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Challenges and requirements for communication technologies in connected zones

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Abstract

With the emergence of communication technologies (CT), humans have become more connected than ever to their environment through various devices and computer platforms. These devices are integrated into everyday life, in an omnipresent way, such that people can interact effortlessly and intuitively. The goal is to improve their life by allowing them access to various services and information at any time and in any situation or place they are even in harsh environment. This intensive technological presence in an area is called smart or connected zones. Within these zones, technology is used to collect, process and share information in order to facilitate citizens' activities and assist authorities in decision-making and efficient service provision. This paper reviews principal requirements and challenges for CT to be used in such zone. First, we introduce its concept by highlighting its characteristics, features, devices and applications. Then we examine related works, communication requirements and challenges. We finish this paper by the conclusion.

Keywords: Connected zone; smart zone; smart cities, communication technologies, communication challenges, communication requirements.

1. Introduction

During recent years, communication systems have developed to such a degree that they have become the cornerstone of modern society. These technologies are ubiquitous and pervasive, facilitating people's lives by providing easy access to services, information and commodities no matter the time, place or context [5]. Thus,

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communication systems (CS) are the bases on which the computer science was able to develop by examining the means to help the different entities to communicate together. Through this, the world has become like a village and people have become able to exchange data across thousands of kilometers in a fraction of a second. In fact, CS are increasingly integrated with the way we work, play and live [7]. The type of computing that exists throughout all sides of life is called ubiquitous computing [22], and the regions where these devices are installed to manage, monitor or facilitate access to information are called smart or connected zones. During the rest of our paper, we will use the connected zones expression as our research is more focused on the connectivity of such zones.

The diversity of people's needs imposes hard constraints and challenges to CS, such as the challenge of staying connected to the internet while moving for information, services or to simply stay in touch with relatives while being extremely mobile no matter which place we are even in harsh environments. Meanwhile, each service requires different communication technology (CT) and has its own specification that has to be met [26]. Furthermore, human mobility imposes high Quality of Service (QoS) requirements, as CS have to keep a stable level of service [27]. People also move through or live in rural areas where signal attenuation of wireless communication services is difficult to estimate accurately due to the random nature of vegetation density and its variation when leaves grow or fall during seasonal changes. As connected zones are based essentially on CS [29], it is important to identify different challenges and requirements for CT in order to choose accordingly supporting technology for needed applications within connected zones' context [30].

1.1. Smart or connected zones

Over the past two decades, technological innovations have miniaturized, integrated and transformed communication networks from desktop computing environment into highly interconnected devices saturated with embedded systems [30]. These devices are quite opposite to earlier technology as they attempt to offer functionality independently of location and time. This functionality is provided so intuitively that these devices may not even be noticed at all, or they may be overlooked as computing elements. Hence, we are living in a world where most of the things around us have processing or computing capability and interact with their external environment.

In this sense, a connected zone can be defined as a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly with the everyday objects of our lives, and connected through a continuous network. It can also be defined as a small world where different kinds of smart devices are continuously working and exchanging information to make its inhabitants' lives more comfortable [23]. While there is no unified definition, connected zones can be abstracted as Ubiquitous Computing areas (home, building, city or region) that can understand their environment and react accordingly to human desires. Those entities are able to get information about their environment through various sensor technologies. Then received information is processed and distributed in order to adjust devices and system configurations, or provide required services to users.

1.2. Features, characteristics, and properties

A connected zone is an enormous network of interconnected and heterogeneous entities that interact with each other and monitor their environment in order to provide convenient services that meet human needs. Even if we have many definitions of connected zones, we can identify many features or properties that are typical of these entities [27, 28]:

- They are occupied by heterogeneous electronic devices such as sensors, actuators and displays that communicate through many CT such as wired or wireless technologies (WT) in order to exchange information. With the advancement of WT, communications for connected zones have been improved [26]. This diversity also includes the software components that are made from various programming languages, or for many operating systems, in addition to the variety of exchanged data between devices and their formats.
- A connected zone must have the ability to sense its environment through sensors and then analyze it with computer-powered devices in order to adapt services or make decisions according to users' needs, preferences or situations. This ability to make the right decision in the right context is what makes such zones smart [24].

