world's population. Estimates are that by 2040 there will be an additional 2-2,5 billion people living in cities, which will make up about 70 % of the world's population. This implies further pressure on land, water, air, raw materials and increases demands for food, water and energy, for education and medical care, employment and care for older people and people with disabilities [8, 9]. Those who live in cities use 75 % of non-renewable natural resources and participate in the production of three-quarters of the world's pollution. As a possible solution we mention the so-called *smart city*. There are more definitions to the *smart city*. One could be: A city that, through information and communication technology (ICT), unifies and coordinates the work of all city services in order to improve their work and better connectivity between city and citizens administration.

A somewhat shorter definition of the *smart city* is that it is a city that effectively integrates physical, digital and human systems in order to build an environment that will contribute to improving the lives of citizens [10, 11]. The third definition of *smart city* is that it is a city that uses ICT technology and, with the application of technological innovations, contributes to more efficient and rational use of resources, which means energy savings and reduction of negative environmental impacts.

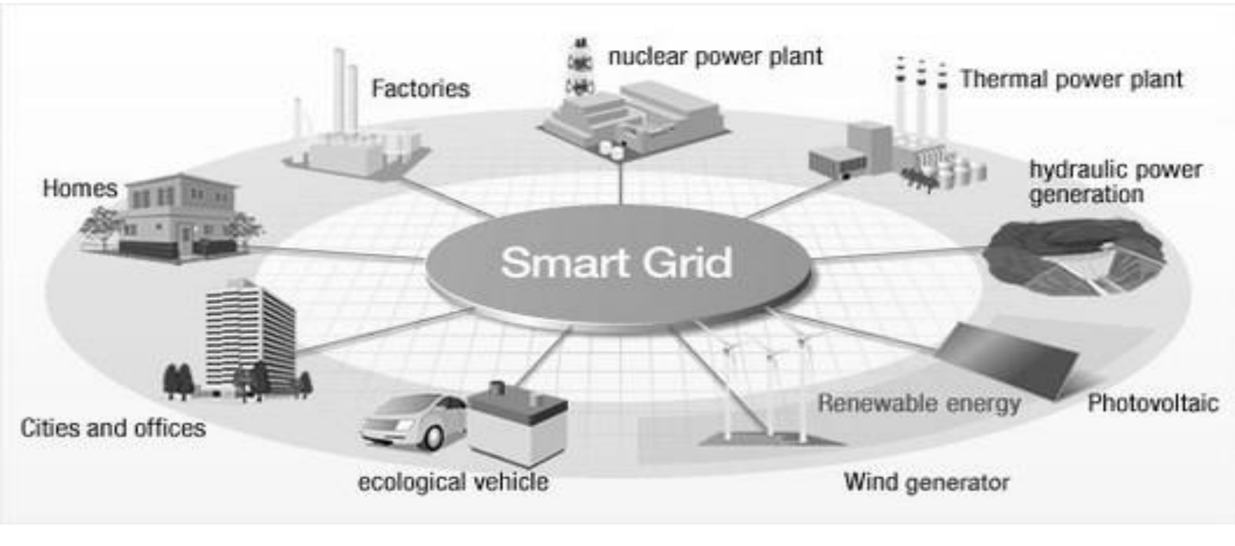

Figure 2. Smart grid.

SMART HOUSE

In the formation of the *smart city*, *smart house* is of great importance. The most important measure in this direction is rational energy consumption. It is implemented through the introduction of renewable energy sources (RES) and better thermal insulation of buildings. With the emergence of new building materials, the cost of building insulation has dropped significantly and the heat energy savings go up to 30 %. The introduction of RES is realized by placing solar thermal collectors for obtaining hot water and installing solar photovoltaic collectors for electricity generation. Another form of savings is a heat pump with a dual function – cooling and heating [12, 13]. Where the building is exposed to stronger airflow, in combination with the above measures, energy efficiency can be achieved within the limits of 80-100 %. Special attention is focused on waste management. The goal is to reduce the amount of waste. One of the measures is: do not discard appliances and appliances before their service life expires. Already at the level of the *smart house*, the waste is sorted into bags. The obligation of the household is to place those bags in containers or to deliver them to collection centers in the city. City offices collect that waste from the container and relate it to further processing, i.e. they are recycled, burned or used for the production of biogas. *Smart House* also includes installations for remote and automatic control, which ensures the security and fire protection of the building.

