**IOSR Journal of Engineering (IOSRJEN)** **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Special Issue || Dec. 2019 || PP 43-48
International Conference on Management Practices, Innovations & Research 2019

# Internet of Things (IOT): Research Challenges and Future Applications

Prof. Anuradha A.Dakhane, Prof. Madhavi L.Tota
*Assistant Professor Rajiv Gandhi College of engineering, research and technology,Chandrapur*

***Abstract—*** *The world is moving forward at a fast speed, and the credit goes to ever growing technology. As of now, we are in an age where every object is a smart object that has embedded electronics and connected to the internet. In other words, specifically, we are in the era of Internet-of-Things (IoT). Automation in IoT (Internet of things) is no longer a virtual reality. Ranging from smart cities, to health care, smart agriculture, logistics and retail, to even smart living and smart environments IoT is expected to insinuarate into virtually all aspects of daily life. Internet of things connects a lot of non-living objects through the internet and enables them to share information with their community network to automate processes for humans and makes their lives easier. The paper presents the future challenges of IoT are classified as Technological, Environmental, and Societal. The technological challenges are further classified into architecture and heterogeneity, resource management, efficient data handling and security. Also discusses the various myths that might obstruct the progress of IOT, security of data being the most critical factor of all. An approach to people in adopting the unfolding changes brought by IOT will also help in its growth.*

***Keywords—****Internet of Things, IoT application, IoT challenges, future technologies, smart cities, smart environment, smart agriculture, smart living, Security, Sensors.*

## I. Introduction

The Internet of Things (IoT) is a designate for the fully interconnected world. The Internet can be described as the communication network that connects individuals to information while The Internet of Things (IoT) is an interconnected system of distinctively addressable physical items with various degrees of processing, sensing, and actuation capabilities that share the capability to interoperate and communicate through the Internet as their joint platform [1]. The main objective of the Internet of Things is to make it possible for objects to be connected with other objects, individuals, at any time or anywhere using any network, path or service. IOT is not a concept but can prove a revolution in advancing technology to change the humans lifestyles altogether. IoT is gradually being regarded as the subsequent phase in the Internet evolution. Internet of Things will make it possible for nornal devices to be linked to the internet in order to achieve countless disparate goals. Now a days, an estimated number of only 0.6% of devices that can be part of IoT has been connected so far [2]. However, upto the year 2020, it is likely that over 50 billion devices will have an internet connection.

Fig. 1. Nowadays, devices like smart phones, industrial systems, vehicles, toys, buildings, cameras home appliances, industrial systems and others can all share information over the Iternet.

Regardless of their sizes and functions, these devices can accomplish smart reorganizations, positioning, tracing, control, real-time monitoring and process control. In the past years, there has been an important propagation of Internet capable devices. Even though its most significant commercial effect has been observed in the consumer electronics field; i.e. particularly the revolution of smart phones and the interest in wearable devices (watches, headsets, etc.),. IoT is expected to continue expanding its reach as pertains the number of devices and functions, which it can run. This is evident from the ambiguity in the expression of "Things" which makes it difficult to outline the ever-growing limits of the IoT [4]. While commercial success continues to materialize, the IoT constantly offers a virtually limitless supply of opportunities, not just in businesses but also in research. Accordingly, the understudy addresses the various potential areas for application of IoT domains and the research challenges that are associated with these applications.

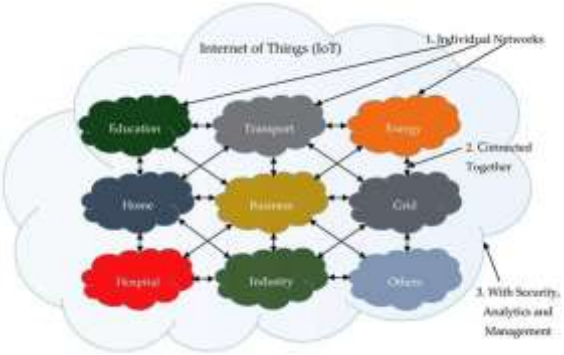


**Fig.1**.IoT can be viewed as a Network of Networks [3].

## II. Growth Of Internet Of Things Over Past Years

The growth of IoT over the years increases in 1992, only 1,00,000 people were using IOT as a technology. Till 2003, the number grew to half a billion people. In 2009 marked the IOT inception, 2012 witnessed a gradually increase in the usage of IOT where the people using IOT reached 8.7 billion, and there was no looking back. The number of users has been increasing exponentially over the years reaching 28.4 billion in 2017. It is expected that the number will broaden to 50.1 billion by 2020.

