Internet of Things as Advanced Technology to Support Mobility and Intelligent Transport

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Abstract. This keynote paper creates the framework for the 2nd EAI International Conference on Mobility in the Internet of Things (IoT). The IoT offers advanced connectivity of devices, systems, and services that goes beyond machine-to-machine communications and covers a variety of domains and applications. The interconnection of embedded devices is expected in many fields including Mobility and Intelligent Transport. In the light of the latest knowledge and scientific projects findings the authors present actual R&D trends in the given field. New ideas, cutting-edge innovations and technologies for mobility agenda are needed together with a multidisciplinary perspective approach. The paper indicates most common recent aspects for future development of the IoT applications for support of Mobility and Intelligent Transport. Research and innovations projects including ERA Chair project in ITS at the University of Žilina are presented as examples of solutions for IoT applications for benefits of citizens (motorized and non-motorized public).

Keywords: Internet of Things · Mobility · Transport · Research · Application · Smart · Information and communication technology · Security and safety · Intelligent Transport Systems

1 Introduction

The Internet of Things (IoT) is an emerging technology that evolved from the convergence of Internet, wireless technologies and micro-electro-mechanical systems (MEMS). For the first time, the term "Internet of Things" was used by Kevin Ashton, founder of Auto-ID Center, in 1999. The 'thing' may be any natural or man-made object, assigned a unique identifier: a car with built-in sensors, a live organism (human or animal) with implanted devices (biochip, heart monitor), a home control system with detectors, etc. As defined in [1], the IoT can be realised in three paradigms – internet oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge). The usefulness of IoT can be released only in an application domain where the three paradigms overlap. Therefore at the moment the prospective applications seem to be in health care, policy making, industry, defence sector, infrastructure monitoring, energy (smart grids), factories of future, retail, environment protection, business intelligence,

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smart metering, home management and many others. A very broad area for IoT deployment associated with mobility is transport and logistics, including parking, highway monitoring, emergency services and many other services. Machine-to-Machine (M2M) communication ability is a prerequisite of so called smartness.

Ubiquitous sensing by Wireless Sensor Networks (WSN) technologies offers in many areas new possibilities for the support of everyday life. One of the important areas for utilisation of ubiquitous sensing is mobility and transport in general. Variety of enabling technologies such as RFID tags, different types of embedded sensors and actuators are transforming the internet utilisation and create new services heading to a fully integrated Future Internet. The Digital Agenda for Europe - Europe 2020 Initiative in chapter “Future Internet” [2] has priorities in internet of services, things and infrastructure. This includes research into the Network Technologies of the Future, Cloud Computing, Internet of Things, Future Internet Research and Experimentation, Public-Private Partnership in Future Internet etc.

The OECD Technology Foresight Forum 2014 refers about the Internet of Things [3] as a term applied to the next 50 billion machines and devices that will go online in the next two decades. The number of connected devices in households in OECD countries is expected to be 14 billion by 2022 in comparison to around 1.4 billion in 2012. The large scale economic and societal influence of these developments will be influenced through the data collected in network with IoT implementation and machine learning can be an essential element for such data and the data they collect can be used to take action. Silver Spring Networks [4] refers that “a controlled plug every 30 m in each street” will be located for smart city solutions.

In accordance with Goldman Sachs [5] the Internet of Things is emerging as the next technology mega-trend, with effects across the business spectrum. By connecting to the Internet, billions of everyday devices – ranging from fitness bracelets to industrial equipment – the IoT merges the physical and online worlds, opening up a host of new opportunities and challenges for companies, governments and consumers. A very large number of embedded devices connected with IoT will generate a huge amount of data, even if individually each of them contributes only a limited amount. In mobility and intelligent transport systems (ITS), sensors and mobile devices (mobile phones, OBUs) generate it. The main role is to extract meaningful information from big data. For that the equivalent and corresponding computer software with optimal processing power and knowledge and skills of experts are needed.

