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Impact of Internet of Things on Urban Mobility

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Abstract

The urban population is predicted to increase to 66% by 2050. The rapid growth of urbanization and increasing congestion are significant challenges faced by the world today. Innovative solutions in urban mobility are key for a successful development and a sustainable future. The new paradigm, Internet of Things (IoT), facilitates the need for new approaches in urban transportation, leading to a modern concept: Smart Mobility. The boom of technology and innovation from recent years allowed a great expansion of IoT. Furthermore, the number of smart devices that communicate, cooperate and complement each other, grows rapidly in every domain broadening the scope of IoT applications. This paper sets to discuss the impact that IoT might have on urban mobility, mentioning its implications, challenges and technical solutions. It further reviews the advancements made in the transport infrastructure along the years that support the emergence of Smart Mobility. Three main research questions stay at the forefront of this paper which are drafted in pursuit of the solutions for the problems and challenges currently faced by urban transportation. Which leads to a sustainable future with efficient and effective urban transportation system. The paper uses a mix-method approach, using on one hand qualitative research for literature review (State of the field) and on the other hand quantitative research to assess public opinion on the research topic, through an online questionnaire. To answer the research questions with proper arguments, both research methods were necessary, which lead to optimal results. The results of the questionnaire were interpreted based on Spearman's correlation and descriptive statistical analysis. They brought an in-depth view on the public opinion regarding IoT and the developments enabled by this paradigm within the urban mobility sphere. The output of the questionnaire highlights the eagerness of participants usually stuck in traffic to see innovation within urban mobility. Over all the results based on the opinions suggest that the public strongly believes in the Internet of Thing's applications and its adaptation will benefit the urban transportation system. Furthermore, new developments in the urban mobility sphere will be largely embraced.

Keywords: *Internet of Things, Urban Mobility, IoT Implications, Sustainability, Smart Mobility, opinion*

Introduction

One of the most important developmental challenges faced today is managing the rapid growth of urbanization and congestion, as the world's population that lives in urban areas is predicted to increase to 66% by 2050. Sustainable cities are key to a successful development (UN, 2014). A crucial aspect for a sustainable city is the urban mobility, which in its current state is not able to support in an efficient way the increase in traffic and commuters flow. This calls for new approaches in urban transportation and here it is where IoT meets urban mobility, transforming it into Smart Mobility (Narayanaswami, 2017).

At this point we already know the internet has transformed almost every aspect of our day to day life, by linking the physical and virtual world. A new paradigm that adds an advanced dimension to the current network is emerging, called the Internet of things (Atzori, et al., 2010). There are almost no limitations to the domains and applications of this connected technology, new smart technologies being launched almost daily. This opens a new world full of possibilities, making IoT a representative of the future (Gubbi, et al., 2013).

The boom of technology and innovation from recent years has allowed the concept of IoT to develop even further with estimates that by 2020 there will be 30 billion smart devices (IHS, 2017). This paper will give an insight into the technology of IoT in relation with the urban transport system, as it is important to determine the impact that innovation and technology have, especially on urban mobility and urban development. They influence and affect directly one's experience within a city (Rikken, 2016).

Objective and research questions

In pursuit of the solutions for the problems and challenges currently faced by urban transportation, as discussed above. The focus of this research paper is on the mobility of people in the urban settings. This paper aims to answer the following research questions (RQ):

1. What are the foreseeable advantages of IoT on urban mobility?
2. What are the possible challenges in application of Internet of things on urban mobility?

State of the field

The following section summarizes important aspects in relation with Internet of things and urban mobility, the core points of this paper. Based on the findings from the available resources in regards with this field, topics like transport infrastructure developments, Smart Mobility, IoT implications and technical solutions, challenges and sustainability will be discussed more in depth.