HOW THE CITY BECOMES *SMART*

It is expected that *smart cities* will become very attractive for high-skilled labor and thus will be incentives for numerous activities [14]. The factors that determine the *friendly urban environment* include: urban planning, development, energy, cleanliness, supply, communications and traffic, health care, education, cultural activities. Urban planning includes the consideration of the city's development flows in the next 10-15 years. Energy consumption involves the use of natural resources (application of RES, sun, wind, geothermal energy and bio-gas). Electricity heating should be replaced by steam heating, and in the future, introduce remote cooling as an alternative to individual air conditioners. The benefit is double: aesthetic and higher energy savings [15, 16]. Ecology of *smart city* means expanding and creating new green areas and setting up solar collectors in places where it is possible. Also, wastewater treatment with the possibility of returning to watercourses, from where they would be used for irrigation.

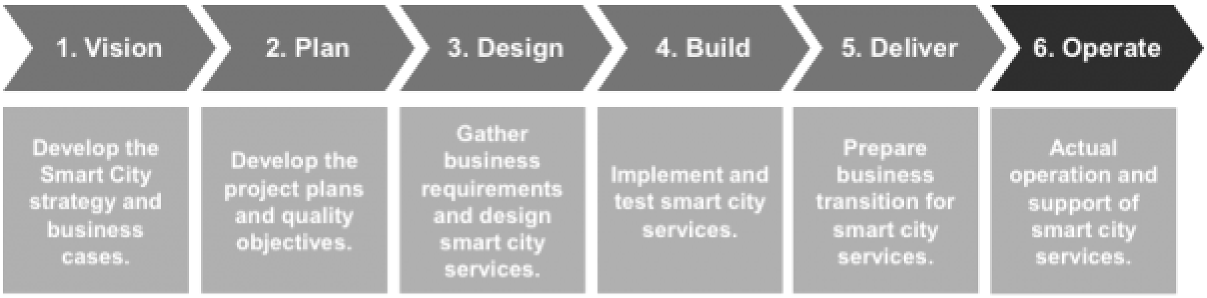

Figure 3. How the city becomes *smart*.

Waste is increasingly becoming a raw material and, in parallel, an increasing problem of large cities with dumps spreading to all sides. The goal is to reduce the amount of waste in cities as much as possible and to process as much as possible. Waste remediation measures are known, but investments are needed for the construction of waste recycling plants, combustion and conversion of waste into gas for electricity generation. By processing in recycling, combustion and biogas plants, the need for landfills is significantly reduced. PVC, LDPE, PP, PS, electronic waste, etc. are recycled [17]. For example, when bottles are being recycled, the benefit is double: it is 60 % less energy consumption than that required for the production of new bottles and less waste. Otherwise, waste management involves a program of measures that begins with the classification of household waste and ends up in the form of a new product or fuel for power plants. In the *smart city* there must be good night lighting of streets and squares. Then, clean and straight hiking trails with a width of at least 2 m without parked vehicles, clean and flat pavements free of animal and other waste, central computer system with control of traffic lights at pedestrian crossings and intersections.

SMART CITIES IN THE WORLD

There are ten cities on the list of *smart cities*, while there are five more for *waiting*. In the first place is Vienna and then followed by: Toronto, Paris, New York, London, Tokyo, Berlin, Copenhagen, Hong Kong and Barcelona. The list includes Amsterdam, Stockholm, Melbourne, Vancouver, Santa Cruz and Singapore [18]. By all criteria, Vienna is in the first place: all wastewater is brought to the main purification plant where it is purified to 95 %. They purified the treated water in the Danube. Water consumption in Vienna is quite high and amounts to 130 l per person per month. The renovated drainage channel and the construction of the embankment Vienna is well protected from floods.

INSTITUTION FOR STUDYING *SMART CITIES*

More than half of the urban areas are under greenery. An artificial island of 21 km long was built, which is used for rest and recreation [19]. The share of public transport is 35 %, the share of cyclists and pedestrians is 31 % and private vehicles 34 %. There is a tendency of further reduction in private transport to 25 % and an increase in public transport from the current 35 % to 40 % by 2020. Vienna has 29 tram and 150 bus routes. About 1000 km of cycling tracks were built. For the next decade, the possibility of remote cooling is considered. The effect of remote cooling is an energy saving of up to 80 % in relation to the already installed individual air conditioners. Some hospitals and business facilities have already been connected to a network of extreme cooling [20]0. The *Virtual City Office* works continuously and helps citizens to carry out numerous administrative tasks. Facilities for sorting, recycling of plastic waste and combustion in order to obtain electricity and biogas from organic waste were built (about 220 000 tonns annualy). The so-produced biogas is connected to the city gas network. Street lighting in Vienna involves about 150 000 pillars with over 227 000 luminaries, predominantly *ice* technology that saves electricity. The prescribed width of the sidewalk is 1,5-2 m. The cleanliness of the city is maintained by numerous cleaning teams, bunkers are placed for street waste disposal and prescribe high penalties for non-compliance with animal waste. On the other side of the world, in Toronto, they use gas as fuel for garbage trucks. In Paris, they are developing a bicycle rental program for 250 stations. A similar program is being prepared for smaller electric cars. In New York, they develop fire prevention systems. In London, the formation of the group is in the Imperial College for the study of *smart cities*. Databases related to transport and job management will be set up at the same site. In Tokyo, the buildings will be built that will combine the operation of solar panels, energy storage batteries and energy efficient appliances.

