Internet of Things (IoT)

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After the World Wide Web (the 1990's) and the mobile Internet (the 2000's), we are now heading to the third phase of the Internet evolution – the Internet of Things. A new era where the real, digital and virtual converge to create smart environments that make energy, transport, cities and many other areas more intelligent. Smart is the new green and the green products and services are being replaced by smart products and services. The Internet of things means billions of smart objects that are incorporated into our everyday life, improving the social, technical and economic benefits. The Internet of Things enables anytime, anyplace connectivity for anything and anyone. However, there are many issues that need to be solved in order to reach the full potential of the Internet of things.

Keywords: *technology, Internet of things, networks, sensors, augmented behaviour, augmented intelligence, standards, interconnectivity, Web, security, privacy, IP, Internet, transfer rate, network protocols, smartphone, interoperability, smart applications.*

1 Introduction

When time is more limited and the volume of information is increasing, the Internet of things emerges and changes radically the lifestyle of people, businesses and society.
Whether it is tangible goods such as consumables, cities, cars, buildings, etc., whether it is intangible goods such as agriculture, health, tourism, energy, etc., all the things in the everyday life of people are expected to be connected to Internet, to have analytical capabilities and communication skills that significantly improve the way people live, work or interact.
This paper outlines what is the Internet of things, the history of IoT, the advantages and disadvantages of IoT, the challenges and possible solutions related to IoT, the technologies driving IoT and some example of IoT applications.

2 Definition and characteristics

Despite the global buzz around the Internet of things (IoT), there is no single, universally accepted definition for the term. However, there are many definitions that describe and promote a particular view of what IoT means such as:

- **IAB (*Internet Arhitecture Board*)** describes IoT as: "*a trend where a large number of embedded devices use communication services provided by Internet protocols. These devices, called "smart objects", are not directly operated by humans, but exist as components in buildings or vehicles or are spread out in the environment.*" [1]
- **ITU (International Telecommunication Union)** has formulated the following definition: "*IoT is a global infrastructure for information society that provides advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.*" [2]
- **IEEE (Institute of Electrical and Electronics Engineers)** definition states that IoT is "*a network of items - each embedded with sensors - which are connected to the Internet.*" [3]
- The **Oxford Dictionary** defines the term Internet of things as: "*the interconnection via the Internet of computing devices embedded into everyday objects, enabling them to send and receive data.*" [4]
- Therefore, we propose the following **definition**: "*IoT is the total number of devices interconnected through the Internet, capable of collecting data in order to monitor and control everyday things, remotely, without the need for continuous interaction between things and people.*"

According to [5], the fundamental **characteristics** of the IoT are as follows:

- **interconnectivity**: anything can be interconnected with the global information and communication infrastructure;
- **things-related services**: the IoT is capable of providing thing-related services within the constraints of things;
- **heterogeneity**: the devices in the IoT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks;
- **dynamic changes**: the state of devices change dynamically, e.g., connected or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically;
- **enormous scale**: the number of devices that could communicate with each other will be at least an order of magnitude larger than the number of devices connected now to the Internet.

As specified in [6], the phase "Internet of Things" points out a **vision** of the machines of the future: in the 19th century, the machines were taught to do, in the 20th century, they learned to think, and in the 21st century they learned to perceive - they actually sense and respond to the interaction with the environment.

Based on [7], the main **objective** of IoT is to enable objects to be connected anytime, anywhere, with anything and anyone, using any network and service. Connections multiply and create a completely new dynamic network of networks - the Internet of things. IoT is not science fiction, but is based on solid technological advances and visions of network ubiquity.