- Connected zones must continually improve services according to the behavior of people in their everyday life. Hence, they must be able to predict contextual or behavior changes.
- As technology is rapidly evolving, many devices included in connected zones may change. Those entities must also be able to continuously adapt to various electronic devices even if technology changes or if new devices have to be integrated with them.
- As connected zones are serving humans in their everyday life independently of location, devices are distributed in several places covering the connected zone entirely. They are continuously interconnected by wired or wireless CT, independent of the state of the environment.
- A smart or connected zone is very dynamic and uncertain; this is due to frequent and random changes in its environment. This constant change is a result of either the users' mobility or the dynamic nature of the interaction between users, equipment and context.
- To deal with problems related to the heterogeneity, connected zones must be interoperable in order to effectively address the differences between brands, and the incompatibility of CS, software and data processing units.
- Connected zones must be scalable in order to support the increasing number of users. This property includes the possibility to integrate more devices and software, or to broaden the area of connected zones.
- A connected zone provides its services to users transparently; hence, technologies and devices are invisible. Furthermore, users have access to services and information in an autonomous and intuitive way, requiring less human intervention and more automation and self-adapting mechanisms.
- Adaptation to context is an indispensable characteristic of connected zones, which requires the modelling of contextual information in a comprehensive way. It must describe the behavior of the system in a particular context in order to respond effectively to users' expectations. Furthermore, adaptation can be provided through learning by taking into account historical context to build new knowledge.

1.3. Applications

Currently, connected zones' applications are present in many fields and provide several services in our everyday life [25, 28, 29]. For example, smart homes include new technologies, techniques and devices that are interconnected together and controlled by users for their comfort and security. Users can activate some services automatically according to a given context, like activating cooling or heating one hour before they arrive home. In addition, users can express their needs directly to devices, or adjust services to be performed. The smart home must be able to identify all possible contexts and user needs, as well as all interconnected equipment in order to monitor the different interactions made between them, or with the users.

Another example of applications is personal assistance specialized in caring for the elderly by providing support services to live in an autonomous way without the intervention of third parties. These applications are also intended for people living with disabilities, to assist them in their daily tasks and achieve or coordinate specific activities. Furthermore, they are equipped with intuitive and simple-to-use interfaces for all concerned, regardless of their computer skills.

1.4. Devices and technologies

Connected zones integrate various types of embedded devices, systems and technologies surrounding our everyday life to collect and process data to accommodate our needs and make pertinent decisions about events or changing contexts. These devices or technologies include sensors, internet of things (IoT), mobile ad hoc networks (MANETs), vehicular ad hoc networks (VANETs), unmanned aerial vehicles (UAVs), social networks, CT, etc. [29]. In this section, we will provide an overview of those technologies:

- Sensor networks: Sensors are the essential technology for collecting heterogeneous data and monitoring environmental conditions [10]. They are used by various applications such as traffic, environment, and health monitoring, waste management, smart grids, etc. [11]. There are many types of sensors such as cameras, motion sensors, thermometers, etc. Many challenges are present when deploying sensors such as resource optimization, efficient routing, connectivity bandwidth, and unified semantics for a diversity of data [12].

