

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/313651150>

Internet of Things Applications, Challenges and Related Future Technologies

Article · January 2017

CITATIONS

4

READS

31,946

2 authors, including:



[Elmustafa sayed ali ahmed](#)

Red Sea University

19 PUBLICATIONS **26** CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



Internet of Things (IoT) Applications [View project](#)



World Scientific News

WSN 67(2) (2017) 126-148

EISSN 2392-2192

Internet of Things Applications, Challenges and Related Future Technologies

Zeinab Kamal Aldein Mohammed^a, Elmustafa Sayed Ali Ahmed^b

Electrical and Electronic Engineering Department, Red Sea University, Sudan

^{a,b}E-mail address: Zeinab_mansour712@hotmail.com , elmustafasayed@rsu.edu.sd

ABSTRACT

Nowadays Internet of Things (IoT) gained a great attention from researchers, since it becomes an important technology that promises a smart human being life, by allowing a communications between objects, machines and every things together with peoples. IoT represents a system which consists a things in the real world, and sensors attached to or combined to these things, connected to the Internet via wired and wireless network structure. The IoT sensors can use various types of connections such as RFID, Wi-Fi, Bluetooth, and ZigBee, in addition to allowing wide area connectivity using many technologies such as GSM, GPRS, 3G, and LTE. IoT-enabled things will share information about the condition of things and the surrounding environment with people, software systems and other machines. by the technology of the IoT, the world will becomes smart in every aspects, since the IoT will provides a means of smart cities, smart healthcare, smart homes and building, in addition to many important applications such as smart energy, grid, transportation, waste management and monitoring . In this paper we review a concept of many IoT applications and future possibilities for new related technologies in addition to the challenges that facing the implementation of the IoT.

Keywords: IoT Applications, Future Technologies, Smart Cities, Smart Environment, Smart Energy and Grid, Smart Manufacturing, Smart Healthcare

1. INTRODUCTION

The Internet of Things (IoT), sometimes referred to as the Internet of Objects, will change everything including ourselves. The Internet has an impact on education, communication, business, science, government, and humanity ^[1]. Clearly, the Internet is one of the most important and powerful creations in all of human history and now with the concept of the internet of things, internet becomes more favorable to have a smart life in every aspects ^[2].

Internet of Things is a new technology of the Internet accessing. By the Internet of Things, objects recognize themselves and obtain intelligence behavior by making or enabling related decisions thinks to the fact that they can communicate information about themselves ^[3]. These objects can access information that has been aggregated by other things, or they can added to other services ^[3]. Figure 1 reviews that with the internet of things, anything's will able to communicate to the internet at any time from any place to provide any services by any network to anyone. this concept will create a new types of applications can involve such as smart vehicle and the smart home, to provide many services such as notifications, security, energy saving, automation, communication, computers and entertainment ^[4,5].

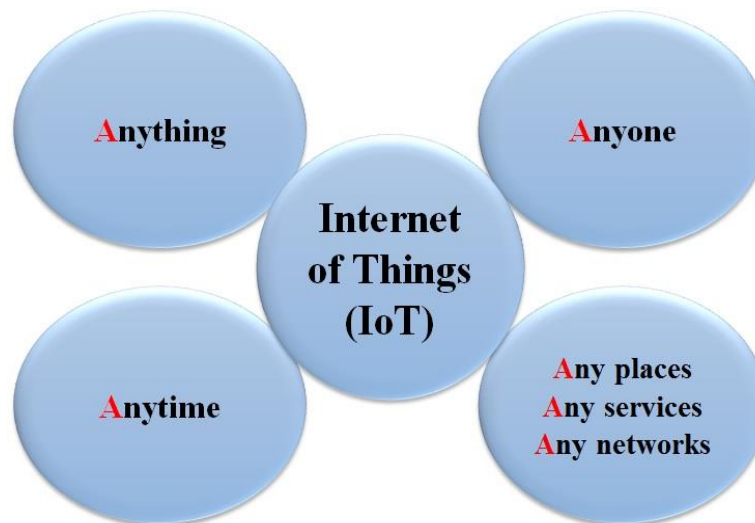


Figure 1. Internet of things Concept

By developing the IoT technology, testing and deploying products it will be much close to implementing smart environments by 2020 ^[6]. In the near future, storage and communication services will be highly pervasive and distributed: people, machines, smart objects, surrounding space and platforms connected with wireless/wired sensors, M2M devices, RFID tags will create a highly decentralized resources interconnected by a dynamic network of networks ^[7].

In the IoT, the communication language will be based on interoperable protocols, operating in heterogeneous environments and platforms ^[8]. IoT in this context is a generic term and all objects can play an active role to their connection to the Internet by creating smart environments, where the role of the Internet has changed ^[9].

The aim of this paper is presents the internet of things Applications, Related Future Technologies, and challenges .The remainder of this paper is structured as follows: section 2 provides a concept of internet of things Standardizations. In section 3 the application of internet of thing will be discussed. Section 4 will provide Internet of Things and Related Future Technologies and the challenges that facing the IoT will be reviewed in section 5. Finally the chapter will ended by a conclusion of the overall sections.

2. INTERNET OF THINGS STANDARDIZATIONS AND PROTOCOLS

By the 2020 around 50 to 100 billion things will be connected electronically by internet ^[10]. Figure 2 shows the growth of the things connected to the internet from 1988 to forecast 2020. The Internet of Things (IoT) will provide a technology to creating the means of smart action for machines to communicate with one another and with many different types of information ^[11]. The success of IoT depends on standardization, which provides interoperability, compatibility, reliability, and effective operations on a global scale ^[12]. Today more than 60 companies for leading technology, in communications and energy, working with standards, such as IETF, IEEE and ITU to specify new IP based technologies for the Internet of Things ^[13].