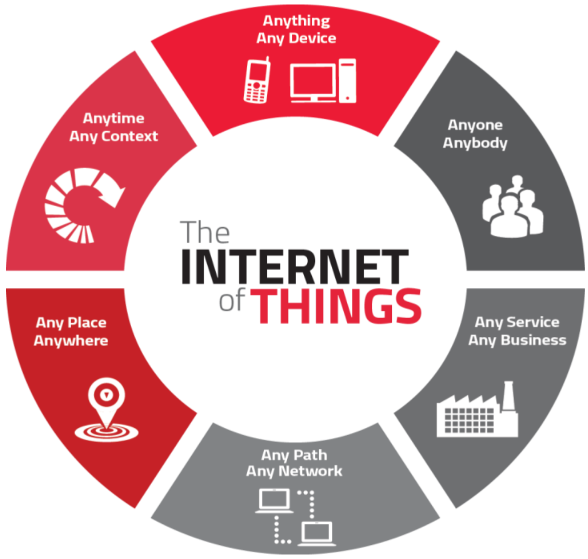

Figure 1 - Main objective of IoT [7]

As maintained in [8], the 3 Cs of IoT are:

- **communication.** IoT communicates information to people and systems such as state of the equipment (e.g., open or closed, connected or disconnected, full or empty) and data from sensors that can monitor the vital signs of a person. Usually, we didn't have access to this information before or it was collected manually and sporadically. For example, in the healthcare industry, IoT can help a hospital to track the location of anything, from wheelchairs to cardiac defibrillators to surgeons.
- **control and automation**. In a connected world, an enterprise or a consumer has the ability to remotely control a device. For example, an enterprise can remotely start or shut down a particular piece of equipment or adjust the temperature in a climate-controlled environment, while a consumer can use IoT to start the washing machine or to unlock the car.
- **cost savings**. With new sensor information, IoT can help an enterprise save money by minimizing equipment failure and enabling the enterprise to perform planned maintenance. Also, sensors have measurement capabilities such as driving behavior and speed in order to reduce fuel expense, wear and tear on consumables.

3 Evolution

3.1 IoT today and tomorrow

The Internet of Things may be a new topic in the IT industry, but it's not a new concept.

As evidenced in [8], in **1999**, **Kevin Ashton** set out guidelines for what has now become IoT at a MIT AutoID lab. Ashton was one of the pioneers who described this concept as he searched for ways that Procter & Gamble could improve business by linking physical objects to the Internet via RFID sensors. The result of his research was as follows: if all objects in everyday life would be equipped with identifiers and wireless connectivity, these objects could communicate with each other and be managed by computers.

In a 1999 article, Ashton wrote: "*If we had computers that knew everything about things - using the data they collected without any help from people - we could greatly reduce waste, loss and cost. We would know when things need to be replaced, repaired or if they are fresh or have expired. We need to develop computers with their own means of collecting information so that they can see, hear and smell the environment for themselves, without being limited to data entered by human.*" [8]

According to CISCO IBSG (Internet Business Solutions Group), IoT is the point in time when more things than people were connected to the Internet. In 2003, there were about 6.3 billion people living on the planet, 500 million devices connected to the Internet and less than one device per person. IoT did not yet exist in 2003, because the number of connected things was relatively small, given that smartphones were just being introduced. [9]

An explosive increase of smartphones and tablets has led to an increase in the number of devices connected to Internet to 12.5 billion in 2010, while the world's population has increased to 6.8 billion, making the number of devices connected per person more than 1 for the first time in history. [9]

Looking to the future, CISCO IBSG predicted that there will be 25 billion devices connected to the Internet in 2015 and 50 billion devices connected to the Internet in 2020. These estimates do not take into account the rapid technological advances and are based on the world's population, of which 60% is not yet connected to the Internet. [9]

2015 was the year when IoT gained notoriety. Companies adopt the following strategy: "*start small think big*" and invest heavily in development of IoT applications. [10]

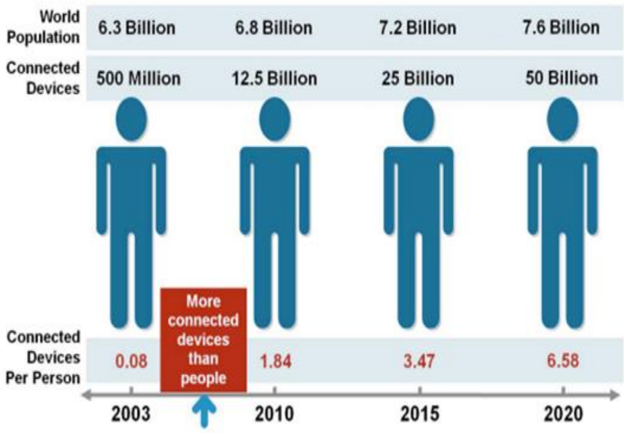

Figure 2 - Number of devices connected to the Internet [9]

