IoT infrastructure as a basis for new information services in the ITS environment

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***Abstract* — Internet of Things (IoT) as a concept can be considered as a continuation of the Internet evolution. IoT can serve as an infrastructure foundation for the development and delivery of new services in the transport system, based on the principle of ITS. The purpose of this paper is to show the increasing role of the IoT concept, its future use in the development of ITS information services and defines the guidelines for further applications.**

***Keywords* — IoT, services, ITS, Traffic environment, M2M.**

I. INTRODUCTION

The Internet as a global communications network has undergone many changes since it was created. With the development of wireless communication technologies and devices based on them, as well as increasing their energy efficiency have created the preconditions for the development of IoT concept. The ultimate aim of the concept is to create an environment that allows the connection of objects from the real (physical) environment at any time, in any place and with any other object through the Internet network. This kind of environment makes objects active participants in terms of sharing information and autonomic responses to information received. Due to the growing role of this concept in all branches of industry and businesses, it is necessary to thoroughly investigate its application in the environment of the transport system.

The paper describes the basics of IoT concept, its architecture and environment applications. This paper shows the communication architecture of intelligent transportation systems (ITS) and the importance of ITS in the transport environment. The role of the IoT concept in enhancing ITS is presented through a variety of research implementations of IoT in a traffic environment. This research is an example of possible applications of ITS services based on the IoT concept to guide the blind and visually impaired people through the transport network. There are given guidelines for the future development of other ITS services based on the concept of IoT.

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II. BASIC IOT CONCEPT

The concept of Internet of Things (IoT) is connecting objects from the environment into the global network based on IP protocol, which makes it a prerequisite for the development of smart environment in large scale. The development of this concept is influenced by previous development of certain areas of engineering sciences such as connecting devices in motion, wireless sensor networks, processing large amounts of data, IPv6 standards and others. There were created the preconditions for the development of IoT concept by linking developed, independent, technical areas through an intermediary program layer [1].

IoT can be viewed as a further development of M2M (Machine-to-machine) communication. M2M communication supports data transmission between machines and automated means of information transfers and orders without human intervention [2]. While M2M communication allows connection of machines and their interaction through the network, IoT affords interaction with objects that reside in the human environment by extending their interaction with different information, such as geolocation, time and so on [3]. The endpoints of such communications can be people or objects such as devices or machines. As a result there are two modes of communication applicable to IoT concept [3]:

1) A person - object communication - people as users generate communication with devices in order to obtain certain information.
2) Object - object communication - an object supplies the information to another object with or without human intervention.

Observed from the point of IoT, objects are things of the physical environment (physical things) or from a virtual surrounding (virtual items). Such objects have the ability to integrate within the network of information and communication and become active participants in terms of information exchange, recognition of events and changes in the environment as well as autonomic reactions to the same events and changes [3], [4].

A. IoT functional model

In order to meet the requirements of various industries, companies, institutions and other organizations the layered IoT functional model was designed and shown in Fig. 1.

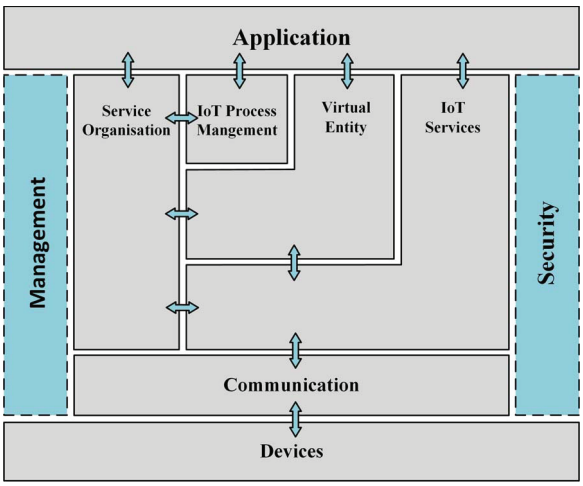

Fig. 1. IoT functional model [6]

The functional model contains seven longitudinal functionality groups (colored gray) and two transversal functionality groups (colored blue). These transversal groups provide functionalities that are required by each of the seven longitudinal groups. The policies governing the transversal groups will not only be applied to the groups themselves, but to the longitudinal groups as well. The interactions between the functional groups can be seen from Fig. 1. The main interactions between the functional groups are depicted with arrows. Since the transversal functional groups (management and security) interface with most of the other functional groups, their interactions with the are not explicitly depicted [6], [7].

B. Application environments

Potential environmental applications of IoT concept are numerous and various, and interfere with the virtually, all areas of private, business and social aspects. Therefore, even in 2010 the strategic research plan of IoT concept - Internet of Things Strategic Research Agenda – and the main application environments has been identified and described [4].

Main environments include: cities, energy, health, buildings, life and transportation.

Listed environments are equipped with facilities that possess a primitive intelligence, most often without the possibility of communication. By integrating communication capabilities and capabilities of processing data collected from the environment, creates a totally new environment that can support a large number of new services [5]. Intelligent Transportation System as application environment of IoT concept is subject of the interest of this study, primarily because of the large market potential of new variety of services in the area concerned.