- Internet of Things (IoT): IoT is a network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors and connectivity. The physical world can be integrated with computer systems, resulting in efficiency improvements, economic benefits, and reduced human exertions [30]. IoT allows the interconnection of physical devices with the internet and/or other remote locations, in order to collect sensed data and transfer it for additional processing to provide required services [13].
- Mobile Ad hoc Networks (MANETs): A MANET is a self-configuring, infrastructure-less network of mobile wireless devices. Their challenge is to maintain connectivity and data flow with efficient routing protocols without deploying any further infrastructure [14].
- Vehicular Ad hoc Networks (VANETs): VANET is the same as MANET but applied to vehicles or smart transportation systems with the exception that they are more dynamic and require special mechanisms to maintain the flow of information. They are used in road safety, traffic, and weather warnings.
- Unmanned Aerial Vehicles (UAVs): They are the same as MANET but they are deployed in hard inaccessible places or where it is difficult to deploy other technologies. Special focus must be given to the service coverage and battery charging [29].
- Social Network: Information posted by people on social media such as Facebook or Twitter can be a rich source of data in many contexts such as providing warnings, extreme events or healthcare. In addition, people can send their input through crowd sourcing applications to inform other people or authorities of an existing problem.
- Communications: The number of IoT-connected devices will be around 50 billion by the end of 2020. In addition, around 70% of the global population (5.5 billion people) will be connected by mobile devices by 2020. There will be more people with a phone than those with electricity, water and cars. In addition, the number of users will increase twice as fast as the global population in the five years from 2015 to 2020 [15]. Furthermore, mobile devices will generate a quantity of data equal to seven thousand billions of video clips on YouTube or transferring 28 images per person each day for a year. Hence, communications will play a pivotal role in the development of connected zones applications and services.

1.5. Research objectives

The aim of this study is to offer a comprehensive review of communication challenges and requirements in connected zones in order to propose and discuss a method to assist entities and users select suitable CT according to their needs during future research. Our research works are motivated by two elements. The first one is the recent technological advances that increased the number of available CS. The second one is the diversification of services and needs of modern ways of life in connected zones. Hence, as there is no unique CT that is able to satisfy all data exchange requirements between the high numbers of smart devices, we need to find a way to choose the best-suited technology for the hard communication challenges in the context of connected zones.

The remaining portion of this paper is organized as follows. In the second section, a review of the literature is presented. In Section 3, communication requirements are examined. In Section 4, communication challenges are presented. In section 5, we examined the ways to ensure the QoS of CT inside a connected zone. We finish this paper by the conclusion.

2. Related works

CT are the cornerstone to provide data exchange between all entities inside connected zones. Hence, they have been a number of published researches over recent years in order to highlight the need for communication systems to support connected or smart zones' applications and services. In this section, we depict related work and pinpoint the contribution of this paper. Gharaibeh et al. [29] described main data management techniques, in addition to many other issues of the data generated by the IoT for smart cities. In addition, they discuss the networking and computing technologies that enable smart cities. Yaqoob et al. [26] compared enabling communication and networking technologies used in smart cities in terms of frequency, range and data rates. Moreover, they established taxonomy in order to classify the literature based on many criteria. Furthermore, some reported case studies of different cities are presented and several research challenges are discussed as future research directions. Balakrishna [9] presented the Mobile Technology perspective of the Smart-city architecture by discussing a conceptualized

framework and highlighting the open and emerging research challenges in this landscape. Rivano et al.[6] presented different wireless access networks intended to empower future smart cities, and discuss their features, complementary and interoperability. Li et al. [2] reviewed the current research state of the art of 5G IoT, key enabling technologies, and main research trends and challenges in 5G IoT. Alonso et al. [3] provided a review of the most novel and relevant WT and a state of the art middleware for Wireless Sensor Networks focusing on structural health monitoring specific requirements. Cimmino et al. [1] considered the communication aspects of Smart City applications. They also demonstrated that the novel concept of small cell fully meets the emerging communication and networking requirements of future Smart Cities. Akpakwu et al. [4] presented a comprehensive review of emerging and enabling technologies with main focus on 5G mobile networks for enabling the IoT. The challenges and open research directions pertinent to the deployment of massive to critical IoT applications are also presented. Mendes et al. [31] discussed Home Area Networks (HAN) CT and applications for smart home and domestic application integration. Then, the main wireless networks are assessed, and later, their suitability to the requirements of HAN considering the application area is analyzed. Yan et al. [8] presented the background, motivation challenges and requirements of communication infrastructures in smart grid systems.