## III. Potential Application Domains Of Iot

The applications of IoT cover broad areas including manufacturing or the industrial sector, health sector, agriculture, smart cities, security and emergencies among many others,according to [5].

A. Smart Cities

The IoT plays a crucial role in improving the smartness of cities and enhancing general infrastructure, according to [6]. Some of IoT application areas in creating smart cities include; intelligent transportation systems [7], smart building, traffic congestion [7, 8] waste management [9], smart parking, smart lighting, and urban maps. This may include different functionalities such as; monitoring available parking spaces within the city, monitoring vibrations as well as material conditions of bridges and buildings, putting in place sound monitoring devices in sensitive parts of cities, as well as monitoring the levels of pedestrians and vehicles. Artificial Intelligence enabled IoT can be utilized to monitor, control and reduce traffic congestions in Smart Cities [6]. Application of IoT to achieve smart cities would require using radio frequency identification and sensors. Applications in this area are the Aware home and the Smart Santander functionalities some of these already developed.

B. Healthcare

Most healthcare systems in many countries are inefficient, slow and inevitably prone to error. This can easily be changed since the healthcare sector relies on numerous activities and devices that can be automated and enhanced through technology. Additional technology that can facilitate various operations like report sharing to multiple individuals and locations, record keeping and dispensing medications would go a long way in changing the healthcare sector [10].

A lot of benefits that IoT application offers in the health-care sector is most categorized into tracking of patients, staff, and objects, identifying, as well as authenticating, individuals, and the automatic gathering of data and sensing. Authentication and identification reduce incidents that may be harmful to patients. In addition to this automatic data collection and transmission is vital in process automation, reduction of form processing timelines, automated procedure auditing as well as medical inventory management.

Application domains in this sector include being able to monitor a patient's compliance with prescriptions, telemedicine solutions, and alerts for patients' well-being. Thereby, sensors can be applied to outpatient and inpatient patients, dental Bluetooth devices and toothbrushes that can give information after they are used and patient's surveillance. Other elements of IoT in this capacity include; RFID, Bluetooth, and Wi-Fi among others. These will greatly enhance measurement and monitoring techniques of critical functions like blood pressure, temperature, heart rate, blood glucose, cholesterol levels, and many others.

The applications of Internet of Things (IoT) and Internet of Everything (IoE) are further being extended through the materialization of the Internet of Nano-things (IoNT) [3]. The notion of IoNT, as the name implies, is being engineered by integrating Nano-sensors in diverse objects (things) using Nano networks. Medical application, as shown in Fig. 2, is one of the major focuses of IoNT implementations. Thus, IoNT will enable new medical data to be collected, leading to new discoveries and better diagnostics.

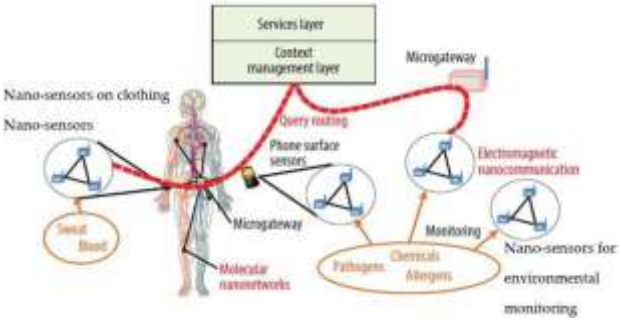


**Fig. 2**. The Internet of Nano-Things [3].

C. Smart Agriculture and Water Management

The Internet of things has the capacity to strengthen and enhance the agriculture sector through examining soil moisture and in the case of vineyards, monitoring the trunk diameter. IoT would be allow to control and preserve the quantity of vitamins found in agricultural products, and regulate microclimate conditions in order to make the most of the production of vegetables and fruits and quality of all, according to [11].

When it comes to cattle, IoT can assist in identifying animals that graze in open locations, detecting detrimental gases from animal excrements in farms, as well as controlling growth conditions in offspring to enhance chances of health and survival and so on. Moreover, through IoT application in agriculture, a lot of wastage and spoilage can be avoided through proper monitoring techniques and management of the entire agriculture field. It also leads to better electricity and water control.In water management, the role of IoT includes studying water suitability in seas and rivers for both drinking and agriculture use as explaining in[11]. IoT applications utilize Wireless sensor networks. Examples of existing IoT applications in this domain include SiSviA, GBROOS, and SEMAT.