The city government of Copenhagen should reduce CO_2 emissions to zero by 2025. About 40 % of local people use bicycles as a means of transport. Hong Kong is the leader in the use of smart cards, which millions of citizens cover the cost of public transportation, shopping and car parking. Barcelona was the first to introduce solar thermal collectors for hot sanitary water, and now it is working on a project for the introduction of electric vehicles and the construction of filling stations for electric vehicles [21]. In Stockholm, it seeks to reduce the amount of greenhouse effect gases by lowering energy consumption for heating apartments enhanced by isolation of apartments, urban traffic control and the development of electronic communications in order to reduce the use of paper. A number of apartments have installed *smart meters* with the aim of reducing energy consumption. Control of city street lighting and traffic lights is under way in order to provide drivers with information on congestion in certain directions of movement. And in Santa Cruz, California, they introduced measures to reduce crime by, on the basis of historical data, sent police patrols in certain places in a high-risk city.

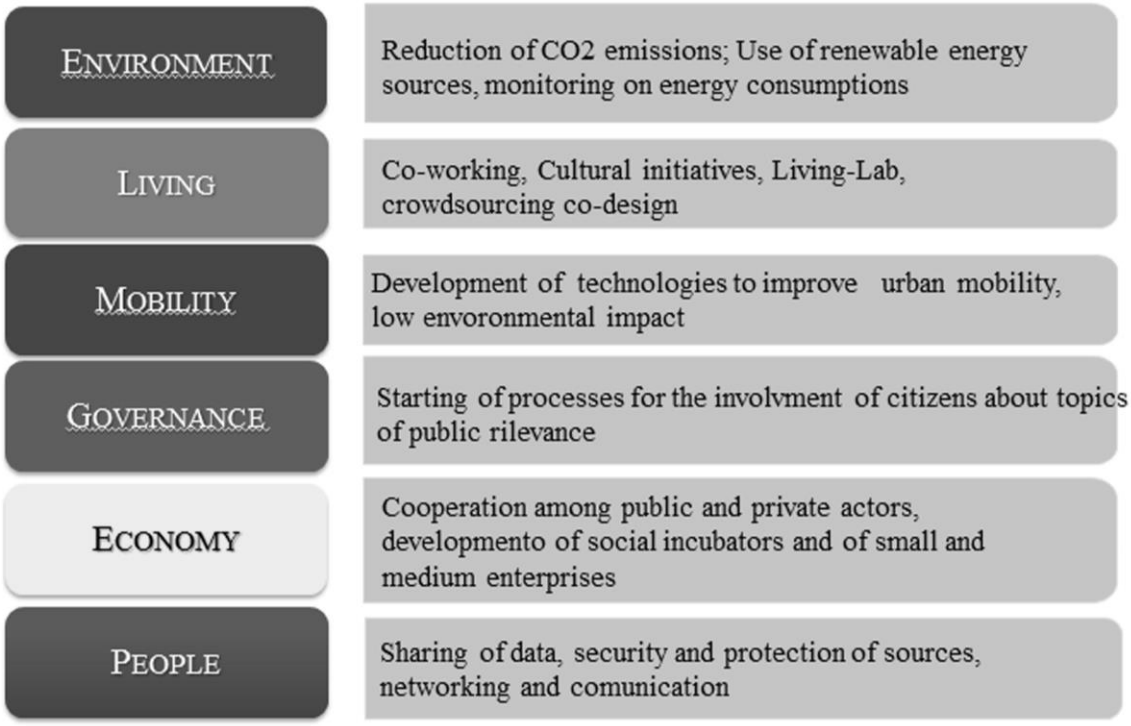

Figure 4. Smart city definition (EU).

THE DEVELOPMENT OF A SMART CITY

The development of a smart city is often associated with the realization of the following elements: smart economy, smart population, smart management, smart traffic, smart environment and smart life [22]. Some examples of the implementation of IoT applications in smart cities include: system control of traffic, smart vehicle parking solutions, air pollution level detection, download of information related to smog and carbon dioxide levels, etc. Areas of application of intelligent solutions in smart cities can be categorized into multiple domains:

- administration,
- health,
- smart buildings,
- education,
- public safety,
- traffic,
- participation programs,
- energy,
- environment.