2.1. Discussion and paper contributions

Modern life is totally influenced by CT, and people are more vulnerable to communication failure as the majority of their everyday activities, services and needs are articulated around CS. Thus, the concept of connected or smart zones has been an important subject of study during recent years. In addition, an important focus has been given to CT used for connected zones, as they are the cornerstone of data exchange between all computerized entities. Hence, a good number of published researches underlined the need for reliable means of communication for various connected zones' applications and services. Their main objective was to help provide compatible and reliable CT for various entities, services and applications in connected zones. According to our review, the majority of papers focus on how to provide CT for a specific application, or how to use a specific technology in connected zone services. Hence, in connected zones context, many issues are related to the use of CT for data exchange between entities, such as technical characteristics, communication challenges, requirements, needs and specifications. It was hard to find a research paper that treats all these issues in detail and explain the connected zones' communication requirements and challenges. Available researches have considered a single connected zone application and its possible CT, or they characterized in detail a specific technology for the use in connected zone applications. Even papers that detailed CT, they did not link communication requirements and challenges to CT characteristics. Our aim is to explain connected zones features, applications and technologies, then detail communication requirements and challenges.

3. Communication requirements

Communication systems are the cornerstone of connected zones, as they ensure communication and interaction between all devices, users and entities. Therefore, they must respect some requirements in order to achieve their goals and fulfill the specifications of the different services they support. However, those requirements are not unique for all connected zone applications, as each one has its own conditions and circumstances [25, 26, 29, 31]. Yet the most important requirements can be summarized as the following [29, 30]:

- Cost: This requirement covers all expenses including development, production, deployment, and maintenance operations. For example, devices that will be employed on a large scale must be produced and deployed in such a way to minimize costs. Low energy consumption, battery lifetime, minimal use of infrastructure, frequency licence cost, and equipment costs are also considered.
- Robustness and tenacity: This includes reliability, availability and resilience. CS may be placed in different environments depending on the desired applications. Thus, they must meet extreme conditions of temperature, corrosion, shock, humidity, etc. with other equipments. For example, in smart grid applications, communications technologies supporting smart meters must stay in operation for around 15 years without component replacement or maintenance [30]. Availability characterizes the CS downtime period, to ensure that communication will

always be running during extreme conditions. Resiliency defines the recoverability and fault tolerance of CS or its capacity to remain in operation even if the damage is occurring [31].

- Security: connected zones are evidently subject to external attacks as they are connected to the internet. Hackers may access sensitive information such as medical or personal records, or remotely handle services or systems that may induce incredible damage to people's lives. Security concerns include confidentiality to allow only authorized access to data, integrity by verifying that data are not modified or manipulated, authenticity that ensures that only dedicated entities exchange data, and availability to guarantee that data is always available.
- Interoperability: as connected zones are highly heterogeneous, information and data must flow freely across many different CT and applications. Hence, communication protocols are standardized to ensure the compatibility of CS from different suppliers.
- Data management: an enormous amount of data is generated from all connected zone systems. Hence, an efficient big data management system is necessary to deal with various types of data. Its goal is to continuously collect, process, prioritize and store enormous and heterogeneous data from sensors installed in connected zones.
- Quality of service: as everything will be linked to CS in connected zones, QoS includes all criteria used to evaluate the quality of communication such as bandwidth, latency, delay, speed, throughput, priority, number of connected devices or received signal level, etc.

4. Communication challenges

Connected zone initiatives are one of the principal consequences of the recent development of information and CT [25-27]. The aim of these technologies is to provide the base, applications, infrastructure, devices and solutions for supplied services. However, due to the technological complexity of connected zones and the cohabitation of many CS together, their inherent challenges and limitations may be amplified or new challenges may appear. Thus, the difference between communication challenges and requirements is that the challenges represent issues that have to be met by future research. However, requirements are considered as specifications that a product has to satisfy to meet the need of its users.