In 2015, there was an explosion of new Internet of Things related job titles such as: IoT value creator, IoT chief architect, IoT technical sales engineer. This trend shows that in 2015 companies have created new IoT departments and this trend is expected to continue in the future. [10]

IoT has become part of the everyday life of people and the phase "Internet of Things" evolves continuously in content, applicability, vision and technology.

3.2 IoT: First evolution of the Internet

On the one hand, the Internet is the physical layer or a network of switches, routers and other transmission equipment, designed to transport information from one computer to another quickly, reliably and securely. On the other hand, the web is the application layer, with the role of providing an interface so that information on the Internet can be used. [9]

According to [9], the web has gone through several evolutionary stages:

- stage 1. During this stage, web was used by the academia for research.
- stage 2. This stage focused on the need of companies to share information on the Internet so that people could learn more about the products and services they offer.
- stage 3. During this stage, web have moved from static data to transactional data, where products and services could be bought and sold online. Also, companies such as eBay and Amazon.com have become very popular among Internet users.

- stage 4. During this stage, people could communicate, share information about themselves with their friends, colleagues, family. Moreover, companies such as Facebook and Twitter have become extremely popular and profitable.

Compared to the web, the Internet has been steadily developing and improving, but it has not changed much. It essentially does the same thing that it was designed to do during the ARPANET era. For example, initially there were several communication protocols, but today the Internet only uses TCP / IP. [9]

In this context, IoT has become extremely important because it is the first real evolution of the Internet, a stage that will lead to the development of applications that could dramatically improve the way people live, learn, work and entertain. IoT has already created the Internet based on sensors, which allows people to be more proactive and less reactive. [9]

4 Advantages and disadvantages

As highlighted in [11], there are many **advantages** of using IoT, which can help individuals, businesses and society on a daily basis.

For individuals, IoT can positively influence various aspects of their existence such as health, safety, financially, daily activities. IoT can also act as a tool for people to save money and time. If their home appliances are able to communicate, they can operate in an energy efficient way.

Also, the advantages of IoT spread to companies, where IoT becomes useful in various activities such as monitoring inventory, location, employees, etc. Physical devices are able to communicate with people, letting them know their condition, location, etc.

Another advantage of IoT is the ability to track the behavior of individual consumers and to identify key customers and their preferences based on information provided by devices.

The IoT has many advantages to businesses, consumers, the environment, but it also has a number of disadvantages. According to [11] and [12], among the **disadvantages** of IoT are:

- **compatibility**. Now, there is no standard for tagging and monitoring all types of sensors.
- **privacy / security**. Although there are security measures that are taken to protect personal information, there is always a possibility of hackers breaking into the system and stealing the data. Hence, all these safety risks become the consumer's responsibility.
- **complexity / over-reliance on technology**. The current generation has grown with the readily availability of the Internet and technology. However, relying on technology, making decisions based on the information it provides could lead to devastating effects. We are the users of complex software systems and we must not forget that no system is robust and fault-free. The more we depend on the Internet and technology, the more it increases the possibility of a catastrophic event if it crashes.
- **connecting an increasing number of devices to the Internet** will lead to job losses. The automation of IoT will have a devastating impact on the employment prospects of the less educated population.

5 Technologies

As described in [13], the main way to capture the processes in Mark Weiser's model is as an **Information Value Loop** with distinct but connected stages.

Through sensors, data is generated about a particular action in the physical environment, which is then communicated over the Internet and aggregated across time and space and eventually analyzed in order to be beneficial for changing future acts.