III. IoT CONCEPT IN INTELLIGENT TRANSPORTATION SYSTEMS

Increasing number of traffic entities on the roads causes traffic congestion, environmental pollution, increased number of traffic accidents and many other problems. ITS imposes itself as a modern approach to solve the above problems which are already inherent in a traffic environment [8].

ITS represents the information and communication upgrade of the transport system which achieves significant performance improvement in the flow of traffic, more efficient transportation, increased safety and comfort of passengers as well as reduced environmental pollution [9].

The communication architecture of ITS is shown in Fig. 3. The connection of different sub-systems and their functionalities is visible, as well as the communication mode together with a set of applied, wired and wireless technologies. Integration of IoT concept within the field of ITS is shown in Fig. 4. Information on the traffic environment are collected via the sensor network by using different wireless technologies (RFID, NFC, Zigbee, etc.), depending on the type and source of the data collected. The information is then forwarded to the processing system and then distributed to the user, either directly or after adjustment supported by external information systems. Although a great progress has been made in recent years in the field of development of ITS, the advent of IoT concept has greatly contributed to improvement of the efficiency of this domain [10].

The development of wireless infrastructure, RFID and wireless sensor networks generally made possible the delivery of information to participants of the transport system in real time [11]. Therefore, the applications of IoT concept in the transport system are numerous and they include monitoring and reporting on overall traffic environment, from the pressure of the tires of vehicles up to the distance between the transport entities [12].

In addition, the following applications of scenarios were considered [13]:

- IoT as an integral part of the management and vehicle control,
- the control and traffic management,
- enabling new transport scenarios (multi-modal transport),
- autonomous driving and the communication (Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I)).

Although IoT is still a relatively new concept in the world, many experts have recognized its importance and potential, which can revolutionize the way of communication. Appreciation of the role of IoT concept has resulted in numerous studies that, among other things, focus on the area of traffic environment.

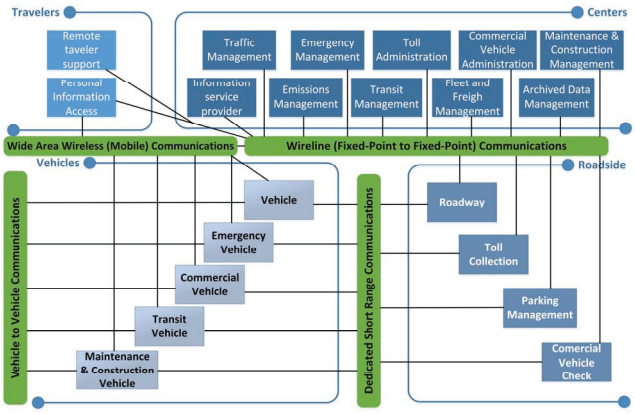

Fig. 3. ITS communication architecture [10]

"Future Internet Public-Private Partnership"(FI-PPP) is an on-going and open European Commission initiative.

Goal of this initiative is to make public service infrastructures and business processes significantly smarter (more intelegent, more efficien and more sustainable).

Aims of the FI-PPP initiative are [21] :

- increasing the effectiveness of business processes and of the operation of infrastructures supporting applications in sectors like transport, health or energy,
- deriving possible innovative business models in these sectors, strengthining the competitive position of European industry in domains like telecommunication, mobile devices, software and service industries, content provide and media.

"Vehicular Communication Systems to Enable Safer, Smarter, and Greener Transportation" is a project with the main focus on the integration of V2V, V2I and I2V (Infrastructure-to-Vehicle) communication systems within the vehicle with a set of intelligent services in order to improve traffic safety. The project seeks to address two key issues [14]:

1) Integration of technologies and protocols for V2V and V2I communication and
2) Effective distribution and smart information management of V2V and V2I / I2V environment.

SAFESPOT project, aims to provide a flexible, robust, cheap and easily sustainable wireless solution, based on intelligent vehicles and road infrastructure, for use in traffic control and traffic safety. The ultimate goal of the project is to prevent accidents and increase road traffic safety [15].

The great potential of IoT concept is in its ability to apply in automatic identification of vehicles. An example of such application is visible from the study "*The Internet of Things: a New Application for Intelligent Traffic Monitoring System*" [16]. Currently the most common technology of the automatic vehicle identification is based on processing license plates' photos. The disadvantages of this technology are: the poor quality of recognition and the dependence on the weather condition. For vehicle identification authors propose the EPC (Electronic Product Code) as a unique identifier for vehicle instead of license plates. The proposed automatic vehicle identification system is functional regardless of weather conditions [16].