D. Retail and Logistics

Executing the IoT in Supply Chain or retail Management has many benefits. Some include; observing storage conditions throughout the supply chain, product tracking to enable trace ability purposes, payment processing depending on the location or activity period in public transport, theme parks, gyms, and others.

IoT can be applied to various applications such as direction in the shop based on a preselected list, fast payment processes like automatically checking out with the aid of biometrics, detecting potential allergen products and controlling the rotation of products on shelves and warehouses in order to automate restocking procedures [12].

The IoT elements mostly used in this setting include; wireless sensor networks and radio frequency identification. In retail, there is a current use of SAP (Systems Applications and Products), while in logistics numerous examples include quality consignment conditions, item location, detecting storage incompatibility issues, fleet tracking among others. In the industry domain, IoT helps in detecting levels of gas and leakages within the industry and its environs, keeping track of toxic gases as well as the oxygen levels within the confines of chemical plants to ensure the safety of goods and workers and observing levels of oil, gases and water in cisterns and storage tanks.

E. Smart Living

In this domain, IoT can be applied in remote control devices whereby one can remotely switch appliances on and off hence preventing accidents as well as saving energy [1, 3]. Other smart home appliances include refrigerators fitted with LCD (Liquid Crystal Display) screens, enabling one to know what is available inside, what has over stayed and is almost expiring as well as what needs to be restocked. This information can also be linked to a smart phone application enabling one to access it when outside the house and therefore buy what is needed. Furthermore, washing machines can allow one to remotely monitor laundry. In addition, a wide range of kitchen devices can be interfaced through a smart phone, hence making it possible to adjust temperature, like in the case of an oven. Some ovens which have a self-cleaning feature can be easily monitored as well. In terms of safety in the home, IoT can be applied through alarm systems and cameras can be installed to monitor and detect window or door openings hence preventing intruders [3].

F. Smart Environment

The environment has a vital role within all aspects of life, from people, to animals, birds and also plants, are all affected by an unhealthy environment in one way or another.

In weather forecasting, IoT can be used to deliver a significant accuracy and high resolution for monitoring the weather by information sharing and data exchange. Through IoT technology, weather systems can collect information such as barometric pressure, humidity, temperature, light, motion and other information, from vehicles in motion and transmit the information wirelessly to weather stations. The information is attained by installing sensors on the vehicles and even on buildings after which it is stored and analyzed to assist in weather forecasting. Radiation is also a threat to the environment, human and animal health as well as agricultural productivity. IoT sensor networks can control radiation through constant monitoring of its levels, particularly around nuclear plant premises for detecting leakage and propagating deterrence.

## IV. Research Challenges

For all the above potential applications of IoT, there has to be proper feasibility into the different domains to ascertain the success of some applications and their functionality. As with any other form of technology or innovation, IoT has its challenges and implications that must be sorted out to enable mass adoption. Even though the current IoT enabling technologies have greatly improved in the recent years, there are still numerous problems that require attention, hence paving the way for new dimensions of research to be carried out. Since the IoT concept ensues from heterogeneous technologies that are used in sensing, collecting, action, processing, inferring, transmitting, notifying, managing, and storing of data, a lot of research challenges are bound to arise. These research challenges require attention that consequently spanned different research areas [14].

### A. Privacy and Security

Owing to the fact that IoT has become a vital element as regards the future of the internet with its increased usage, it necessitates a need to adequately address security and trust functions. Researchers are aware of the weaknesses which presently exist in many IoT devices. Furthermore, the foundation of IoT is laid on the existing wireless sensor networks (WSN), IoT thus architecturally inherits the same privacy and security issues WSN possesses [3, 15]. Various attacks and weaknesses on IoT systems prove that there is indeed a need for wide ranging security designs which will protect data and systems from end to end.

This security gap further motivates comprehensive security solutions that consist of research that is efficient in applied cryptography for data and system security, non-cryptographic security techniques as well as frameworks that assist developers to come up with safe systems on devices that are heterogeneous.

There is a need for more research to be conducted on cryptographic security services that have the capability to operate on resource constrained IoT devices.

In addition to the protection and security aspects of the IoT, additional areas like confidentiality in communication, trustworthiness, and authenticity of communication parties, and message integrity, and supplementary safety requirements should also be incorporated.