Urban mobility

The term mobility indicates both the willingness and capability for movement from point A to point B, with the objective to fulfill the demand for accessibility for multiple activities. There

are more types of mobility, such as intellectual, social, professional or spatial mobility (Wegener, 2013). As the population continues to grow, it is projected that by 2050 the world's urban population will grow by 2.5 billion more people. In this context, the urban mobility plays a key role in the development and adaptation of cities to accommodate such a rapid growth in congestion and urbanization. Sustainable development solutions are being increasingly demanded in cities to facilitate a better urban experience. Cities increasingly face problems caused by traffic and transport, with needs for mobility to reduce congestion, accidents and pollution. (UN, 2014).

A Brief overview of evolution of urban mobility and transport infrastructure

Table 1

Brief overview of evolution of urban mobility and transport infrastructure

Phase	Explanation	Authors
Early transport infrastructures	Generations ago the transportation of people and goods was difficult, time consuming and hard. The automobile was just a luxury item, roads and bridges were almost nonexistent in that era. Significant turns in history were the construction of the first railways, highways and the apparition of automobiles and planes.	Grübler and Nakicenovic, (1991)
Semi-automated infrastructures	This refers to the current infrastructure of roads, tunnels, turnpikes, bridges and modern amenities available to complement the innovation in mobility. The past decade has seen the emergence of concepts and tools to support automation, which brings agility in development and operations. One of the most prominent and visible application of automation in urban transportation is the automated vehicle. The prime objective of such technology is eliminate congestion and accidents by making automobile safer, effective, efficient and environment friendly. Though we stand on the edge of complete automation in road transportation, still, there are multiple levels of automation that have to be passed in order to reach full automation.	ISA, (2017) Azmat, et al., (2018) Azmat, et al., (2016) ECSEL Europe, (2016)
Fully Integrated and intelligent infrastructures	This refers to the modernization of existing infrastructure and adapting technological innovations in both automobile and information technology a leap towards fully integrated and intelligent infrastructures. Due to challenges caused by congestion and urbanization, intelligent infrastructure presents a solution to optimize cities, transforming everything	Siemens AG, (2017) Siemens AG, (2014)

	in smart technologies, from architecture, environment and transport to economy and governance. According to some researchers smart mobility should be viewed, as an organic whole – as a network, as a linked system. Where people, infrastructure and vehicles are the most important nodes. People must play an active role in the transformation towards a smart mobility and the fulfillment of their needs in an intelligent and efficient manner. Transforming the current transport system into one that allows seamless, efficient and flexible travel across various modes is the future of urban mobility.	Kanter and Litow (2009) Papa and Lauwers, (2015) Benevolo, Dameri, and D'Auria, (2016)

Internet of things and its implications on urban mobility

The researchers like Atzori, et al., (2010) and Mishra, et al., (2016) highlight the variety of application domains of IoT. They claim, differences will be seen in logistics and transportation, health care, environment, industrial manufacturing and social domains. The devices mentioned above already exist in the majority of these environments with different levels of smartness. The goal is to bring all these items to the same level of intelligence and communication capability. The term "things" refers to any physical and virtual object that can be identified, located and controlled by using "Internet". These smart devices will influence not only one's day to day life but also the economic activity and the way business and industry will act further in the digitalized world. They further explain IoT will allow the circulation of information in real time to provide accurate traffic status, best route and vital information for all participants in traffic to facilitate a better management and control of traffic and safety.

The implications of Internet of things on transportation will have an impact on the following:

Table 2

A brief overview of implications of internet of things on transportation

Implications	Explanation	Authors
Smart infrastructure layers	The emergence of IoT added several layers to the traditional infrastructure: The operational technology (collects data from the physical infrastructure), the communications technology (enable real time communication with all the nodes within the infrastructure) and the information technology (enables the use of intelligent transport system). These all enable smart devices to function properly within the urban mobility context.	Schneider Electric, et al., (2014)
Mobility as a service	Together with IoT and its application on urban mobility, a multitude of possibilities that benefit travelers, transport operators and urban planners have emerged. Examples of	Schneider Electric,