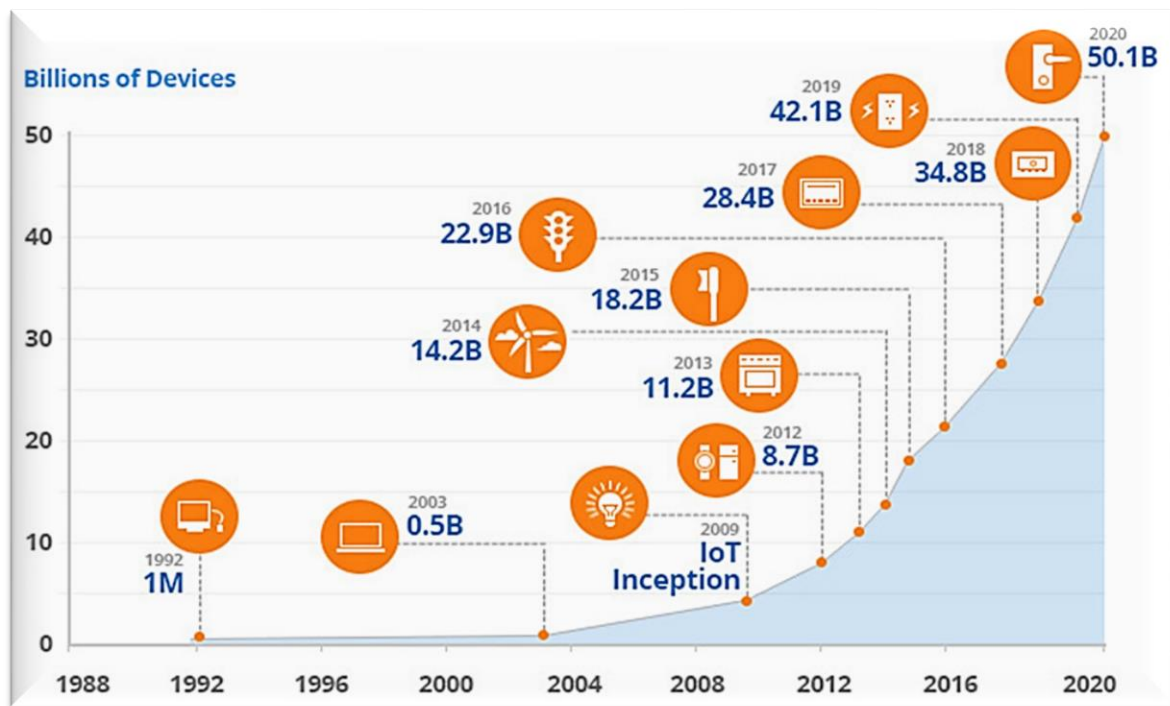


Figure 2. Internet of Things Growth

The design of the IoT standards is required to consider the efficient use of energy and network capacity, as well as respecting other constraints such as frequency bands and power levels for radio frequency communications ^[14,15]. As IoT evolves, it may be necessary to

review such constraints and investigate ways to ensure sufficient capacity for expansion, for example in case of additional radio spectrum allocation as it becomes available ^[16].

IEEE Standards Association (IEEE-SA) develops a number of standards that are related to environment need for an IoT. The main focus of the IEEE standardization activities are on the Physical and MAC layers ^[17]. The IEEE provides an early foundation for the IoT with the IEEE802.15.4 standard for short range low power radios, typically operating in the industrial, scientific and medical band in addition to use ZigBee technology ^[18]. The IEEE-SA has an over 900 active standards and more than 500 standards under development. In its research into IoT, it has identified over 140 existing standards and projects that are relevant to the IoT. The base project related to IoT is IEEE P2413 which it is currently considering the architecture of IoT ^{[19][20]}.

ETSI produces globally applicable standards for information and communications technologies (ICT), including fixed, mobile, radio, converged, broadcast and Internet technologies, discusses a similar concept under the label of “machine to machine (M2M) communication. These standards are considered as one of the basic standards of IoT, because its associate with M2M technology which is one of the basic techniques related to IoT ^[21,22].

Internet Engineering Task Force (IETF) is concerned with the evolution of the Internet architecture and the smooth operation of the Internet and known as large, open to international community of network designers, operators, vendors and researchers ^[23]. IETF provides its own description of IoT which provides a most recognizable enhancement to support IPv6, with the 6LoWPAN ^[24-26]. The 6TiSCH Working Group is being formed at the IETF to address the networking piece of that unifying standard. Based on open standards, 6TiSCH will provide a complete suite protocols for distributed and centralized routing operation over the IEEE802.15.4e TSCH MAC ^[27]. ITU's Telecommunication Standardization Sector (ITU-T) considered as a first organization of standards development and coordination of the Internet of Things. They but standards to gain benefit of integrated information processing capacity, and industrial products with smart capabilities ^[28,29]. In addition to make development on electronic identities that can be queried remotely, or be equipped with sensors for detecting physical changes around them.

3. INTERNET OF THINGS APPLICATIONS

Internet of things promises many applications in human life, making life easier, safe and smart. There are many applications such as smart cities, homes, transportation, energy and smart environment.

A. Smart Cities

Many major cities were supported by smart projects, like Seoul, New York, Tokyo, Shanghai, Singapore, Amsterdam, and Dubai. Smart cities may still be viewed as a cities of the future and smart life, and by the innovation rate of creating smart cities today's, it will became very feasible to enter the IoT technology in cities development ^[30]. Smart cities demand require careful planning in every stage, with support of agreement from governments, citizens to implement the internet of things technology in every aspects. By the IoT, cities can be improved in many levels, by improving infrastructure, enhancing public transportation

reducing traffic congestion, and keeping citizens safe, healthy and more engaged in the community as shown in Figure 3^[31]. By connection all systems in the cities like transportation system, healthcare system, weather monitoring systems and etc., in addition to support people by the internet in every place to accessing the database of airports, railways, transportation tracking operating under specified protocols, cities will become smarter by means of the internet of things^[32,33].