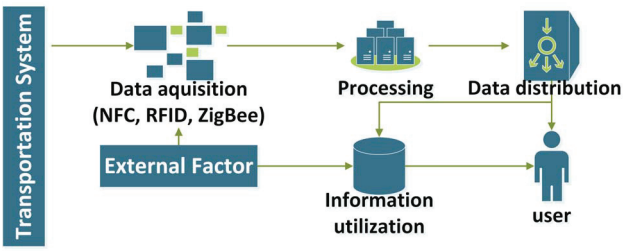

Fig. 4. IoT in ITS environment [8]

IV. Future Development and Research of IoT Concept within Assistive Technology of Transport Environment

According to the research of the Gartner Company shown in Fig. 5., the number of physical objects connected via Internet network by 2020 will be greater than 25 billion, while the market based on the concept of IoT will reach $309 billion [17]. Accordingly, the challenges associated with the development of new services based on the concept of IoT require a multidisciplinary and coordinated approach.

Applying the concept of IoT in the traffic environment must include smart mobile terminal devices, users and sensor networks within and outside of the vehicle to collect information from users, vehicles and transport infrastructure. Such a system has the ability to communicate with external systems such as traffic control systems, management of parking lots, charging infrastructure for electric vehicles, etc. [17], [18]. A large amount of data collected in the traffic environment requires communication that is based on M2M communication protocols which match criteria of safety, energy efficiency and cost [18]. The ultimate goal of this concept will be comprehensive connectivity and mutual interaction of objects [19].

Possibilities of implementing IoT concept relate to all users of the transport system. Very good examples are the users who belong to a group of blind and partially sighted people. Currently, they use exclusively their own supplies (white cane, guide dog, etc.) in the independent movement around transport network. Development and application of IoT concept can provide users with information on traffic environment [20]. This application brings the benefits to residents as well, who live near traffic light intersections adapted to visually impaired people. Currently, the noise generated by sound information on traffic intersections reduces the quality of life. By applying the concept of IoT it is possible to control the volume level of the sound information in relation to the existence of visually impaired people within the defined zone of traffic intersection. The present example demonstrates the application of IoT in developing assistive technologies applicable in a traffic environment, so there are further significant researches and projects expected in this area.

The infrastructure for the development of ITS services based on the concept of IoT must necessarily include elements shown in Fig. 6.

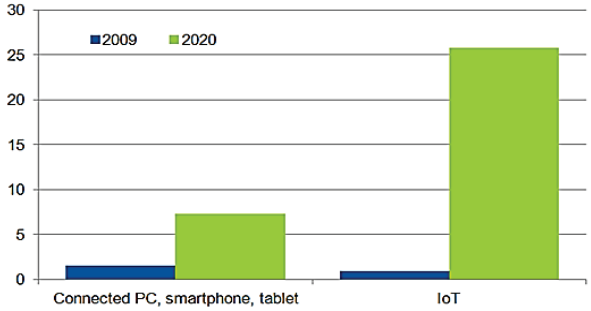

Fig. 5. The increase of the number of linked objects [17]

This involves the application of a large number of objects that possess identification or sensory characteristics and have the ability of mutual interaction. During data processing it is necessary to make a distance from a centralized way of processing and exploit the advantages provided by cloud computing. An important

element of the shown infrastructure is external factor that represents the systems beyond the traffic environment, and can provide information to raise the level of quality of service provided.

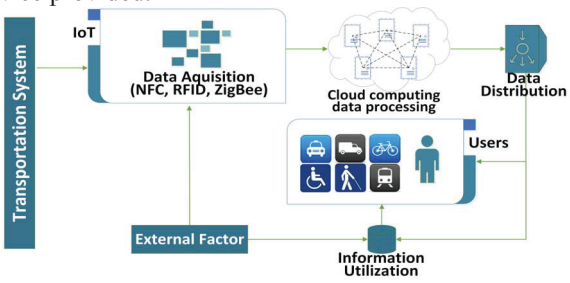

Fig. 6. IoT in the traffic environment

With research and development of assistive services it is necessary to direct the efforts in research and development services based on the concept of IoT for all segments of the transport system. During the development of such services the following is important:

- to offer new value to the end user,
- to increase traffic safety and reduce the negative environmental influences to the environment,
- to increase the effectiveness of monitoring and traffic management while reducing costs,
- to ensure confidentiality, integrity and availability of information during collection, processing, storage and transmission.

The adoption of these guidelines will ensure sustainability, efficiency and acceptance of IoT services in the traffic environment.

V. Conclusion

The development of different areas in technical sciences causes the development of new modes of communication and information transfers. One of the outputs of this continuous process is the IoT concept that defines the distinctive ways of communication and connection of different objects, which then allows the interaction between them. Expected number of related objects by 2020, according to research, will be greater than 25 billion dollars, and the value of the market share in the IoT concept will reach a value of 309 billion dollars. According to these data it is concluded that this concept provides an infrastructure base for numerous information and communication services, and is emerging as a trend of the future development of numerous information and communication services, and is emerging as a logical solution for the ITS environment. However, to be sustainable, accepted and effective, the future development of IoT services that apply to intelligent transportation systems must meet conditions such as providing new value to the end user, increase traffic safety, effectiveness of supervision, information security and many others. One of the important issues when implementing IoT concept within the traffic system is the privacy and security of data communications. Because of actual time of positioning the individual vehicles in the traffic environment it is important to provide a communication channel through which such information is transmitted in order to not compromise the users' privacy.

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