	smart mobility services are smart parking, smart ticketing, journey planer and vehicle sharing service. These solutions represent the future of urban mobility, which is mobility on demand. Users can to plan in an efficient and effective manner each trip and have easy access to different transport modes and related information.	et al., (2014) Azmat, et al., (2018)
Interoperability	Due to the integration of multiple domains and several smart devices. The interoperability challenge between these devices has surfaced lately. To keep innovation on track manufacturer of different devices and operating systems need to develop a standard IOT integration platform for seamless usage of IoT technology.	Valerio, (2015) Prophet, (2016)
Digital divide	It refers to the gap between people who use/ have access to digital and smart devices and those that do not. The most prominent digital divide is between the emerging and developed countries and rural and urban communities. A solution to this fragmentation is highly needed to bring the advantages of the Internet of things everywhere in the world	Valerio, (2015)

Internet of things and its technological Solutions

There are multiple technological solutions for the urban mobility that are based on the Internet of things technology, with the aim to enable a better life and experience in a city for individuals. The urban mobility is headed towards a smart future and all technological solutions work to achieve and develop a smart mobility. Public, integrated and on-demand transport are key aspects of urban mobility in the future. Access to real time information from traffic and efficient transport management are both fundamental objectives in a Smart Mobility.

INTEGRATED mobility platform

An integrated mobility platform offers the opportunity to connect all modes of transport, increase their functionality and implement new services. The goal of this platform is to be one step closer in reaching the full potential of Smart Mobility by giving the user access to information about all the available modes of transport, the chance to book, plan, pay and use them. This platform tries to combine all challenges of urban mobility: efficiency, integration, easy access, sustainability and safety. The future of mobility is being able to rely on a variety of transport alternatives and use them on demand, whether it is a car, taxi or bicycle (smile mobility, 2014).

VEHICLE-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication

The idea behind V2V and V2I is the autonomous communication between electronic systems, without human intervention. This goal is achievable, due to the emergence of IoT (Booysen, et al., 2012). V2I means that the transport infrastructure sends valuable information to vehicles regarding traffic and road conditions, collision danger, speed limitations, traffic jam at intersections, etc. and recommends certain actions to vehicles situated in traffic. The communication between two or more vehicles, V2V, aims at the interaction and collaboration between them. The information that is interchanged is based on the on-site traffic aspects (Glielmo, 2011). The main goal of using these technologies is to avoid accidents mainly caused by human errors and provide a safer transport system with strong incentives for the further development of these concepts. Moreover, an intelligent traffic and infrastructure management are highly needed to support a sustainable transport environment (Booysen, et al., 2012).

Challenges

One of the main challenges faced by the internet of things today concerns the security and privacy of the collected data, resulting in the need for new guidelines, rules and regulations to accommodate the changes in the transportation system (Azmat, et al., 2018) .The communication between devices puts in danger data authentication and integrity. This kind of wireless communication is still vulnerable to cyber-attacks. IoT connects so many items, making it an extremely large smart network, where the method for data collection and distribution will be completely different to the one that users are currently used to, making data privacy a significant concern. There will be a change in the extension that individuals can control the disclosure of personal information provided by them to different devices. Data privacy should be a top priority in regards with IoT and it should be clearly established what personal details are being collected, by whom, over which time period and for what reason. Improving the security of the IoT technology should be one of the priorities in the further development of this network, as only by achieving top security and privacy of data, IoT could be used at its full potential (Atzori, et al., 2010).

Sustainability

Sustainability stays at the core of the Smart Mobility. With the pressure of climate change problems, it is important for all the advancements in technology to come with solutions for a sustainable environment and future. Smart Mobility poses to be a valuable answer for the reduction of fuel consumption and CO2 emission, traffic congestion, air pollution caused by vehicles, or the transfer of transportation from fossil-based energy to renewable energy. Together with the advancements in urban mobility, a sustainable transport structure is increasingly being promoted with alternatives to the classic system. Mobility on demand and the integration of all modes of transport are trends towards which the urban mobility is headed.

Stressing the importance of public transport for day to day life not only on occasional option should achieve the Smart Mobility goals for a better and sustainable life (Wegener, 2013).