Getting information allows an organization to create value; how much value is created depends on "value drivers", which define the characteristics of the information along the loop. These factors include:

- **magnitude** - the factor that determines the amount of information that informs action;
- **risk** - the factor that determines the probability that information will create value in the manner expected;

- **time** - the factor that determines how quickly value can be created from the information. [14]

Figure 3 - The Information Value Loop [13]

For example, a sales manager wants to be able to influence customer decisions, so he needs to know what customers want "now and here". This can require information with higher frequency, accuracy and timeliness so that the manager can influence customer action in real time by offering complementary products or incentives. [14]

5.1 Sensors

Below we present the first stage in the value loop, create, as indicated in [13].

IEEE provides the following definition of the term sensor: "*A sensor is an electronic device that produces electrical, optical or digital data derived from a physical event. Then the data produced from the sensors is transformed into information that is useful in making decisions done by other intelligent devices or individuals.*"

Different sensors capture different types of information. For example, the accelerometer detects if an object moves and in which direction, a gyroscope measures more complex, multi-dimensional motions by tracking the position and rotation of an object.

Now, sensors can measure everything: motion, power, pressure, position, light, temperature, humidity, radiation and can be incorporated into everything: power sources, vehicles, smartphones, wearables, houses, etc.

There has been a rapid increase in the use of smaller sensors that can be embedded into smartphones and wearables. The average number of sensors on a smartphone increased from three (including accelerometer, proximity, ambient light) in 2007 to at least ten (including fingerprints and gesture sensors) in 2014.

The price of sensors has declined significantly over the last several years and these price declines are expected to continue in the future. The average cost of an accelerometer in the US was about 40 cents in 2016 compared to $ 2 in 2006.

5.2 Networks – RFC 7452

Below we present the second stage in the value loop, communicate, as identified in [13].

The information created by the sensors is not useful at the time and the place of creation. The signals from sensors are communicated to other devices for analysis. This involves sending data over a network. Sensors are connected to networks through network devices such as hubs, gateways, routers, bridges and switches. The first step in the process of passing data from one machine to another via a network is to uniquely identify each machine.

Network protocols are a set of rules that define how computers identify each other. There are two main categories of network protocols:

- **proprietary protocols** that ensure identification and authorization of machines with specific hardware and software components, allowing manufacturers to differentiate their offerings.
- **open protocols** that ensure interoperability across heterogeneous devices and improve scalability.

IP (Internet Protocol) is an open protocol that provides unique addresses to devices connected to the Internet.

Currently, there are two versions of the protocol: **IP version 4** (IPv4) and **IP version 6** (IPv6). IPv6 is characterized by the increasing the number of unique addresses from 232 addresses provided by IPv4 to 2128 addresses provided by IPv6. Network technologies can be wired or wireless. With continuous user and device growth, wireless

networks are useful for continuous connectivity, while wired networks are useful for transporting a large amount of reliable and secure data.
Choosing a network technology depends on the geographical range to be covered. When data is transferred over small distances (e.g., inside a room), devices can use wireless personal area network technologies (Bluetooth, ZigBee) or wired technology (USB). When data is being transferred over relatively large distances (e.g., inside a building), devices can use wired local area technologies (Ethernet, fiber optics) or wireless technology (Wi-Fi). When data is transferred over longer distances (e.g., beyond buildings and cities), devices can use WAN technologies (WiMAX, weightless, mobile technologies: 2G, 3G, 4G). Technologies such as 4G (LTE, LTE-A) and 5G are favorable for the development of IoT applications, given their high data transfer rates. Technologies such as Bluetooth Low Energy and Low Power Wi-Fi are suited for the development of IoT applications, taking into account the low energy consumption.
In the last 30 years, the data transfer rates have increased from 2 Kbps to 1 Gbps. The transition from the first to the second generation of phones changed the way messages were sent, from analog signals to digital signals. The transition from the second to the third generation of phones offered users the possibility of sharing multimedia files over high speed connections.
In 2003, the price to transfer 1 Mbps in the US was $120, while in 2015 the price dropped to 63 cents. Also, in 2018, 50% of all mobile and fixed device connections were IPv6-based, compared with 16% in 2003.