Figure 3. Smart Cities Aspects

B. Smart Home and Buildings

Wi-Fi's technologies in home automation has been used primarily due to the networked nature of deployed electronics where electronic devices such as TVs, mobile devices, etc are usually supported by Wi-Fi^[34]. Wi-Fi have started becoming part of the home IP network and due the increasing rate of adoption of mobile computing devices like smart phones, tablets, etc. For example a networking to provide online streaming services or network at homes, may provide a mean to control of the device functionality over the network^[35]. At the same time mobile devices ensure that consumers have access to a portable 'controller' for the electronics connected to the network. Both types of devices can be used as gateways for IoT applications^[36]. Many companies are considering developing platforms that integrate the building automation with entertainment, healthcare monitoring, energy monitoring and wireless sensor monitoring in the home and building environments^[37]. By the concept of the internet of things, homes and buildings may operate many devices and objects smartly, of the most interesting application of IoT in smart homes and buildings are smart lighting, smart environmental and media, air control and central heating, energy management and security as shown in Figure 4 below.

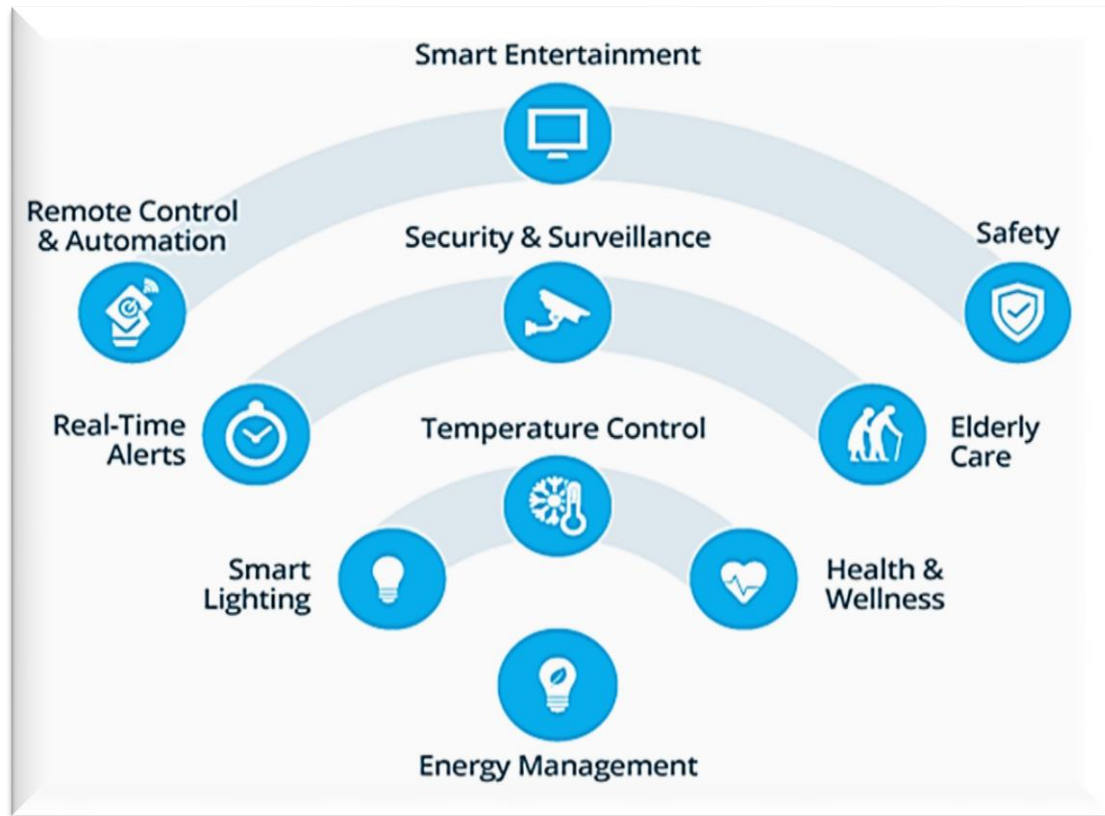


Figure 4. Smart Home & building applications

Wireless sensor networks (WSNs) with integration to the internet of things technology will provides an intelligent energy management in buildings, in addition to the obvious economic and environmental gains. Internet together with energy management systems also offers an opportunity to access a buildings' energy information and control systems from a laptop or a smartphone placed anywhere in the world ^[38]. The future Internet of Things, will provide an intelligent building management systems which can be considered as a part of a much larger information system used by facilities managers in buildings to manage energy use and energy procurement and to maintain buildings systems ^[39,40].

C. Smart Energy and the Smart Grid

A smart grid is related to the information and control and developed to have a smart energy management ^[41]. A smart grid that integrate the information and communications technologies (ICTs) to the electricity network will enable a real time, two way communication between suppliers and consumers, creating more dynamic interaction on energy flow, which will help deliver electricity more efficiently and sustainably ^[42]. The Key elements of information and communications technologies will include sensing and monitoring technologies for power flows; digital communications infrastructure to transmit data across the grid; smart meters with in home display to inform energy usage; coordination, control and automation systems to aggregate and process various data, and to create a highly interactive,

responsive electricity^[43]. Many applications can be handling due to the internet of things for smart grids, such as industrial, solar power, nuclear power, vehicles, hospitals and cities power control. Figure 5 shows the most important application may be enabled by the internet of things as in smart grid aspect.



Figure 5. Smart grid applications

Today's grid is very reliable and can deal with normal electricity fluctuations and it will take a step further towards using a low carbon energy system, by allowing integration between the renewable energy and green technologies, and offering many benefits to customer in cost savings through efficient energy use at home^[44].

D. Smart Health

A close attention that required to hospitalized patients whose physiological status should be monitored continuously can be constantly done by using IoT monitoring technologies. For smart health sensors are used to collect comprehensive physiological

information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review as shown in Figure 6 below ^[45]. It replaces the process of having a health professional come by at regular intervals to check the patient's vital signs, instead providing a continuous automated flow of information. In this way, it simultaneously improves the quality of care through constant attention and lowers the cost of care by reduces the cost of traditional ways of care in addition to data collection and analysis ^[46].