- Interoperability and heterogeneity: Despite recent progress in all facets of technology, interoperability and heterogeneity continue to offer many challenges in connected zones. In addition, as most CT are wireless, signals belonging to different applications may interfere if they are of the same frequencies. Hence, advanced interference management techniques are required in order to prevent data communication errors. By 2020 the total number of connected devices may reach 50 billion and there is no doubt that most CT may potentially be exposed to this challenge [16]. In addition, finding ways to improve compatibility between devices using different CT is essential for data exchange. Furthermore, as connected zones are using massive technology integration, those devices have to operate in a transparent way between each other and with people.
- Quality of service: In connected zones, billions of devices are collecting and transferring data to management centers where they are processed and stored [17]. Consequently, extra bandwidth is required to prevent congestion and latency to respond efficiently to heavy traffic loads. Evidently, some applications need to operate in real time and even a short information delay risks creating a negative or even dangerous impact on human life, such as alarm dissemination or health monitoring. In addition, CS must deal with environmental conditions that affect signal attenuation due to rain, snow, vegetation and buildings. Furthermore, some critical systems require a high degree of availability and cannot afford downtime. Moreover, scalability must be considered as connected zones are expanding, and current CS must grow with future needs [18].
- Mobility: One of the major challenges to alleviate in the context of connected zones is maintaining connectivity for people while moving [19]. This challenge arises from the need to provide service wherever people are, especially for healthcare services, working remotely and rural areas. In this context, increasing battery life by reducing power consumption for mobile devices and sensors is essential to prevent frequent recharging, when power sources are hard to reach [19]. Furthermore, bringing connectivity to rural areas is an important issue, and it can be accomplished by using wide range wireless CT and predicting the effect of vegetation and buildings.
- Ease of use: As CT will be used by people of different cultures, education levels, and technical knowledge; ease of use and adaptability are also important goals. Even if we can design the best technology, all our efforts may be wasted if people are not able to adopt it on a wide scale and apply it to their daily activities [20].

- Cost: Evidently, connected zones require significant investment in communication infrastructure, sensors, and computing equipment. Substantial financial investment is also needed for development and maintenance, in addition to the cost of professional experts. Developing low-cost CS may reduce barriers that limit this concept to strong economies and even promote it within developing countries.
- Security and privacy: Personal data protection is important in the connected zone concept, as it is transferred across many CS. As people use CS for their everyday life and services, the collection of their personal data may create a privacy issue. Thus, CS must be well guarded against any unauthorized access to this data [21].

5. Ensuring QoS for connected zones

To insure communication QoS in connected zones, we will consider three main issues during our future work:

- Choice of CT: as many CT are available for deployment, there is a need to select convenient CS based on its ability to satisfy services' and applications' requirements. Hence, many CT will be compared according to their characteristics and a tool will be developed to ease the choice of CT that ensures the required QoS.
- Characterization of environmental effects on the QoS of CT: environmental effects include all surrounding factors that affect positively or negatively the QoS or the operation of CS such as: weather, building, vegetation, season variation. Their effects need to be characterized early in order to take them into account and compensate the QoS degradation.
- Resource allocation: each CT has its own resources such as: frequency channel, bandwidth frequency, modulation, etc. An optimal resource allocation based on service requirements and environmental effects can maximize QoS that a given CT can deliver.

6. Conclusions

The principal objective of connected zones is to increase the quality of life, services and information provided to citizens with a convenient cost. As the concept of connected zone requires the integration and deployment of various infrastructures, applications, services, resources, and technologies, the realization of this concept requires a maturity in many fields. Furthermore, supporting CS may be subject to several challenges and requirements to provide a fluent data exchange between all implied devices of different technologies and providers.

In this research paper, we studied the state of the art of communication requirements and challenges in connected zones. During our future research, we will make a comparative study between CT, in order to design a tool to better select convenient CS based on propagation environment. Finally, we conclude that even with technological advancements, there is no ultimate communication system that can satisfy all challenges at the same time. Hence, the researchers have to make tradeoffs between achieved investments and service requirements, as well as prioritize challenges that contribute the most to final performances.