Observed from the aspect of communication, management and data processing, the multi-layered IoT architecture of smart cities consists of:

- measurement and Reading Layer (Sensing),
- network layer for access to IoT infrastructure (Network-Centric IoT),
- cloud-Oriented Component of IoT Infrastructure (Cloud-Centric IoT) and
- application layer of IoT infrastructure (Data-Centric IoT).

The development of IoT infrastructure in smart cities includes: development platforms, accessing technologies, data warehouses, data analytics services and data security services. There are a number of platforms that are used to build IoT solutions. Among the most famous cloud platforms are: IBM Bluemix, Microsoft Azure, Amazon Web services, HP Helion, Oracle Cloud and others. The trend of increasing population in cities is causing many problems in the social and organizational sphere, which greatly burdens the management of city structures, leads to a lack of resources, makes traffic difficult, threatens the environment and causes health problems for the population. IoT solutions can contribute to their resolution [23]. The basic idea of implementing the IoT is to provide a smart infrastructure for areas such as traffic, electricity, water supply, housing construction and public services [24, 25].

PLATFORMS FOR THE DEVELOPMENT OF THE *SMART CITY* ELEMENTS

The IoT platform is a software and hardware environment for the efficient development of the IoT system. The management of the IoT platform is complex and includes processes such as: Resource Discovery, Resource Monitoring, Platform Reconfiguration [26, 27]. On the server side, the components that are responsible for providing the platform management functionality are: Resource Directory, IoT Resources Manager, Application Configuration Configuration Configuration Manager, Configuration Testing Sub-System Configuration, Crowdsourcing Manager. IoT nodes differ in roles in the platform, so there are the following types: Infrastructure nodes, Experimental IoT nodes, Service nodes, Participating nodes are handheld devices.

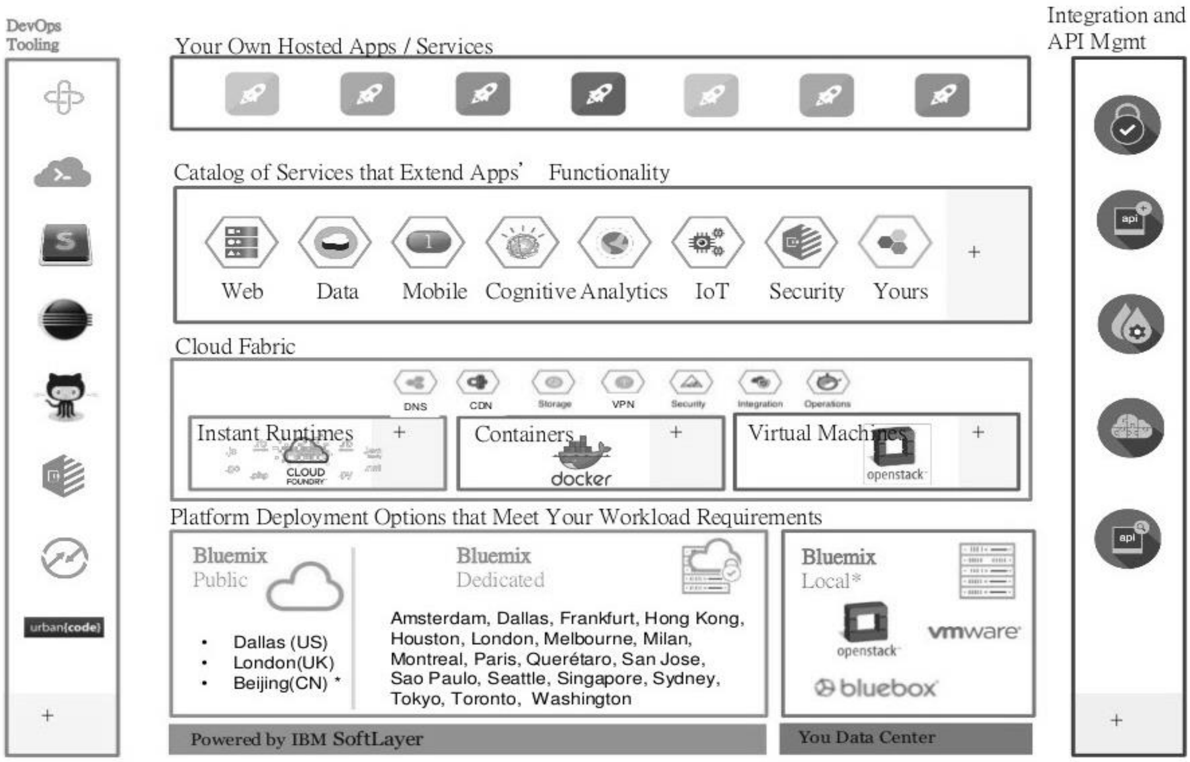

Figure 5. IBM Cloud Bluemix – Innovation platform.