5.3 Standards

As mentioned in [13], the third stage in the value loop, aggregate, refers to data manipulation, processing and storage activities. Aggregation is achieved through the use of different standards depending on the IoT application.
International Organization for Standardization (ISO) defines a standard as follows: "*A standard is a document that provides specifications, guidelines or features that can be used consistently to ensure that products and services are suitable for their purpose.*"
There are two types of standards for the aggregation process:

- **regulatory standards** refer to recommendations on data security and privacy of data.
- **technical standards** include: network protocols, communication protocols and data aggregation standards. Network protocols define how machines identify each other, while communication protocols provide a set of rules or a common language for devices to communicate. Once the devices are connected to the network, identify each other and exchange data with each other, aggregation standards help aggregate and process data so that those data become useful.

Now, there are many efforts to develop standards that can be adopted widely. There are two types of developments: vendors (from the IoT value chain) setting standards together and standardization bodies (e.g., IEEE) collaborating to develop a standard that vendors will follow. But, it's difficult to create a single universal standard or a rule that dominates all other rules, either at the network level or at the data aggregation level.
As far as network protocols are concerned, some important players in the IT industry have had the opportunity to develop standards that IoT developers will follow in the next years. For example, Qualcomm, together with companies such as Sony, Bosch, Cisco has developed the AllSeen Alliance that offers AllJoyn platform. Also, Intel launched the open-source IoTivity platform.

5.4 Augmented intelligence

As claimed in [13], the fourth stage in the value loop, analyze, is determined by cognitive technologies and associated models that facilitate the use of cognitive technologies. These are known as augmented intelligence to highlight the idea that systems can automate, complete and improve intelligence in a way that excludes people.
The analytics stage involves a thorough search through a large quantity of confusing and conflicting data to get meaningful information that helps take better decisions. There are three

different ways in which the analytics can inform action:

- **descriptive analytics** tools answer the question "What has happened?" and augment intelligence so that it can work effectively with complex datasets that are normally hard to access and use.
- **predictive analytics** tools answer the question "What could happen?" and exploit a large and growing amount of data to build useful models that can correlate seemingly unrelated variables.
- **prescriptive analytics tools** answer the question "What should one do for a desired result?" and include optimization techniques that are based on large data sets, business rules and mathematical models.

Cognitive technologies that have become increasingly used for predictive and prescriptive analytics are:

- **computer vision**. It refers to the ability of computers to identify objects, scenes and activities in images.
- **natural language processing**. It refers to the ability of computers to process text in the same way human do, extracting the real meaning of the text or even generating text that is easy to read.
- **speech recognition**. It refers to accurate transcription of human speech.

5.5 Augmented behaviour

According to [13], the concept of augmented behaviour refers to doing a certain action, which is the result of all previous stages of the value loop, from the creation to analysis of data.

The augmented behavior, the last stage in the value loop, restarts the loop because an action leads to the creation of other data when it is configured to do so.

The difference between augmented intelligence and augmented behaviour is: augmented intelligence refers to informed actions, while augmented behavior refers to an observable action in real world.

Augmented behaviour finds information in at least three ways:

- **machine-to-machine interfaces** (M2M). These refer to the set of technologies that enable machines to communicate with each other and drive action.
- **machine-to-humans interfaces** (M2H). Based on collected data and computational algorithms, machines have the potential to convey meaningful actions to people who then decide whether or not to take the recommended action.
- **organizational entities**. Organizations include people and machines and therefore the benefits and challenges of both M2M and M2H interfaces.

Augmented behaviour is influenced by a number of factors such as:

- **low machine prices.** Lower prices of underlying technologies in IoT such as sensors, network connections, data processing tools, cloud based storage leads to lower prices of robots.
- **improved machine functionality**. Typically, robots take decisions based on programmed algorithms, regardless of situation and information availability. However, recent advances in robotics offer machines the possibility to request more information if there is insufficient information to take a decision.