### B. Processing, Analysis and Management of Data

The procedure for processing, analysis and data management is tremendously challenging because of the heterogeneous nature of IoT, and the large scale of data collected, particularly in this era of Big Data [18]. Now a days, most systems utilize centralized systems in offloading data and carrying out computationally intensive tasks on an international cloud platform. Nevertheless, there is a constant concern about conventional cloud architectures not being effective in terms of transferring the massive volumes of data that are produced and consumed by IoT. IoT enables devices and to be able for further support the accompanying computational load and simultaneously meet timing constraints [19]. Most systems are therefore relying on current solutions such as mobile cloud computing and fog computing which are both based on edge processing, to mitigate this challenge.

Another research direction as regards data management is applying Information Centric Networking (ICN) in the IoT. Data analysis and its context not only plays a crucial role in the success of IoT, it also poses major challenges. Once data has been collected it has to be used intelligently in order to achieve smart IoT functions. Accordingly, the development of machine learning methods and artificial intelligence algorithms, resultant from neural works, genetic algorithms, evolutionary algorithms, and many other artificial intelligence systems are essential in achieving automated decision making.

### C. Monitoring and Sensing

Even if technologies concerned with monitoring and sensing have made tremendous progress, they are constantly evolving particularly focusing on the energy efficiency and form aspect. Sensors and tags are normally expected to be active constantly in order to obtain instantaneous data, this aspect makes it essential for energy efficiency especially in lifetime extension. Simultaneously, new advances in nanotechnology/ biotechnology and miniaturization have allowed the development of actuators and sensors at the Nano-scale.

D. M2M (Machine to Machine) Communication and Communication Protocols

There are already existing IoT oriented communication protocols like Constrained Application Protocol (CoAP) and Message Queuing Telemetry Transport (MQTT), there is still no standard for an open IoT. Although all objects require connectivity, it is not necessary for every object to be made internet capable since they only need to have a certain capability to place their data on a particular gateway. Additionally, there are a lot of options in terms of suitable wireless technologies such as LoRa, IEEE 802.15.4, and Bluetooth even though it is not clear whether these available wireless technologies have the needed capacity to continue covering the extensive range of IoT connectivity henceforth.

E. Blockchain of Things (BCoT): Fusion of Blockchain and Internet of Things

Similar to IoT, blockchain technologies have also gained tremendous popularity since its introduction in 2018. Even though blockchain was first implemented as an underlying technology of Bitcoin cryptocurrency, it is now being used in multifaceted nonmonetary applications [21]. Miraz argues that both IoT and Blockchain can strengthen each other, in a reciprocal manner, by eliminating their respective inherent architectural limitations [22]. The underlying technology of IoT is WSN. Therefore, analogous to WSN, IoT also suffers from security and privacy issues. On the contrary, the primary reasons for blockchain's implementation trend in non-monetary applications is due to its inbuilt security, immutability, trust and transparency. These attributes are powered by blockchain's consensus approach and utilization of Distributed Ledger Technologies (DLTs) which require extensive dependency on participating nodes. Therefore, the fusion of these two technologies Blockchain and Internet of Things (IoT) conceives a new notion i.e. the Blockchain of Things (BCoT) where blockchain strengthens IoT by providing extra layer of security while the "things" of IoT can serve as participating nodes for blockchain ecosystems [22]. Thus, blockchain enabled IoT ecosystems will provide enhanced overall security [23] as well as benefit from each other.

F. Business

The major issue is a inventiness for beginning, putting resources into and managing any venture, without a full proof plan of action for IoT. We will have another hurdle this model should fulfill every one of the prerequisites for all kinds of e-commerce; vertical markets, horizontal markets and consumer markets. This class is always a sufferer of administrative and lawful inspection. Application of IoT technologies plays a significant role to create a source of additional income so that reduce the burden on the existing communication infrastructure.

G. Society

Understanding IoT from the clients and regulators point of view is not a simple task for the following reasons:

• Customer requests and requirements change regularly.

• New uses for devices grow and develop dangerously fast.

• Inventing and reintegrating have features and capabilities that are more costly which require significant investment and assets.

• The uses for an Internet of things technology are growing and changing regularly in uncharted waters.

• Consumer Confidence: Each of these issues could put a dent in buyers want to buy associated items, which would keep the IoT from satisfying its real potential [26]. IoT data is very sensitive data but if it leaked can give the control of the system in the attacker hands. Hence we requires the strong and reliable technology to secure how IoT data is being used. Business policies and procedures pose some social challenges to IoT and government laws and rules pose legal challenges to its use [27].