References

[1] Cimmino, A., Pecorella, T., Fantacci, R., Granelli, F., Rahman, T. F., Sacchi, C., Carlini, C. and Harsh, P. (2014), The role of small cell technology in future Smart City applications. Trans. Emerging Tel. Tech., 25: 11-20. doi:10.1002/ett.2766

[2] Shancang Li, Li Da Xu, Shanshan Zhao: 5G Internet of Things: A survey, Journal of Industrial Information Integration, Volume 10, 2018, https://doi.org/10.1016/j.jii.2018.01.005.

[3] Luis Alonso, Javier Barbarán, Jaime Chen, Manuel Díaz et al.: Middleware and communication technologies for structural health monitoring of critical infrastructures: A survey, Computer Standards & Interfaces, Volume 56, 2018, https://doi.org/10.1016/j.csi.2017.09.007.

[4] G. A. Akpakwu, B. J. Silva, G. P. Hancke and A. M. Abu-Mahfouz, "A Survey on 5G Networks for the Internet of Things: Communication Technologies and Challenges," in IEEE Access, vol. 6, pp. 3619-3647, 2018. doi: 10.1109/ACCESS.2017.2779844

[5] Brown, Suzana and Alan Mickelson. "A Decision Framework for Choosing Telecommunication Technologies in Limited-Resource Settings." Future Internet 10 (2018): 8.

[6] HervéRivano, Isabelle Augé-Blum, WalidBechkit, Khaled Boussetta, Marco Fiore, RazvanStanica, Fabrice Valois: Wireless Access Networks for Smart Cities, Smart Technologies: Breakthroughs in Research and Practice, 2018, DOI: 10.4018/978-1-5225-2589-9.ch022

[7] Wang, Wenye& Xu, Yi & Khanna, Mohit. (2011). A Survey on the Communication Architectures in Smart Grid. Computer Networks. 55. 3604-3629. 10.1016/j.comnet.2011.07.010.

[8] Y. Yan, Y. Qian, H. Sharif and D. Tipper, "A Survey on Smart Grid Communication Infrastructures: Motivations, Requirements and Challenges," in IEEE Communications Surveys & Tutorials, vol. 15, no. 1, pp. 5-20, First Quarter 2013. doi: 10.1109/SURV.2012.021312.00034.

[9] C. Balakrishna, "Enabling Technologies for Smart City Services and Applications," 2012 Sixth International Conference on Next Generation Mobile applications, Services and Technologies, Paris, 2012, pp. 223-227. doi: 10.1109/NGMAST.2012.51

[10] MohdFauzi Othman, KhairunnisaShazali, Wireless Sensor Network Applications: A Study in Environment Monitoring System, Procedia Engineering, Volume 41, 2012, Pages 1204-1210, ISSN 1877-7058, https://doi.org/10.1016/j.proeng.2012.07.302.

[11] Jennifer Yick, Biswanath Mukherjee, DipakGhosal: Wireless sensor network survey, Computer Networks, Volume 52, Issue 12, 2008, Pages 2292-2330, ISSN 1389-1286, https://doi.org/10.1016/j.comnet.2008.04.002.

[12] Lance Doherty, Jonathan Simon and Thomas Watteyne: Wireless Sensor Network Challenges and Solutions ,Microwave Journal, Agust 2012.

[13] Korzun D.G., Balandin S.I., Gurtov A.V.: Deployment of Connected zones in Internet of Things: Overview of the Design Challenges. In: Balandin S., Andreev S., Koucheryavy Y. (eds) Internet of Things, Connected zones, and Next Generation Networking. ruSMART 2013, NEW2AN 2013. Lecture Notes in Computer Science, vol 8121. Springer, Berlin, Heidelberg.

[14] M. Conti and S. Giordano, "Mobile ad hoc networking: milestones, challenges, and new research directions," in IEEE Communications Magazine, vol. 52, no. 1, pp. 85-96, January 2014. doi: 10.1109/MCOM.2014.6710069.