6 Challenges and potential solutions

Below we present some challenges and potential solutions for IoT technology as stated in [13].

With regard to sensors, there are three main factors driving the deployment of sensor technology: price, capability and size. Even if sensors are sufficiently small, smart and inexpensive, there are some challenges such as:

- **power consumption**. The sensors are powered either through inline connections or by batteries. Inline connections are constant, but can be impractical or expensive. Batteries can be a convenient alternative, but battery life, charging and replacement, especially in remote areas, can represent significant issues.
- **interoperability**. Most of the sensor systems in operation are proprietary and are designed for specific applications. Specific communication protocols are required to facilitate communication between heterogeneous sensor systems, namely lightweight communication protocols (e.g., Constrained Application Protocol (CoAP)).

- **data security**. The use of encryption algorithms ensures data protection, though low memory capacity, power consumption concerns and sensors relatively low processing power could limit data security.

With reference to networks, there are two main factors driving the deployment of networks technology: cost and speed. Even if network technologies have improved in terms of higher data transfer rates and lower costs, there are some challenges such as:

- **interconnections**. The value of a network is proportional to the square of the number of compatible communication devices. Now there is limited value in connecting devices to the Internet. To solve this challenge, companies should connect all devices to the network and to each other.
- **penetration**. There is a limited penetration of networks through high-bandwidth technologies such as LTE and LTE-A, while 5G technology has just emerged in the information technology market. Currently, LTE-A holds 5% of total mobile connections worldwide and LTE holds 2% of the world's total mobile connections, given the investments of network providers in 3G technology over the last 3-5 years.
- **security**. With an increase in the number of sensors connected to the network, there is a need for effective solutions for authentication and access control. The Internet Protocol Security (IPsec) provides a favorable level of secured IP connection between devices.
- **power consumption**. Devices connected to network consume power and require continuous power supplies. Using protocols such as power-aware routing protocols and sleep-scheduling protocols it can improve network management. Power-aware routing protocols determine their routing decision on the most energy-efficient route for transmitting data packets, while sleep-scheduling protocols define how devices can be inactive for better energy efficiency.

For aggregation of IoT data, there is a need for solving the following challenges:

- **standard for handling unstructured data**. Structured data is stored in relational databases and queried through SQL. Unstructured data is stored in different types of NoSQL databases without a query standard. Therefore, new databases created from unstructured data can not be manipulated and used by the old database management systems that companies typically use.
- **regulatory standards for data markets**. Data brokers are companies that sell data collected from different sources. Since most data is sold offline, it is necessary to apply regulatory standards for transactions between providers and users.
- **technical abilities to use newer aggregation tools**. Although there is an upward trend in the number of people trained to use newer tools like Spark and MapReduce, this is far fewer than the number of people trained to use traditional programming languages, such as SQL.

The challenges of augmented intelligence result from data quality, human incapacity to develop a foolproof model and limited capability of old systems to manage unstructured data in real time. Even if the data and model are shipshape, there are some challenges such as:

- **inaccurate analysis due to data or model flaws**. Lack of data or the presence of outliers can lead to false positives or false negatives, thus exposing different algorithmic limitations. The algorithm might make incorrect conclusions if all decision rules are not set correctly.
- **the ability of new systems to analyze unstructured data**. Now, most analytics systems allow the management of structured data, but most IoT interactions generate unstructured data.
- **the ability of old systems to manage real-time data**. Currently, traditional analytics systems use batch-oriented processing, but IoT requires data to be processed in real time in order to get meaningful conclusions.

For augmented behavior, there are some challenges related to machines' actions in unpredictable situations and the security of information that brings to mind such judgments. Interoperability is an additional issue that occurs when heterogeneous machines have to work together in a M2M configuration. Beyond machine behavior issues, managing human behavior in M2H interfaces and organizational entities presents their own challenges.

7 Smart applications

The evolution of applications, their economic potential and their impact in addressing the societal trends for the years after the emergence of IoT have changed dramatically. Societal trends have created significant opportunities in various areas such as: health and wellness, transport and mobility, security and safety, energy and environment, communication and e-society. [5]

Potential IoT applications are numerous and diverse, covering practically all areas of the everyday life of individuals, businesses and society.