It is assumed that the massive growth of M2M traffic based on IoT will require a more efficient and ubiquitous technology to carry the data traffic and the use of communication – especially wireless – technologies by humans and by machines. 5G technologies won’t just be faster, it will bring new functionalities and applications with high social and economic value for mobility and intelligent transport too. The main current research directions were given at Globecom in December 2013. The capacity is to increase by a factor of 1,000. Data rates are to go up to 50 Gbps for low mobility, 5 Gbps for high mobility and 1 Gbps anywhere, i.e. this seems to be the minimum everyone should be able to enjoy also in remote areas. The latency should further decrease to less than 1 ms (it is 5–10 ms in LTE), and energy consumption should be reduced by a factor between 10 and 100. These targets will be achieved by enhancement of LTE which will include the deployment of dense, smaller cells and may include other general enhancements like the combined usage of higher and lower frequency bands and the substantial use of MIMO technologies and specification of completely new radio access technologies (11).

2 Innovation Cycle of the IoT

As any other new technology the IoT also follows a typical innovation cycle going through the usual phases: innovation trigger, inflated expectations, disillusionment, enlightenment and productivity. Seeing examples of the Gartner's hypo curve for emerging technologies published in recent years 2012–2015 it is apparent that since 2012 when the IoT was situated closely to the end the of the 1st phase this year the technology has reached the peak of inflated expectations.

Expectations are 5–10 years to reach plateau of productivity which means to have tools and products saturating the market. The promises are huge – the IoT seems to be the world's most massive device market in few years; however, estimations of exact size vary greatly. The Hype Cycle includes series of various emerging technologies; some of them being interconnected and/or interdependent. Each of them usually depends on one or more other sub-technologies that (if not quite ready) can limit the true potential and successful bringing to the life. For the IoT the right *balance of power consumption, cost and bandwidth* will have to be found for both industry or people needs. Otherwise the massive scale connection of things may come rather in the form of idle wishes than reality.

A *lack of standards* may turn out to be another troublesome barrier for rapid IoT development. Currently the IoT lacks a common set of standards and technologies that would allow for compatibility and ease-of-use. The war of IoT protocols has already started and hardly any winner can be identified at the moment. There are currently few standards/regulations for what is needed to run an IoT device. Instead of a single standard for connecting devices on the IoT there are several competing standards run by the following coalitions: The Thread Group (Qualcomm, The Linux Foundation, Microsoft, Panasonic), The Industrial Internet Consortium (Intel, Cisco, AT&T, IBM, Microsoft), Open Interconnect Consortium (Samsung, Intel, Dell), Physical Web (Google), AllSeen Alliance (Samsung, Intel, Dell) and huge number of smaller non-standardized protocols in use [6]. As far as the industrial IoT is concerned, the Industrial Internet Consortium (IIC) was founded in March 2014 to bring together the organizations and technologies necessary to accelerate growth of the Industrial Internet by identifying, assembling and promoting best practices [7].

A lot of potential applications will put increasing pressure on *security and safety issues*. Anything associated with the Web contains potential hazards, so more devices will have to be considered critical than nowadays. On one side data generated by the IoT has the potential to reveal far more about users than any technology in history. On the other side systems generating data could be (and surely will be) the subject of hacking with all negative consequences to the systems themselves, their users, environment, on local or even global scale. The industrial IoT opens the door of safety risks to industry and enterprises. Transportation may be a good example of potential vulnerability (web connected cars, communicating road-side infrastructure, railway SCADA systems, planes and airline systems).

The need to store and analyse big data in a secure way may require unexpectedly high demands on additional costs. Even at present, various countries and domains apply different privacy-related legislations that limit personal and other sensitive data processing [9]. Thus success and failure of IoT applications may be country specific. People do not use technology that they do not trust. Since in principle nothing may be 100 % secure or safe, the serious and open game with societal acceptance of risks must be played. After all, the benefits of privacy by design smart connected product should outweigh privacy and safety concerns.

At present it is hard to imagine all kinds of things potentially connected to the network in the future and their functionalities - from “dumb” objects such as light switches, toasters, fans up to “smarter” ones such as transport means, health monitoring stations, smart homes, etc. Even though it is clear that *natural interactions* will be highly preferred, i.e. using systems that understand gestures, expressions and/or movements and engage people in a dialogue, while allowing them to interact naturally with each other and the environment [8]. The aspect of intuitiveness may also become very important, with no need to wear any special device or to learn a set of instructions.