Methodology

The paper uses a mix-method approach, using on one hand qualitative research for literature review (State of the field) and on the other hand quantitative research to assess public opinion on the research topic, through an online questionnaire. To answer the research questions with proper arguments, both research methods were necessary, which lead to optimal results (Brannen, 2005).

Methods of data collection

The secondary data for the qualitative part of this research was extracted from different articles and journals that were published in relation with the searched field. Most of the papers cited in this paper were easily available and accessible at databases like EBSCO Business Source Premier, web of science and Google Scholar. The following keywords were used to gather most of the secondary data for this research: internet of things, IoT, implications, infrastructure development, transportation, urban mobility.

Apart from the qualitative studies a part of this research concludes analysis of participants in a survey on the impact that the Internet of things has on Urban Mobility, considering its implications, technical solutions and challenges. The aim of the questionnaire was to give a better insight into the public perspective on Internet of things as a solution in the global challenges of urban mobility.

Analysis technique

The survey was followed by the correlation and descriptive statistical analysis using SPSS to interpret the results. Spearman's correlation was chosen, as it is one of the most common statistical tests to assess the relationship between two statements. To ensure coherence in interpreting the correlation coefficient r_s, the scale proposed by Cohen was used: 0.1 is for a small correlation, 0.3 for a medium one and a 0.5 coefficient represents a large correlation. The size of the population is indeed important, as even if the correlation coefficient is rather low for some statements, for a large participation pool (181 participants for this survey), the result is still very significant (Cohen, 1988).

Results and analysis

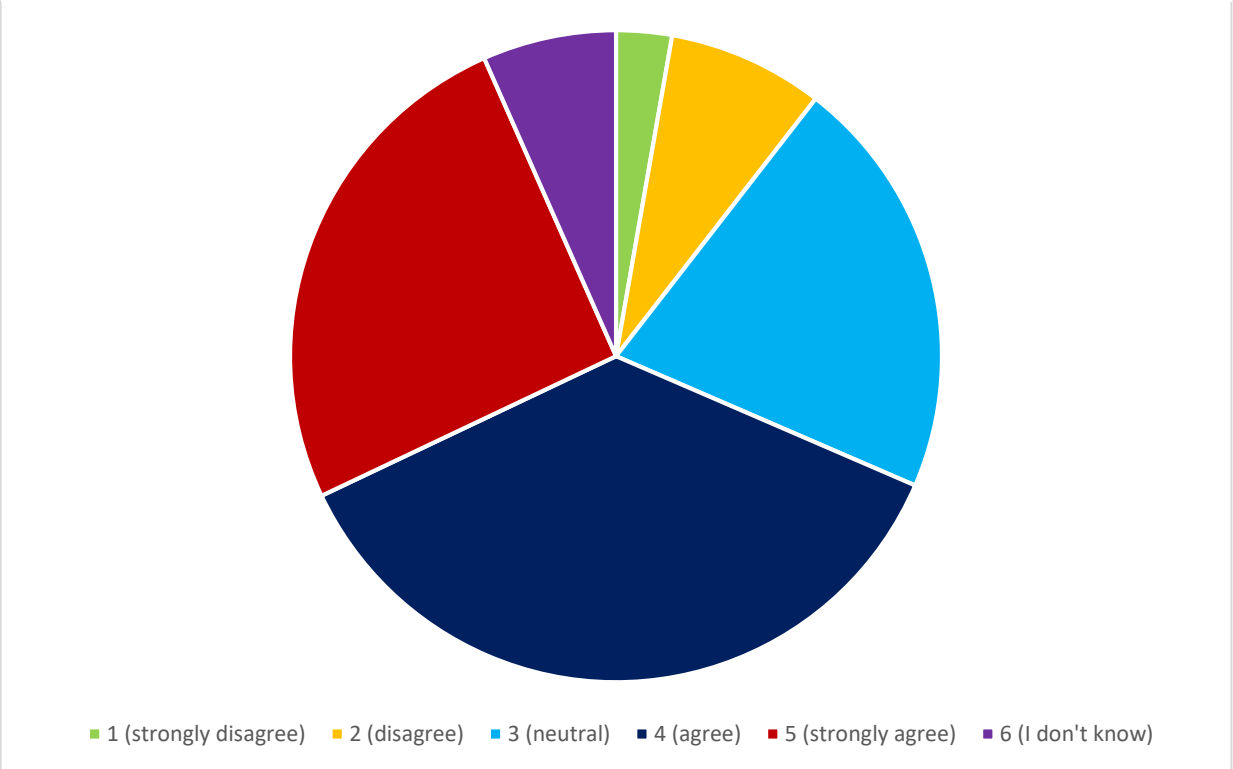
The paper aimed from the beginning to answer three main questions, which are recurring in relation with its central topics, the Internet of things and urban mobility. This chapter focuses on the peoples' opinion on the implementation of IoT within the urban transportation system through analyzing the survey results based on the Spearman's rank order correlation and descriptive analysis.