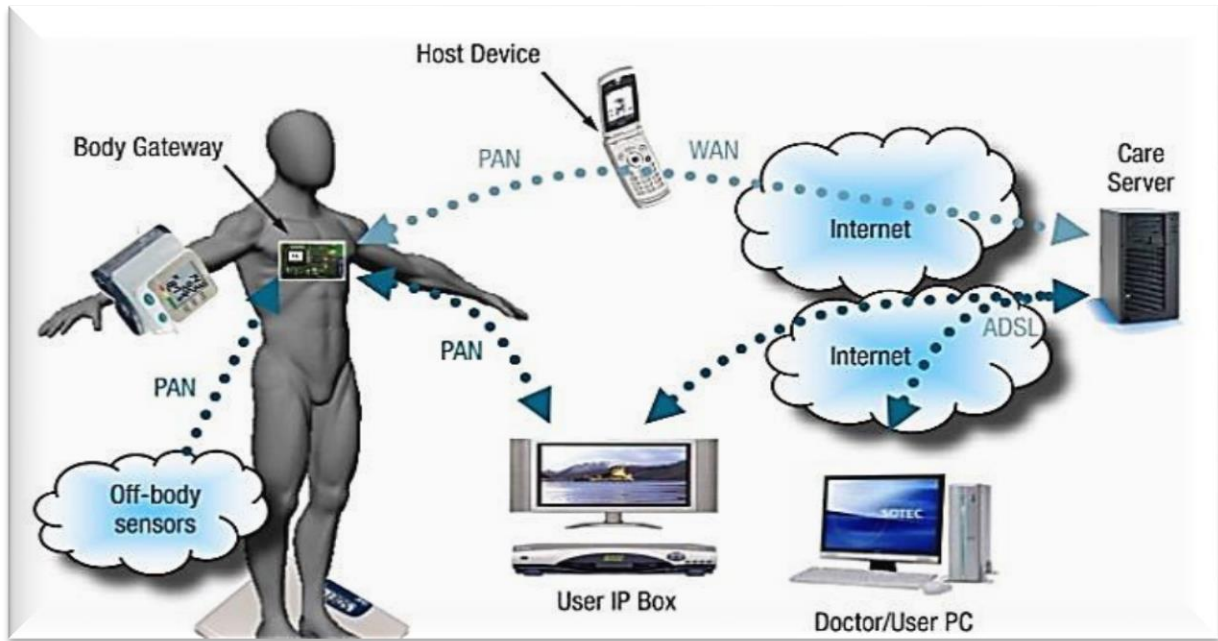


Figure 6. Smart healthcare concept

Many peoples around the worlds are suffering from the bad health because they don't have ready access to effective health monitoring and may be a suspected to be as critical situation patients. But with small, powerful wireless solutions connected through the IoT are now making possible for monitoring to come to these patients. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyze the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations ^[47].

E. Smart Transportation and Mobility

The development in transportation is one of the factors to indicate the wellbeing of the country. A road condition monitoring and alert application is one of the most important of IoT transformation application ^[48]. The main idea of the concept of smart transportation and mobility is to apply the principles of crowd sourcing and participatory sensing. The process began with user identified the route wishes and marked some points as pothole in the smart phone's application ^[49]. The smart transportation is deal with three main conceptions as shown

in Figure 7, they are transportation analytic, transportation control, and vehicle connectivity. The transportation analytic represents the analysis of demand prediction and anomaly detection. The routing of vehicles and speed control in addition to traffic management are all known as transportation control which they actually tightly related to the way of the vehicles connectivity (V2X communication), and overall governed by multi-technology dissemination.

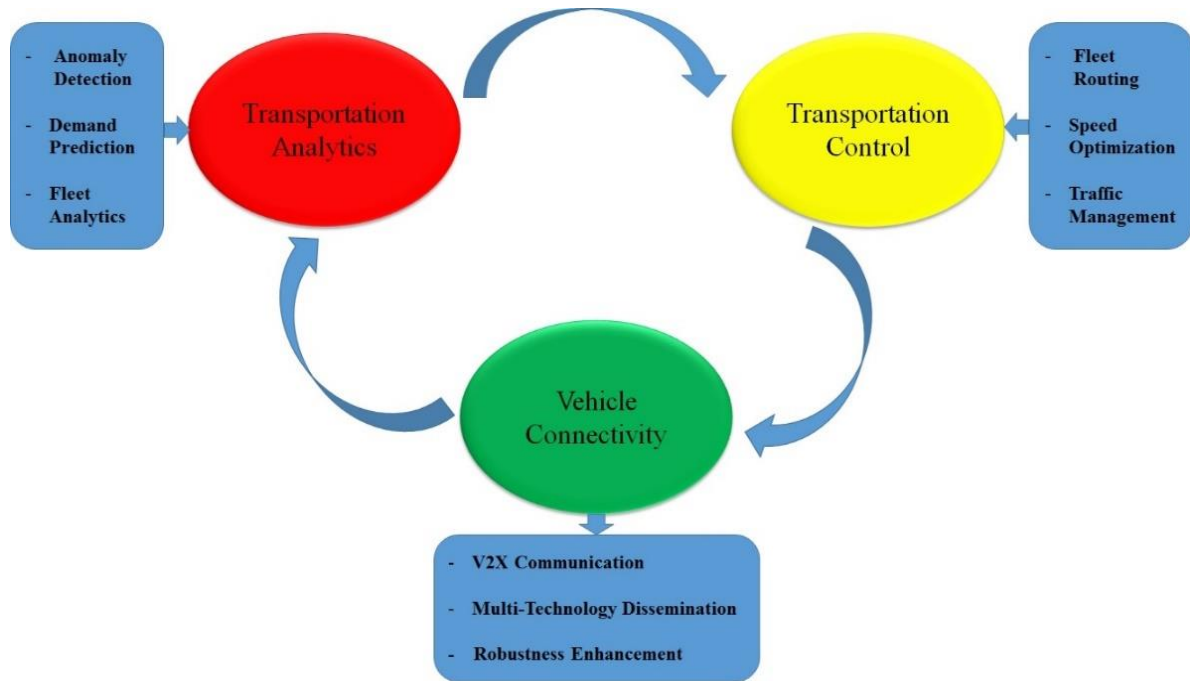


Figure 7. Smart Transportation Aspects

IoT can also be used in transportation is an electric vehicles, which is an important means to reduce both the fuel cost and the impact of global warming have also gained considerable attention from drivers. Government in many countries has supported researches on systems to monitor performance of Lithium-ion (Li-on) battery for electric vehicle as explored. The system presented was designed to detect the functions of Li-on power battery by deriving the driving situation from the realistic working conditions for driver so that the driver was able to get the idea of the route status. This solution was embedded with many essential functions such as dynamic performance test of the Li-on battery, remote monitoring with on-line debugging and error correction that could significantly reduce the maintenance cost ^[50].