The idea of monitoring and controlling everything via wireless networks will bring a huge increase of data. ABI Research estimates [10] that the IoT communication in 2014 generated data traffic of 200 exabytes. At the end of the decade in 2020 the Internet of Things is expected to transmit 8 times of this data volume, i.e. 1 600 exabytes or 1,6 zettabytes. However, the real added value will be not in the data itself or technologies providing it but in the provided services.

We could foresee that IoT deployment will speed up customization trends and inevitably bring *changes to social and working patterns*. As an example the trend known as BYOD (Bring Your Own Device) is being often mentioned – enterprises allow their employees to bring their own personal devices into the work environment, to use them, share working data, etc. Gartner calls BYOD the “most radical change in the economics and the culture of client computing in decades” and expects that, by 2017, half of all companies will have mandatory BYOD policies.

Sometimes new technologies are adopted applying the so called M-U-D (Middle – Upper - Down) approach. The middle layer represented by managers in the field can see an added value of the new technology and convince the upper managers of benefits of adopting it by the lower layer employees. It is probable that IoT deployment initiatives may be operated in a similar approach. In any case, companies are expected to have sufficient level of maturity to manage their information and organization processes.

Filling the facts associated with IoT deployment is a big *challenge to semiconductor industry*. According to Dean Freeman, semiconductor manufacturing analyst at Gartner, Inc., perhaps by the end of this decade - the world may be home to a trillion sensors - eventually, a trillion sensors a year could be consumed [12].

3 ITS Projects Continuity at the UNIZA

The University of Žilina (UNIZA) uses its intellectual, technological, scientific, and research potential to solve problems of basic and applied research in the field of intelligent transport. At the turn of the century UNIZA became involved in the resolution of key transportation challenges on national and international level.

The titles of pinpointing university projects are shown in Fig. 1.

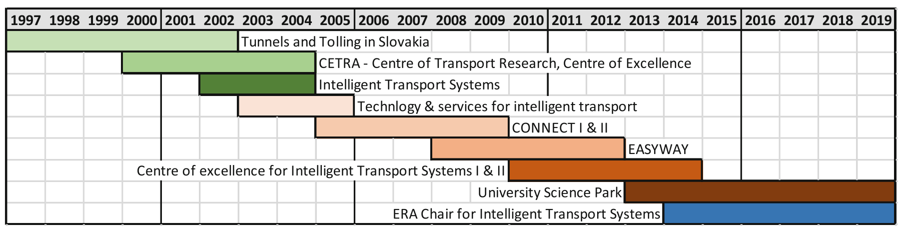

Fig. 1. ITS project continuity of UNIZA

These research directions are fully compatible with the European research heading formulated in the Strategic Research Agenda 2020 document, an EU frame programme for research and innovations Horizon 2020, as well as with the Long-term plan of state scientific and technical policy until 2015 (The Fénix strategy), National plan of research and development infrastructure – SK ROADMAP, and the Danube region strategy. On these foundations, a modern scientific-research infrastructure is further built, a cooperation with foreign research and educational institutions as well as with commercial sphere is being developed. New generation of experts has been formed focusing on intelligent transport technologies and services. The result of these activities was the acquirement of University Science Park.

UNIZA demarcated 2 long-term strategic development directions – “intelligent transport” and “digital enterprise”. In line with this heading, in 2014 the construction of University Science Park (USP) and University Science Centre (USC) started. The initial conception of USP structure in the area of intelligent transport, as defined at the beginning of the USP project proposition, is shown in Fig. 2.

Its centre is constituted by a computer system in the position of a monitoring and control system (Virtual Smart City - ViSC), which enables to build the concept of “smart city” with emphasis on control of processes primarily related with monitoring of traffic state in a selected geographically defined area. The conceptual scheme of intelligent city virtual platform is based on traffic models using data gained from sensor networks. Using manually entered or generated input data, it will enable to model the operation of city, thereby serving as a source of virtual sensor information for the superordinate monitoring and control system. The superordinate system can subsequently, based on the acquired sensor data and analysis of the defined models, intervene the infrastructure control and optimize the traffic process.