## V. Conclusion

The application areas of IoT are quite diverse to enable it to serve different users, who in turn have different needs The IoT can best be described as a Complex Adaptive System that will continue to evolve. hence requiring new and innovative forms of software engineering, systems engineering, project management, as well as numerous other disciplines to develop it further and manage it the coming years.. The technology serves three categories of users, individuals, the society or communities and institutions. As discussed in the application section of this research paper, the IoT has without a doubt a massive capability to be a tremendously transformative force, which will, and to some extent does already, positively impact millions of lives worldwide. According to [25], this has more evident, as different governments around the world have shown an interest in the IoT concept by providing more funding in the field that is meant to facilitate further research. A good example is the Chinese Government. Countless research groups have initiated from different parts of the world, and their main objective is to follow through IoT related researches. As more research studies are conducted, new dimensions to the IoT processes, technologies involved and the objects that can be connected continue to emerge, further paving way for much more application functionalities of IoT. The fact that IoT is so expansive

and affects practically all areas of our lives, makes it a significant research topic for studies in various related fields such as information technology and computer science. The paper highlights various potential application domains of the internet of things and the related research challenges.

## References


[1]. M. H. Miraz, M. Ali, P. S. Excell, and R. Picking, "A Review on Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano Things (IoNT)", in 2015 Internet Technologies and Applications (ITA), pp. 219– 224, Sep. 2015, DOI: 10.1109/ITechA.2015.7317398.

[2]. P. J. Ryan and R. B. Watson, "Research Challenges for the Internet of Things: What Role Can OR Play?," Systems, vol. 5, no. 1, pp. 1–34, 2017.

[3]. M. Miraz, M. Ali, P. Excell, and R. Picking, "Internet of Nano-Things, Things and Everything: Future Growth Trends", Future Internet, vol. 10, no. 8, p. 68, 2018, DOI: 10.3390/fi10080068.

[4]. E. Borgia, D. G. Gomes, B. Lagesse, R. Lea, and D. Puccinelli, "Special issue on" Internet of Things: Research challenges and Solutions".," Computer Communications, vol. 89, no. 90, pp. 1–4, 2016.

[5]. K. K. Patel, S. M. Patel, et al., "Internet of things IOT: definition, characteristics, architecture, enabling technologies, application future challenges," International journal of engineering science and computing, vol. 6, no. 5, pp. 6122–6131, 2016.

[6]. S. V. Zanjal and G. R. Talmale, "Medicine reminder and monitoring system for secure health using IOT," Procedia Computer Science, vol. 78, pp. 471–476, 2016.

[7]. R. Jain, "A Congestion Control System Based on VANET for Small Length Roads", Annals of Emerging Technologies in Computing (AETiC), vol. 2, no. 1, pp. 17–21, 2018, DOI: 10.33166/AETiC.2018.01.003.

[8]. [8] S. Soomro, M. H. Miraz, A. Prasanth, M. Abdullah, "Artificial Intelligence Enabled IoT: Traffic Congestion Reduction in Smart Cities," IET 2018 Smart Cities Symposium, pp. 81–86, 2018, DOI: 10.1049/cp.2018.1381.

[9]. Mahmud, S. H., Assan, L. and Islam, R. 2018. "Potentials of Internet of Things (IoT) in Malaysian Construction Industry", Annals of Emerging Technologies in Computing (AETiC), Print ISSN: 2516-0281, Online ISSN: 2516-029X, pp. 44-52, Vol. 2, No. 1, International Association of Educators and Researchers (IAER), DOI: 10.33166/AETiC.2018.04.004.

[10]. Mano, Y., Faical B. S., Nakamura L., Gomes, P. G. Libralon, R. Meneguete, G. Filho, G. Giancristofaro, G. Pessin, B. Krishnamachari, and Jo Ueyama. 2015. Exploiting IoT technologies for enhancing Health Smart Homes through patient identification and emotion recognition. Computer Communications, 89.90, (178-190). DOI: 10.1016/j.comcom.2016.03.010.

[11]. V. Sundareswaran and M. S. null, "Survey on Smart Agriculture Using IoT," International Journal of Innovative Research in Engineering & Management (IJIREM), vol. 5, no. 2, pp. 62–66, 2018.

[12]. P. Tadejko, "Application of Internet of Things in logistics-current chal- lenges," Ekonomia i Zarz{a¸}dzanie, vol. 7, no. 4, pp. 54–64, 2015.

[13]. S. Rajguru, S. Kinhekar, and S. Pati, "Analysis of internet of things in a smart environment," International Journal of Enhanced Research in Man-agement and Computer Applications,vol. 4, no. 4, pp. 40–43, 2015.