RQ1: What are the foreseeable advantages of IoT on urban mobility?

The responders (highly) agreed (62.98%) that the urban transportation system is too crowded. The correlation between the power of IoT to enable modern alternatives and the agglomeration in public transport is relatively strong. Moreover, it is no surprise that there is a strong and significant correlation between IoT and the public transport system. It shows that people strongly believe in the integration of IoT within urban mobility and how beneficial the modern alternatives for transport will be to accommodate the constant growth of population in cities. It is largely recognized that the problem of congestion in cities is rapidly increasing and the IoT presents itself as a suitable source to help release traffic and public transport congestion. This is proved also by the strong correlation between IoT as a facilitator of modern alternatives in urban mobility and the congestion in cities. The core point of Smart Mobility should be to tackle the problem of congestion in cities, that is increasing everyday due to urbanization.

One last correlation between the benefits brought by Smart Mobility and the importance to use sustainable urban transportation depicts a significant and rather strong relationship between these two. An impressive number, 115 out of 181 participants, recognized the importance of using sustainable and environmentally friendly modes of transport.

Figure 1 Smart Mobility as an enabler for the reduction rate of road congestion, road



In view of the above results, can be considered that people understand what Smart Mobility is and the opportunities brought by this concept and are confident in its powers and significance within urban transportation. People associate IoT with a key player in providing a sustainable future in transport. Sustainability holds an important role in all technological developments, including Smart Mobility.

Table 3

RQ1 Spearman's Correlation

Statements		**Spearman's correlation coefficient (0.01 significance level, N = 181)**
"Internet of things" has the power to enable modern alternatives for the urban mobility.	The urban transportation system is too crowded.	0.390
	The public transport system will benefit from the implementation of IoT.	0.608
	One pressing problem nowadays is congestion in cities. IoT could help identify the cause of congestion and work towards eliminating it.	0.569
Smart Mobility proposes to reduce road congestion, road accidents rate and reduce costs across all modes of transport. Thus, the full implementation of Smart Mobility has to take place in the near future, as will benefit the urban experience.	In the context of climate change, it is vital to provide a sustainable future in urban transportation.	0.431
	Sustainability is important for me. I make sure that the modes of transport I use are sustainable and environmentally friendly.	0.404

RQ2: What are the possible challenges in application of IoT on urban mobility?

One of the major challenges that is starting to be sensed by people is about data security and privacy, it is not surprising that 61% of participants (highly) agreed. The results of the questionnaire show general agreement that the safety and privacy concerns within IoT must be taken seriously and acted upon solving them. Often there are problems of connectivity, compatibility and general annoyance that one must use multiple providers to satisfy one's needs. A Spearman's correlation was run to determine the relationship between the compatibility of different smart devices and the need to use multiple smart platforms and service providers to achieve a certain task/ goal, which resulted in a moderate and significant correlation. More than 55% of responders (highly) agreed with the statements below, showing that the compatibility problem still exists among devices powered by IoT and it can be an impediment in daily activities performed in urban mobility.