When developing the *smart city* Platform, it is necessary to consider the necessary functional elements, such as:

- devices that have functions of collecting data and executing pre-defined actions and monitoring and control,
- communication components that allow connection of devices within IoT platform,
- services within the IoT platform that should enable device monitoring, device management, reporting of collected data, and discovery of devices online,

- manage the functions of the IoT platform, such as configuring, monitoring platform performance, and more,
- a security component that relates to the realization of functionality, authentication, authorization, integrity protection and data privacy,
- the application component that refers to providing the capabilities of users can monitor and use the functions of the IoT platform and manage them.

The components for the development of the Internet platform of intelligent devices are:

1.) hardware

- sensors (eg. for measuring temperature, humidity, pressure),
- actuators (eg. for lighting control, air conditioning),
- microcomputers (eg. Raspberry Pi),
- microcontrollers (eg. Arduino) and
- network infrastructure (routers, switches, cables, etc.).

2.) software

- development environments (eg. Eclipse, Arduino IDE, etc.),
- operating systems customized for devices (eg. Raspbian) and
- software for a specific smart environment.

Intelligent devices can be connected to Personal Area Network, PAN, Local Area Network, LAN, Metropolitan Area Network, WAN (Wide Area Network), and sensor networks [28-30]. Mobile technologies that have contributed to the development and application of the Internet of intelligent devices are mobile and mobile Internet, Bluetooth, RFID, WiMAX, Global Positioning System (GPS), Near Field Communication (NFC), ZigBee and others. Cloud computing and Vig data infrastructure can be used to build a quality IoT infrastructure. Cloud computing is a paradigm of delivering computer resources as a service. IoT services can also be delivered via clouds [31-33]. Regarding the integration of IoT with cloud, the following requirements must be met:

- cloud services should facilitate the communication of hardware and software in the IoT ecosystem,
- cloud protocol support is needed, such as Websocket, REST, MQTT, CoAP,
- support is needed for secure remote software updates on devices,
- web and mobile applications should allow data display, data processing, and remote device management,
- areas of application of the Internet of intelligent devices.

Internet intelligent devices can be applied to:

- personal and business purposes – automation of houses, buildings, apartments and offices,
- urban environment – automation of cities and its head parts such as roads, parking lots, lighting, surveillance systems and emergency response systems,
- education – automation of faculties, classrooms and libraries,
- healthcare – automation of hospitals, health centers, monitoring of patients and athletes, use of wearable devices,
- logistics – automation of transport, monitoring of delivery of goods and remote diagnostics of the condition of transport vehicles,
- industries – automation of factories, warehouses and warehouses, monitoring of machines and tools,
- environment – monitoring of weather conditions, pollution of air, noise, fire and floods,
- energy systems – smart electricity networks and renewable energy systems,

- retail – automation of inventory management and smart payments,
- farms – automation of irrigation systems and control of greenhouses,
- robotics – smart robots.

CONCLUSION

The concept of smart, sustainable cities is based on a simple paradigm of sustainable development, which presupposes an informatically bound metropolis that collects, analyzes, shares and displays information in a way that suits their consumer – a citizen, a member of a city administration, a policeman, a fireman, a healthcare worker or a teacher in one of the city gymnasiums. Directly on the story of the use of energy and water, the section on responsible attitude towards the environment is added. Whatever business is dealing with today, the basic maxim that ensures its future is sustainability. By 2025, the buildings will use more energy than any other class of consumers. In the United States, the share of buildings in the use of energy is high 72 %, while 40 % of the raw materials that are produced eventually end up in buildings. In the process of environmental protection, energy management, waste management and reduction of emissions of harmful gases are the core activities. A significant increase in care in these areas has been recognized in Europe and the USA. IBM is talking about an increase of more than 50 % when it comes to investing in reducing emissions, while waste and energy management is *progressing* every year with an advantage of more than 60 % compared to the previous one. Both Intel and IBM suggest that sustainability begins in the family. The ways in which individuals flow to water, electricity, and other limited resources greatly affect the social context that shapes our lives. It is precisely in this module that the importance of education is greatest, because it guarantees the availability of critical information on the importance of preserving energy resources from the earliest days of development.

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