F. Smart Factory and Smart Manufacturing

Smart factory added a new values in manufacturing revolution by integrates artificial intelligence, machine learning, and automation of knowledge work and M2M communication with the manufacturing process ^[51]. The smart factory will fundamentally change how products are invented, manufactured and shipped. At the same time it will improve worker

safety and protect the environment by enabling low emissions and low incident manufacturing. These advances in the way machines and other objects communicate and the resulting way in which decision-making moves from humans to technical systems means that manufacturing becomes “smarter”^[52]. new technologies such ; Automation, robotics, and autonomous mobility are all provides a means of smart manufacturing but M2M communications enabled by the “industrial” internet of things will provides a full meaning of smart factory and smart manufacturing by the way of Big Data concept which in this context, refers to the analytical possibilities offered by the volume and variety of data that is generated by a networked economy to optimize the industrial processes to implying less maintenance downtime, fewer outages and much reduced energy consumption^[53].

Industries and manufacturing revolution became one of the most developed technologies nowadays, the growth of the industry evolution taken many generations. The first generation related to the mechanical machines in addition to water and stream power. The second industry generation deal with mass production, assembly lines and electricity. In the end of the last century, industries operated under control of computers and automation which recognized as third generation of industries.

The smart industry as a fourth generation known as industry 4.0 is based on cypher physical systems which can able to connect with the internet. The industry 4.0 concept with the internet of things can achieve a great expectations for industries resolution deals with many aspects a shown in Figure 8. By introducing the high-tech strategy 2020 initiative focusing the country’s research and innovation policy on selected forward-looking projects related to scientific and technological developments.

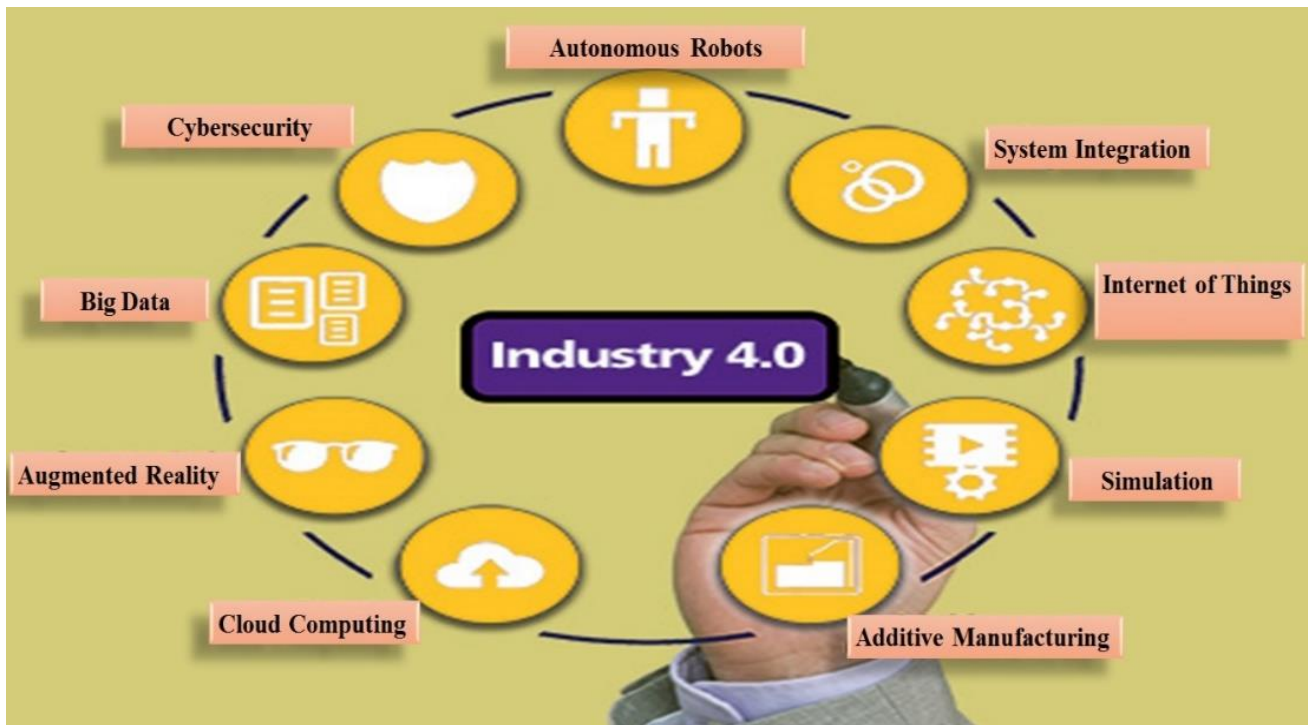


Figure 8. Smart Factory (Industry 4)