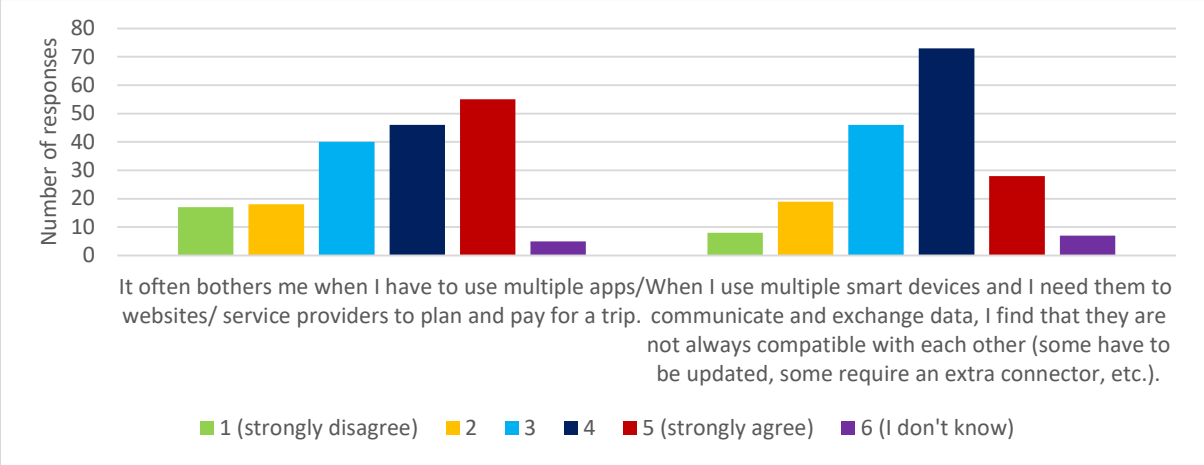


Figure 2 Consumer view point on challenges associated with IOT applications

The correlation between the need for real time travel behavior data and connectivity problems of smart devices is rather medium. The responses show that the majority of participants at the questionnaire agreed with both statements, namely that real time travel behavior data is highly requested to improve the urban transportation planning and facilitate optimality in urban mobility, but users often have problems with the connectivity of their smart devices which makes it hard to track data immediately.

Table 4

RQ2 Spearman's Correlation

Statements	**Spearman's correlation coefficient (0.01 significance level, N = 181)**
It often bothers me when I have to use multiple apps/ websites/ service providers to plan and pay for a trip.	0.307
When I use multiple smart devices and I need them to communicate and exchange data, I find that they are not always compatible with each other (some have to be updated, some require an extra connector, etc.).	
To improve the urban transportation planning, travel behavior data is required. Together with the emergence of IoT, transmission of real-time data is possible. This facilitates optimality in urban mobility and ultimately improves user's experience.	0.221
I expect to have access to Internet and to be able to use smart objects everywhere (within and outside my city/ country), but I often have problems to find good connection or service.	

Conclusion

The new dimensions added to the power of Internet and the capability of devices to exchange information and cooperate with each other will have a significant impact on the world. Digitalization is a term that is nowadays on everybody's mouth and leads to a total connection between the physical world and the cyber world. IoT is continuously transforming the urban mobility as we know it into a modern, efficient and sustainable system, that offers a better life for citizens and a better experience in the city for all participants in traffic. It brings technological solutions in the urban transportation sector, that will ultimately revolutionize all modes of transport and change commuter's habits and approaches towards urban mobility.

Additionally, the survey results have brought an in-depth view on the people's opinion regarding the Internet of things and the developments facilitated by this paradigm within the urban mobility sphere. The outputs have underlined even more the problem of congestion in cities, with the urban transportation system being unable to accommodate the rapid growth of population. Even though the majority of the participants were accustomed with Internet of things, the public still requires more awareness on the benefits that this technology can bring and its possibilities to transform the urban mobility into an efficient and optimal system. The results of the survey proved to be in favor of the technological implications of IoT on urban mobility, the participants being especially eager about the idea of Mobility as a Service. Naturally, the public is conscious of the security and privacy concerns that come together with this technology and a rapid solution to this challenge is very much requested.