[14]. H. U. Rehman, M. Asif, and M. Ahmad, "Future applications and research challenges of IOT," in 2017 International Conference on Informa-tion and Communication Technologies (ICICT), pp. 68–74,

[15]. Z. Alansari, N. B. Anuar, A. Kamsin, M. R. Belgaum, J. Alshaer, S. Soomro, and M. H. Miraz, "Internet of Things: Infrastructure, Architecture, Security and Privacy", in 2018 International Conference on Com- puting, Electronics Communications Engineering (iCCECE), pp. 150– 155, Aug 2018, DOI: 10.1109/iCCECOME.2018.8658516.

[16]. J. A. Chaudhry, K. Saleem, P. S. Haskell-Dowland, and M. H. Miraz, "A Survey of Distributed Certificate Authorities in MANETs," Annals of Emerging Technologies in Computing (AETiC), vol. 2, no. 3, pp. 11–18, 2018, DOI: 10.33166/AETiC.2018.03.002.

[17]. A. S. A. Daia, R. A. Ramadan, and M. B. Fayek, "Sensor Networks Attacks Classifications and Mitigation", Annals of Emerging Technologies in Computing (AETiC), vol. 2, no. 4, pp. 28–43, 2018, DOI: 10.33166/AETiC.2018.04.003.

[18]. Z. Alansari, N. B. Anuar, A. Kamsin, S. Soomro, M. R. Belgaum, M. H. Miraz, and J. Alshaer, "Challenges of Internet of Things and Big Data Integration", in Emerging Technologies in Computing (M. H. Miraz, P. Ex- cell, A. Ware, S. Soomro, and M. Ali, eds.), (Cham), pp. 47–55, Springer International Publishing, 2018, DOI: 10.1007/978-3-319-95450-9_4.

[19]. J. Cooper and A. James, "Challenges for database management in the internet of things"IETE Technical Review,vol.26,no.5,pp.320–329,2009.

[20]. D. B. Ansari, A.-U. Rehman, and R. Ali, "Internet of Things (IoT) Proto- cols: A Brief Exploration of MQTT and CoAP," International Journal of Computer Applications, vol. 179, pp. 9–14, 03 2018.

[21]. M. H. Miraz and M. Ali, "Applications of Blockchain Technology beyond Cryptocurrency", Annals of Emerging Technologies in Computing (AETiC), vol. 2, no. 1, pp. 1–6, 2018, DOI: 10.33166/AETiC.2018.01.001.

[22]. Miraz, M.H., "Blockchain of Things (BCoT): The Fusion of Blockchain and IoT Technologies", Advanced Applications of Blockchain Technology, Studies in Big Data 60, 2019, DOI: 10.1007/978-981-13-8775-3_7, https://doi.org/10.1007/978-981-13-8775-3_7.

[23]. Miraz, M. H. and Ali, M., 2018. Blockchain Enabled Enhanced IoT Ecosystem Security, Proceedings of the International Conference on Emerging Technologies in Computing 2018, London Metropolitan University, UK, Part of the Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering (LNICST), vol. 200, pp. 38-46, Online ISBN: 978-3-319-95450-9, Print ISBN: 978-3-319-95449-3, Series Print ISSN: 1867-8211, Series Online ISSN: 1867-822X, DOI: 10.1007/978-3-319-95450-9_3, Springer-Verlag, https://link.springer.com/chapter/10.1007/978-3-319-95450-9_3.

[24]. A. Mazayev, J. A. Martins, and N. Correia, "Interoperability in IoT Through the Semantic Profiling of Objects," IEEE Access, vol. 6, pp. 19379–19385, 2018.

[25]. R. Porkodi and V. Bhuvaneswari, "The Internet of Things (IoT) Applications and Communication Enabling Technology Standards: An Overview," in 2014 International Conference on Intelligent Computing Applications, pp. 324–329, March 2014.

[26]. Coetzee, L., & Eksteen, J. (2011, May). The Internet of Things-promise for the future? An introduction. In IST-Africa Conference Proceedings, 2011 (pp. 1-9). IEEE.International Journal of Computer Science & Information Technology (IJCSIT) Vol 10, No 2, April 2018

[27]. Ji, Z., & Anwen, Q. (2010, November). The application of internet of things (IOT) in emergency management system in China. In Technologies for Homeland Security (HST), 2010 IEEE International Conference on (pp. 139-142). IEEE.