G. Smart Environment

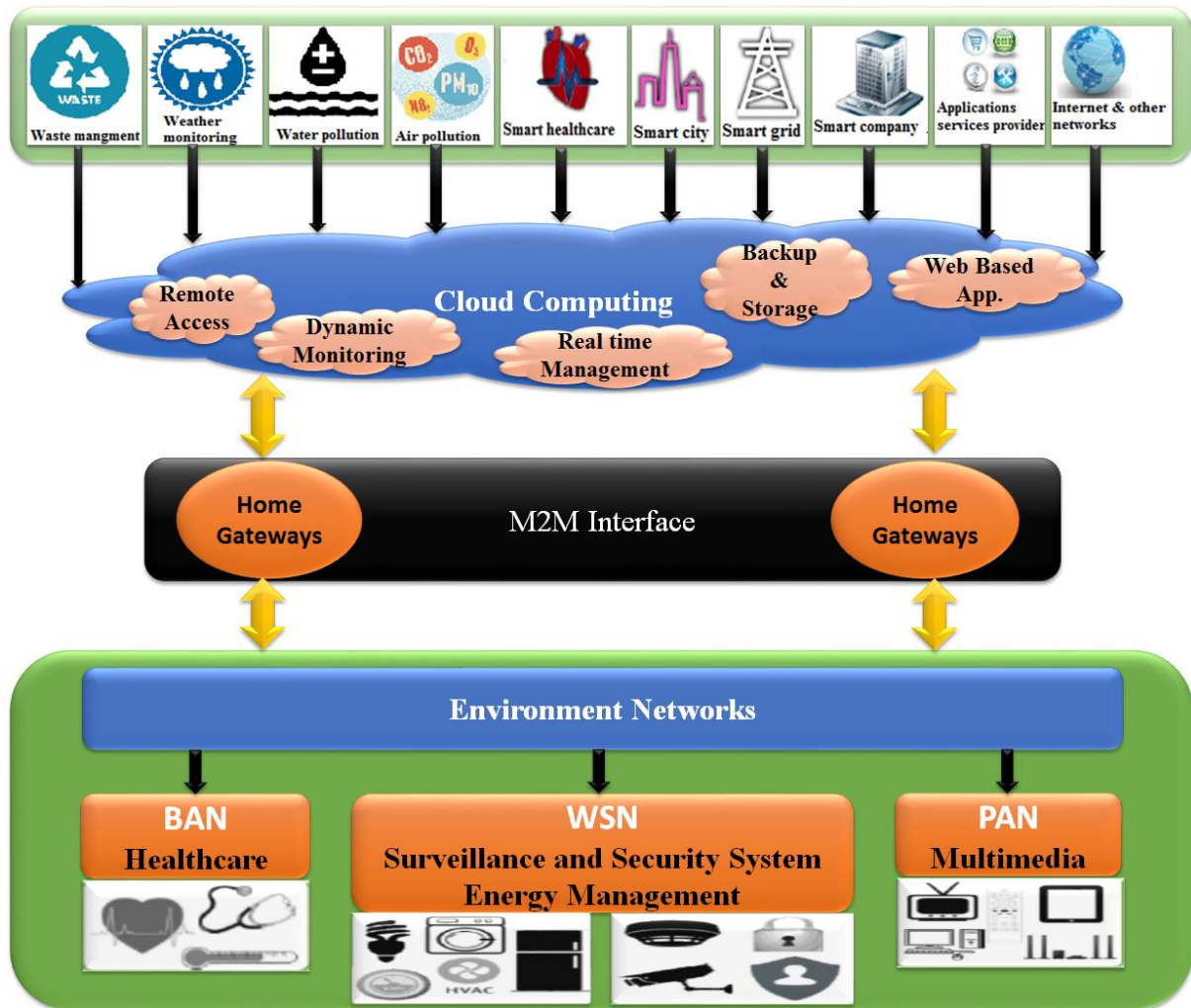


Figure 9. Smart Environment based internet of things

Environment plays a major effect in human life. People, even animals, birds, fishes and plants may be affected in unhealthy environment. There were many researches efforts has been paid to solve the problems of environmental pollution and waste resources^[54]. Creating of a healthy environment is not easy because of industries and transportations wastes, with irresponsible human activities are daily factors that make the environment damaged^[55].

The environment needs a smart ways and new technologies for monitoring and management. Monitoring the environment is important in order to assess the current condition of the environment to takes correct life decision according to collected data from monitoring systems, and management is needed to have an efficient resources consuming and use in addition to decrease the factories and vehicles wastes. Both monitoring and waste management provide a large amount of data to force the health standard by governments or

healthy environment organizations to protect people and environment, and to mitigate or to avoid natural disaster that might occur^[56].

Smart environment is an important technology in our everyday life which provides many facilities and solutions for many environmental applications such as water and air pollution, weather and radiation monitoring, waste management, natural disaster, and many other environment indicators as shown in Figure 9 and all may connected to each persons through home area network. Smart environment devices integration with Internet of Things (IoT) technology is developed for tracking, sensing and monitoring objects of environment which provide potential benefits to achieve a green world and sustainable life^[57].

There are many applications of internet of things in environment and that can be divided to two main categories environmental resources management, and environmental quality and protection management^[58]. The resources management relates to all natural resources include animals, planets and forests, birds and fishes, coal , petroleum , land, freshwater, air and heavy metals including gold, copper and iron. All these resources are likely to decrease significantly or affected by several factors, including pollution, waste, and abuse. IoT can provides an effective way to communicate between each of these resources sensors with research and monitoring centers to make appropriate decisions in the consumption of these sources. Renewable resources include sunlight, and wind also can be managed and sensed to Ideal use in several uses, such as the provision of renewable energy sources. IoT can control these sources and their use in a number of important applications in the environment^[59].

The IoT technology is able to monitoring and managing the air quality by to collecting data from remote sensor across the city, and providing full-time geographic coverage to achieve a way of better managing urban traffic in major cities^[60]. The IoT also can be used to measure the levels of pollution in water in order to inform decisions on water usage and treatment. Waste management is also one of the most important environment issues^[61]. The various types of waste material chemical or elements can pollute the environment and threaten life in a number of ways in ground effect on animals, peoples and plants and in addition to air and water. IoT provides an environmental protection means by control the industrial pollution by real time monitoring and management systems integrated to supervision and decision-making networks to reduce waste, and improved environment^[62].

Other environment aspect is a weather forecast and monitoring. IoT can provide a high resolution, and accuracy for weather monitoring by data exchange and information sharing. It's enabling weather systems to collect data from various vehicles on the road, and wirelessly communicate to the weather stations to support data that is inclusive of air temperature, barometric pressure, visibility or light, motion and other data needed. Sensors equipped in many buildings, vehicles integration with IoT help in collecting weather data which is further stored in clouds for analysis^[63].

Radiation of course is one of the most serious problems facing the safety of the environment. The radiation produced by nuclear power plants and some industries negatively affected safety of an environmental and human health, animal and agricultural productivity^[64]. For nuclear radiations, radiation control IoT sensor network is able to continuous monitoring of radiation levels around nuclear facilities for leakage detection and propagation prevention^[65]. The sensors network formed by wireless link dozens of sensor devices in areas surroundings nuclear power plants with closes proximity to cities^[66].