The impact of Internet of things on urban mobility was thoroughly shown in this paper, discussing on one hand the advantages that come with this connected technology, such as the emergence of Smart Mobility and the technological solutions that influence positively the urban mobility, and on the other hand it mentioned the current flaws of IoT, like interoperability problems, the danger of creating a bigger digital divide and concerns related to data privacy and security.

To conclude, the analysis of the survey has undoubtedly shown the increased interest of the participants in IoT and their confidence in this paradigm that it can help the urban mobility to expand its capacity and keep up to date with modern times. The full implementation of IoT within the urban transportation is a must to be able to continuously respond to the commuter's needs.

Research limitations

Although this paper covers a multitude of aspects regarding Internet of things, urban mobility and the impact that this technology has on urban transport, there are still elements that weren't included. The topic of IoT is very broad and complex, therefore this paper focused on the most important elements that have a direct impact on urban mobility. As only one research database was used, this limited the amount of references. The keywords had a direct influence as well, as perhaps another combination of words would have given other references.

Implications for further research

Internet of things offers a great variety of research possibilities. As this technology is rather new there are a lot of domains and aspects that weren't fully investigated until now. The need to conduct such researches comes from the necessity to explore the impact that IoT has on multiple elements that influence the day to day life. There is a gap in papers that bring evidence-based examples, not only theoretical aspects in relation with IoT. Although a few experts, scientists and researchers started to study the IoT and its impact on the world, there are still a lot of possibilities to expand these studies and bring a much deeper insight on this topic and everything that it implies.

References

Atzori, L., Iera, A. & Morabito, G., 2010. The Internet of Things: A survey. *Computer Networks, Volume 54, Issue 15, 28 October 2010,* pp. 2787-2805.

Azmat, M. et al., 2018. *Impact of innovative technologies on highway operators: Tolling Organizations' perspective.* April 6-9. Vienna, Transport Research Arena (TRA), pp. 1-10.

Azmat, M., Schuhmayer, C. & Kummer, S., 2016. *Innovation in mobility: Austrian Expert's Perspective on the future of urban mobility with self-driving cars.* 7-9 March, Dubai, UAE, HBMSU Publishing House.

Benevolo, C., Dameri, R. P. & D'Auria, B., 2016. Smart Mobility in Smart City: Action Taxonomy, ICT Intensity and Public Benefits. In: *Empowering Organizations. Lecture Notes in Information Systems and Organisation 11.* s.l.:Springer International Publishing Switzerland, pp. 13-28.

Booysen, M., Gilmore, J., Zeadally, S. & Van Rooyen, G.-J., 2012. Machine-to-Machine (M2M) Communications in Vehicular Networks. *KSII Transactions on Internet and Information Systems, Vol. 6, Issue: 2,* pp. 529-546.

Brannen, J., 2005. Mixing methods: The Entry of Qualitative and Quantitative Approaches into the Research Process. *International Journal of Social Research Methodology,* Volume 8(Number 3), pp. 173-184.

Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciences.* Second Edition ed. s.l.:Lawrence Erlbaum Associates.

ECSEL Europe, 2016. *Austrian Research, Development & Innovation Roadmap for Automated Vehicles.* Retrived June 05, 2017, from https://www.ffg.at/sites/default/files/downloads/call/austrian_roadmap_automated_vehicles_0.pdf

Fluidtime Data Services GmbH, 2015. *Integrated Mobility. With Smart Fluidtime IT-Services.* Retrived June 07, 2017, from

https://www.fluidtime.com/files/cto_layout/content/data/content/integrierte-mobilitaet/Integrated%20Mobility_Broschuere_en.pdf

Glielmo, L., 2011. Vehicle-to-Vehicle/Vehicle-to-Infrastructure Control. In: *The Impact of Control Technology. Overview, Success stories, and Research Challenges.* s.l.:IEEE Control Systems Society, pp. 211-212.