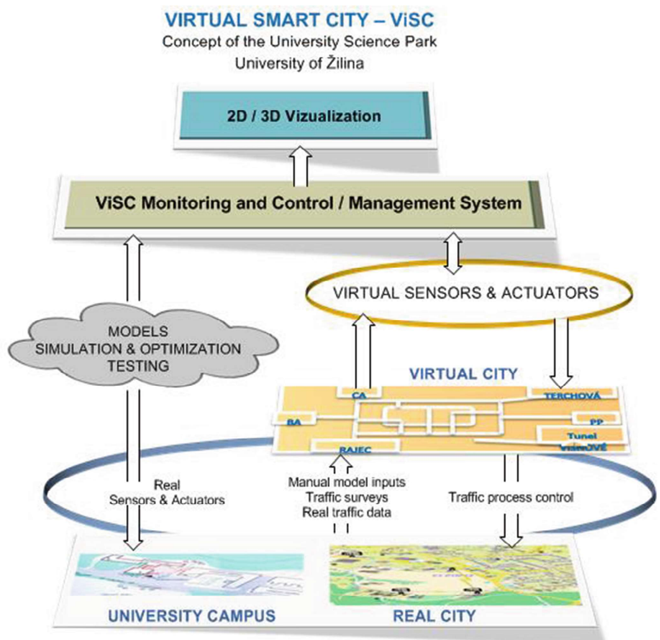

Fig. 2. The Virtual Smart City concept (ViSC) according to University Science Park

By the end of June 2014, UNIZA started a testing operation of IBM Intelligent Operations Center for Smarter Cities, specifically a transport oriented modification - IBM Intelligent Operations Center for Transportation (IOT) providing advanced analytical, optimisation and prediction tools. The basic idea of this concept is that the quality of life in city agglomerations is highly dependent on the quality of services provided to the residents, which is significantly affected by the perceived quality standard of transportation and many other services. This requires a considerable volume of information, real-time communication and cooperation of several subjects involved within the control of distinct city processes with the objective to counteract the emergent problems before they arise, if possible.

The current problem is that all critical data is typically stored in heterogeneous and mutually incompatible systems located within the premises of various administrators, thus disabling a single complex and integrated view on the events taking place. The system would enable a rapid sharing of information and a mutual coordination of all units and thereby to improve the effectiveness of the services provided.

The initial project phase will focus on the UNIZA campus at the Velky Diel, therefore this phase is referred to as Smarter Campus. In order to implement these strategic objectives, the Faculty of Electrical Engineering acquired in advance several new technologies which will provide a momentum for the development of so-far activities and enable to prepare their integration into the planned processes. The core of these technologies are the products of Libelium® (Meshlium® networks for Wapsmote® sensors).

4 ERA Chair

The EU-funded ERAdiate project [13] is promoting excellence of the University of Žilina and the Žilina convergence region in the field of Intelligent Transport Systems aiming for enhanced competitiveness in the European Research Area (ERA). The University Science Park (USP) of UNIZA is the home base of the ERA Chair Holder and his team. Using the research infrastructure the focus will be on ITS innovations such as cooperative ITS (connected vehicles and infrastructure, an already available and standardised pre-phase to IoT), decarbonisation of mobility (i.e. electro-mobility and its requirements), big and open data, interoperability, and human factors. These include acceptance, usability, data protection and privacy aspects, as well as liability aspects, where resilience and resistance to fraud, hacking, etc. are important.

5 Conclusions

Internet of Things is a crucial technology for the implementation of ICT into transportation in general. There are many areas which will be supported with this technology. IoT is a huge challenge and has urgent need to be standardised in many areas (information and communication networks and services, safety and security, etc.) for faster and more effective applications. IoT in general is always an innovative task for utilisation of the Interned networks and services and gives new requirements in many fields for it. New requirements are needed for collaboration among industries producing equipment, those who operate transport infrastructure, municipalities, academia, and citizens to answer on such challenges. Support from research and development agencies is very needed to speed up processes for developing smarter and greener solutions in transport and mobility.

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