A natural disaster is a major adverse event resulting from natural processes of the earth include floods, volcanic eruptions, earthquakes, hurricanes, wildfires, blizzards and, and other

geologic processes. IoT can avoid or reduce the impact of a large number of natural disasters that affect in many aspects of life through the distribution of a number of sensor systems for many types of natural disasters and linking these systems with research and rescue announcement stations, also for declaration of emergency networking with hospitals and police stations^[67].

IoT will provides a means of smart agriculture and adding great potential in resource saving. By using sensors networks, and scientific research databases, growing of plants and other agriculture productions needed by humans like vegetables and fruits can monitored and save their production processes based on managing many resources such as weather, water and sunlight. In addition, the IoT for environmental monitoring can aid in measuring emissions from factories detect forest fires or aid in agriculture^[68].

4. INTERNET OF THINGS CHALLENGES

The fact that Internet of things applications and scenarios outlined above are very interesting which provides technologies for smart every things. , but there are some challenges to the application of the Internet of Things concept in cost of implementation. The expectation that the technology must be available at low cost with a large number of objects. IoT are also faced with many other challenges^[69,70], such as:

- **Scalability:** Internet of Things has a big concept than the conventional Internet of computers, because of things are cooperated within an open environment. Basic functionality such as communication and service discovery therefore need to function equally efficiently in both small scale and large scale environments. The IoT requires a new functions and methods in order to gain an efficient operation for scalability.
- **Self-Organizing:** Smart things should not be managed as computers that require their users to configure and adapt them to particular situations. Mobile things, which are often only sporadically used, need to establish connections spontaneously, and able to be organize and configure themselves to suit their particular environment.
- **Data volumes:** Some application scenarios of the internet of things will involve to infrequent communication, and gathering information's form sensor networks, or form logistics and large scale networks, will collect a huge volumes of data on central network nodes or servers. The term represent this phenomena is big data which is requires many operational mechanism in addition to new technologies for storing, processing and management.
- **Data interpretation:** To support the users of smart things, there is a need to interpret the local context determined by sensors as accurately as possible. For service providers to profit from the disparate data that will be generated, needs to be able to draw some generalizable conclusions from the interpreted sensor data.
- **Interoperability:** Each type of smart objects in Internet of Things have different information, processing and communication capabilities. Different smart objects would also be subjected to different conditions such as the energy availability and the communications bandwidth requirements. To facilitate communication and cooperation of these objects, common standards are required.

- **Automatic Discovery:** In dynamic environments, suitable services for things must be automatically identified, which requires appropriate semantic means of describing their functionality.
- **Software complexity:** A more extensive software infrastructure will be needed on the network and on background servers in order to manage the smart objects and provide services to support them. that because the software systems in smart objects will have to function with minimal resources, as in conventional embedded systems.
- **Security and privacy:** In addition to the security and protection aspects of the Internet such in communications confidentiality, the authenticity and trustworthiness of communication partners, and message integrity, other requirements would also be important in an Internet of Things. There is a need to access certain services or prevent from communicating with other things in IoT and also business transactions involving smart objects would need to be protected from competitors' prying eyes.
- **Fault tolerance:** Objects in internet of things is much more dynamic and mobile than the internet computers, and they are in changing rapidly in unexpected ways. Structuring an Internet of Things in a robust and trustworthy manner would require redundancy on several levels and an ability to automatically adapt to changed conditions.
- **Power supply:** Things typically move around and are not connected to a power supply, so their smartness needs to be powered from a self-sufficient energy source. Although passive RFID transponders do not need their own energy source, their functionality and communications range are very limited. Hopes are pinned on future low power processors and communications units for embedded systems that can function with significantly less energy. Energy saving is a factor not only in hardware and system architecture, but also in software, for example the implementation of protocol stacks, where every single transmission byte will have to justify its existence.
- **Wireless communications:** From an energy point of view, established wireless technologies such as GSM, UMTS, Wi-Fi and Bluetooth are far less suitable; more recent WPAN standards such as ZigBee and others still under development may have a narrower bandwidth, but they do use significantly less power.

5. INTERNET OF THINGS AND RELATED FUTURE TECHNOLOGIES

Many new technologies are related to IoT to prove the integration of wired as well as wireless control, communication and IT technologies together which are responsible for connecting several subsystems and things which operate under a unified platform controlled and managed smartly.

A. Cloud Computing

The two worlds of Cloud and IoT have seen a rapid and independent evolution. These worlds are very different from each other, but their characteristics are often complementary in general, in which IoT can benefit from the virtually unlimited capabilities and resources of

cloud to compensate its technological constraints for example storage, processing, and communication ^[71]. Cloud can offer an effective solution for IoT service management and composition as well as for implementing applications and services that exploit the things or the data produced by them. On the other hand, cloud can benefit from IoT by extending its scope to deal with real world things in a more distributed and dynamic manner, and for delivering new services in a large number of real life scenarios. In many cases, Cloud can provide the intermediate layer between the things and the applications, hiding all the complexity and functionalities necessary to implement the latter. This will impact future application development, where information gathering, processing, and transmission will generate new challenges, especially in a multi cloud environment or in fog cloud ^[72]. Cloud facilitates for IoT application to enabling data collection and data processing, in addition to rapid setup and integration of new things, while maintaining low costs for deployment and for complex data processing ^[73]. Cloud is the most convenient and cost effective solution to deal with data produced by IoT and, in this respect, it generates new opportunities for data aggregation, integration, and sharing with third parties. Once into Cloud, data can be treated as homogeneous through well-defined APIs, can be protected by applying top level security, and can be directly accessed and visualized from any place ^[74].

B. Big Data

Due to the rapid expansion in the networks nowadays, the number of devices and sensors in networks are increased more and more in the physical environments which will change the information communication networks, services and applications in various domains ^[75]. The expectations in the next year's show that around 50 billion devices will generate large volumes of data from many applications and services in a variety of areas such as smart grids, smart homes, healthcare, automotive, transport, logistics and environmental monitoring. The related technologies and solutions that enable integration of real world data and services into the current information networking technologies are often described under the term of the Internet of Things (IoT) ^[76].