[15] Web site: https://www.statista.com, visited on 01-011-2018

[16] W. Liu, Y. Han, J. Li and Y. Ma, "Topological Interference Management With Transmitter Cooperation for MIMO Interference Channels," in IEEE Transactions on Vehicular Technology, vol. 67, no. 11, pp. 10564-10573, Nov. 2018. doi: 10.1109/TVT.2018.2866235

[17] M. Mohammadi and A. Al-Fuqaha, "Enabling Cognitive Smart Cities Using Big Data and Machine Learning: Approaches and Challenges," in IEEE Communications Magazine, vol. 56, no. 2, pp. 94-101, Feb. 2018. doi: 10.1109/MCOM.2018.1700298

[18] Ma, S., Zhang, H. & Xing, X.: Scalability for Smart Infrastructure System in Smart Grid: A Survey, Wireless PersCommun (2018) 99: 161. https://doi.org/10.1007/s11277-017-5045-y

[19] Anthony M. Townsend (2000) Life in the Real-Time City: Mobile Telephones and Urban Metabolism, Journal of Urban Technology, 7:2, 85-104, DOI: 10.1080/713684114

[20] Yangil Park,and Jengchung V. Chen, (2007) "Acceptance and adoption of the innovative use of smartphone", Industrial Management & Data Systems, Vol. 107 Issue: 9, pp.1349-1365, https://doi.org/10.1108/02635570710834009

[21] Rolf H. Weber: Internet of Things – New security and privacy challenges, Computer Law & Security review, Volume 26, Issue 1, 2010, Pages 23-30, ISSN 0267-3649, https://doi.org/10.1016/j.clsr.2009.11.008.

[22] Weiser, M & Gold, R & Brown, J.S.. (1999). Origins of ubiquitous computing research at PARC in the late 1980s. IBM Systems Journal. 38. 693 - 696. 10.1147/sj.384.0693.

[23] Cook, Diane & Das, Sajal. (2005). Smart Environments: Technology, Protocols and Applications. 10.1002/047168659X.

[24] Jianhua Ma, Yang LT, et al. (2005) A Walkthrough from Connected zones to Smart Hyperspaces Towards a Smart World with Ubiquitous Intelligence. Proc IEEE 11th International Conference on Parallel and Distributed Systems. Fukuoka, Japan 1: 370–376.

[25] Hashem, Ibrahim & Chang, Victor &Anuar, Nor& S, Adewole&Yaqoob, Ibrar&Gani, Abdullah & Ahmed, Ejaz&Chiroma, Haruna. (2016). The Role of Big Data in Smart City. International Journal of Information Management. 36. 10.1016/j.ijinfomgt.2016.05.002.

[26] Yaqoob, Ibrar& Hashem, Ibrahim &Mehmood, Yasir&Gani, Abdullah & Mokhtar, Salimah&Guizani, Sghaier. (2017). Enabling Communication Technologies for Smart Cities. IEEE Communications Magazine. 55. 10.1109/MCOM.2017.1600232CM.

[27] Kiani, Saad&Moltchanov, Boris &Knappmeyer, Michael & Baker, Nigel. (2011). Large-scale context-aware system in connected zones: Issues and challenges. 173 - 180. 10.1109/BCFIC-RIGA.2011.5733229.

[28] M. Yusupov, R &Ronzhin, Andrey. (2010). From Smart Devices to Connected zone. Herald of The Russian Academy of Sciences - HER RUSS ACAD SCI. 80. 63-68. 10.1134/S1019331610010089.

[29] Gharaibeh, Ammar &Salahuddin, Mohammad et al. Ala. (2017). Smart Cities: A Survey on Data Management, Security and Enabling Technologies. IEEE Communications Surveys & Tutorials. PP. 1-1. 10.1109/COMST.2017.2736886.

[30] Ministry of communication and information technology, department of telecommunication, gouvernment of India: Enabling Technologies for Smart Cities, INTERNET OF THINGS DIVISION

[31] Tiago D. P. Mendes, RaduGodina, Eduardo M. G. Rodrigues, João C. O. Matias and João P. S. Catalão: Smart Home Communication Technologies and Applications: Wireless Protocol Assessment for Home Area Network Resources, Energies 2015, 8, 7279-7311; doi:10.3390/en8077279