Grübler, A. & Nakicenovic, N., 1991. *Evolution of Transport Systems: Past and Future,* Laxenburg, Austria: IIASA Research Report.

Gubbi, J., Buyya, R., Marusic, S. & Palaniswami, M., 2013. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems,* September, Volume 29(Issue 7), pp. 1645 - 1660.

IHS, 2017. *Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions).* Retrived June 02, 2017, from https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/

ISA, 2017. *What is Automation?.* Retrived May 27, 2017 from https://www.isa.org/about-isa/what-is-automation/

Kanter, R. M. & Litow, S. S., 2009. Informed and Interconnected: A Manifesto for Smarter Cities. *Harvard Business School Working Paper,* June.Issue No. 09-141.

Mishra, D. et al., 2016. Vision, applications and future challenges of Internet of Things: A bibliometric study of the recent literature. *Industrial Management & Data Sytems, Vol. 116 Issue: 7,* pp. 1331-1355.

Narayanaswami, S., 2017. Urban transportation: innovations in infrastructure planning and development. *The International Journal of Logistics Management, Vol. 28 Issue: 1,* pp. 150-171.

Papa, E. & Lauwers, D., 2015. *Smart Mobility: Opportunity or Threat to Innovate Places and Cities?.* Ghent, Belgium, s.n., pp. 543-550.

Prophet.com, 2016. *Interoperability: The Challenge Facing the Internet of Things.* Retrived June 02, 2017, from https://www.prophet.com/thinking/2014/02/interoperability-the-challenge-facing-the-internet-of-things/

Rikken, M., 2016. *The Internet of Things and the city of tomorrow.* Retrived May 25, 2017, from https://www.researchgate.net/blog/post/iot-and-the-city-of-tomorrow

Schneider Electric, ARUP & The Climate Group, 2014. *Smart Cities cornerstone series: Urban Mobility in the Smart City Age.* Retrived June 01, 2017, from http://www.schneider-electric.co.th/en/download/document/998-2095-06-07-14AR0_EN/

Siemens AG, 2014. *Our future depends on intelligent infrastructures.* Retrived June 05, 2017, from https://www.siemens.com/digitalization/public/pdf/siemens-intelligent-infrastructure.pdf

Siemens AG, 2017. *Intelligent Infrastructure.* Retrived June 05, 2017 from https://www.siemens.com/global/en/home/company/topic-areas/intelligent-infrastructure.html

smile mobility, 2014. *The future of mobility.* Retrived June 07, 2017, from http://smile-einfachmobil.at/index_mobile_en.html

The EXTRA project, 2001. *Thematic Synthesis of Transport Research Results. Paper 5 of 10. Urban Transport. The EXTRA project, within the European Community's Transport RTD Programme, Issue 7.* Retrived June 05, 2017, from http://www.transport-research.info/sites/default/files/thematic-analysis/20040809_152835_59539_urban_transport.pdf

UN, 2014. *World Urbanization Prospects: The 2014 Revision.* Retrived May 29, 2017, from https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.Pdf

UN, 2014. *World's population increasingly urban with more than half living in urban areas.* Retrived May 29, 2017, from http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html

Valerio, P., 2015. *IoT: Can It bridge The Digital Divide To Fulfill Its Promise?* Retrived June 08, 2017, from http://www.informationweek.com/strategic-cio/digital-business/iot-can-it-bridge-the-digital-divide-to-fulfill-its-promise-/a/d-id/1322466

Walden, S., 2015. *How the Internet of Things is affecting urban design.* Retrived May 28, 2017, from http://mashable.com/2015/02/23/urban-design-internet-of-things/#GbcDUBr_5Gqn

Wegener, M., 2013. The future of mobility in cities: Challenges for urban modelling. *Transport Policy, Volume 29, September 2013,* pp. 275-282.

Wonning, P. R., 2012. *A Short History of Transportation: Transportation Past and Present.* s.l.:Smashwords Edition.