Below we will present the main objectives and uses of IoT applications in different domains as reported in [5].

7.1 Smart Health

The main objective of smart health systems is to improve the quality of life for people in need of permanent help, to decrease barriers for monitoring important health parameters, to reduce health costs and to provide right medical support at the right time.

The uses of smart medical systems in the everyday life of people are:

- assistance for elderly people suffering from diseases such as dementia, memory loss, Alzheimer's or for people with disabilities living alone by using sensors to monitor home movements or to send notifications of the times at which certain medicines should be taken;
- monitoring vital signs for athletes in high performance centers by using sensors to measure physical exercise, walking / running steps, sleep, weight, blood pressure, etc.;
- remote monitoring of patients with chronic diseases such as pulmonary or cardiovascular disease, diabetes to obtain reduced medical center admissions or shorter hospital stays;
- sleep control by using sensors to measure small movements such as heart rate, breathing and large movements caused by tossing and twisting during sleep and to record data through the smartphone application;
- toothbrush connected with smartphone application to analyze the brushing use and habits and to display statistics to the dentist.

7.2 Smart city

A smart city is defined as a city that can monitor and create favorable conditions for all its critical infrastructures, which can better optimize its resources, plan its preventive maintenance activities, ensure security while maximizing its services to citizens.

Smart cities can change the everyday life of people as follows:

- real-time monitoring of available parking spaces in the city to identify and book the closest spaces;
- real-time monitoring of noise in crowded and central areas;
- monitoring the vehicles and pedestrians to optimize the driving and walking routes;
- intelligent and adaptive lighting according to time;
- apps on smartphone that supports QR codes to provide interesting and useful information on city sights such as museums, art galleries, libraries, monuments, shops, buses, taxis, parks.

7.3 Smart living

The smart living affects the everyday life of people as follows:

- monitoring energy, water and gas consumption to get recommendations on how to save money and resources;
- turning on and off remotely appliances to avoid accidents and save energy;
- LCD refrigerators that provide information on the products inside them, products that are about to expire, products that should be purchased or washing machines that allow monitoring of the laundry remotely and all this information is accessed via a smartphone application;
- home video surveillance and alarm systems to increase the security of people at home;
- increase personal safety by wearing jewelry that incorporates Bluetooth enabled technology and interacts with a smartphone application that will send alarms to selected

people in the social circle with information that you need help and current location.

7.4 Smart environment

The smart environment can be composed of:

- monitoring the combustion gases and fire conditions to identify alert areas;
- monitoring soil moisture, earth vibrations to detect possible landslides, avalanches, earthquakes;
- locating and tracking wild animals via GPS coordinates;
- study of weather conditions to forecast the formation of ice, rain, drought, snow, strong wind;
- use of sensors integrated in airplanes, satellites, ships etc. to control the maritime and air activities in certain areas.

7.5 Smart energy

The smart energy is characterized by:

- monitoring and optimizing the performance in solar energy plants;
- monitoring and analyzing the flow of energy from wind turbines;
- measuring the water pressure in water transportation systems;
- measuring the level of radiation in nuclear power stations to generate alerts;
- controllers for power supplies to determine the required energy and improve energy efficiency with less energy waste for power supplies of computers and electronics applications of consumers.

8 Conclusions

The Internet of Things changes everything: from users, organizations to today's society. The benefits and opportunities of IoT are endless. Everything is connected with wire or wireless through the Internet.

The Internet of Things offers some interesting applications to make people's lives easier, spanning numerous application domains: health, transport, agriculture, building etc.

However, the Internet of Things presents a number of security and privacy issues because smart devices collect personal data of users regardless of their source or confidentiality. Smart devices know when we are at home, what electronic products and appliances we use, the type of data transmission used and other data that will be retained in the databases of delivery, installation or maintenance service providers. The risk of loss of information in the hands of malicious persons is extremely high.

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