The volume of data on the Internet and the Web is still growing, and everyday around 2.5 quintillion bytes of data is created and it is estimated that 90% of the data today was generated in the past two years. Collected data from sensors related to different events and occurrences can be analyzed and turned into real information to give us better understanding about our physical world and to create more value added products and services. Such these sensory data like data of predicted and balanced power consumption in smart grids, analyzed data of pollution, weather and congestion, sensory data recorded to provide better traffic control and management, and monitoring and processing health signals data that collected by sensory devices to provide better healthcare services ^[77]. In addition, the information available from social media such as Facebook, tweeter, WhatsApp and user submitted physical world observations and measurements also provide a huge amount of data (Big Data) ^[78]. Integration of data from various physical, cyber, and social resources with the IoT enables developing applications and services that can incorporate situation and context awareness into the decision making mechanisms and can create smarter applications and enhanced services. With large volumes of distributed and heterogeneous IoT data, issues related to interoperability, automation, and data analytics will require common description and data representation frameworks in addition to machine readable and interpretable data descriptions ^[79].

C. Security and Privacy

Due the fact that IoT applications able to access the multiple administrative domains and involve to multiple ownership regimes , there is a need for a trust framework to enable the users of the system to have confidence that the information and services being exchanged can indeed be relied upon ^[80]. The trust framework needs to be able to deal with humans and machines as users, for it needs to convey trust to humans and needs to be robust enough to be used by machines without denial of service. The development of trust frameworks that address this requirement will require advances in areas such as lightweight public key infrastructures (PKI) as a basis for trust management ^[81]. Lightweight key management systems is used to enable trust encryption materials using minimum communications and processing resources, as is consistent with the resource constrained nature of many IoT devices ^[82].

IoT based systems require a quality of information for metadata which can be used to provide an assessment of their liability of IoT data. A novel methods is required for IoT based systems for assessing trust in people, devices and data. One of the most methods used are trust negotiation that allows two parties to automatically negotiate, on the basis of a chain of trust policies, the minimum level of trust required to grant access to a service or to a piece of information. Internet of things uses a methods for access control to prevent untrusted data breaches by control the process of ensuring the correct usage of certain information according to a predefined policy after the access to information is granted ^[83].

Recently, the IoT becomes a key element of the future internet, the need to provide adequate security for the IoT infrastructure becomes ever more important. A large scale applications and services based on the IoT are increasingly vulnerable to disruption from attack or information theft. Many advanced security methods are required in several areas to make the IoT secure from attacks, thefts and many other security problems such as DoS/DDOS attacks, compromised nodes, and malicious code hacking attacks, that because the IoT is susceptible to such attacks and will require specific techniques and mechanisms to ensure that transport, energy, city infrastructures cannot be disabled or subverted ^[84].

The IoT requires a variety of access control and associated accounting schemes to support the various authorization and usage models that are required by users. The heterogeneity and diversity of the devices/gateways that require access control will require new lightweight schemes to be developed ^[85]. The IoT needs to handle virtually all modes of operation by itself without relying on human control. New techniques and approaches for example like machine learning, are required to lead to a self-managed IoT. Cryptographic techniques is also very important in IoT based systems for enable a means of protection for data to be stored processed and shared, without the information content being accessible to other parties. Technologies such as homomorphic and searchable encryption are potential candidates for developing such approaches ^[86].

D. Distributed Computing

Distributed computing uses groups of networked computers for the same computational goal. Distributed Computing has several common issues with concurrent and parallel computing, as all these three fall in the scientific computing field. Nowadays, a large amount of distributed computing technologies coupled with hardware virtualization, service oriented

architecture, and autonomic and utility computing have led to cloud computing. Internet of Things with distributed computing represents a vision in which the Internet extends into the real world embracing everyday objects. Physical items are no longer disconnected from the virtual world, but can be remotely controlled and can act as physical access points to Internet services^[87].

E. Fog Computing

Fog computing is related to the edge computing in the cloud. In contrast to the cloud, fog platforms have been described as dense computational architectures at the network's edge. Characteristics of such platforms reportedly include low latency, location awareness and use of wireless access. While edge computing or edge analytics may exclusively refer to performing analytics at devices that are on, or close to, the network's edge, a fog computing architecture would perform analytics on anything from the network center to the edge. IoT may more likely be supported by fog computing in which computing, storage, control and networking power may exist anywhere along the architecture, either in data centers, the cloud, edge devices such as gateways or routers, edge equipment itself such as a machine, or in sensors^[88].

6. CONCLUSIONS

Internet of things is a new technology which provides many applications to connect the things to things and human to things through the internet. Each objects in the world can be identified, connected to each other through internet taking decisions independently. All networks and technologies of communication are used in building the concept of the internet of things such technologies are mobile computing, RFID, wireless sensors networks, and embedded systems, in addition to many algorithms and methodologies to get management processes, storing data, and security issues. IoT requires standardized approach for architectures, identification schemes, protocols and frequencies will happen parallels, each one targeted for a particular and specific use. by the internet of things many smart applications becomes real in our life , which enable us to reach and contact with every things in addition to facilities many important aspects for human life such as smart healthcare, smart homes, smart energy , smart cities and smart environments.

Internet of things may facing two major challenges in order to guarantee seamless network access; the first issue relates to the fact that today different networks coexist and the other issue is related to the big data size of the IoT. Other current issues, such as address restriction, automatic address setup, security functions such as authentication and encryption, and functions to deliver voice and video signals efficiently will probably be affected in implementing the concept of the internet of things but by ongoing in technological developments these challenges will be overcome. The internet of things promises future new technologies when related to cloud, fog and distributed computing, big data, and security issues. By integrating all these issues with the internet of things, smarter applications will be developed as soon. This paper surveyed some of the most important applications of IoT with particular focus on what is being actually done in addition to the challenges that facing the

implementation the internet of things concept, and the other future technologies make the concept of IoT feasible.

AUTHORS BIOGRAPHY

Zainab Kamal Aldein Mohammed, received her B.Sc. (Honor) degree in Electrical Engineering, Telecommunication in 2010, and presently doing her M.Sc. degree in telecommunication. She worked as a network engineering under TETRA project in Sea Port Corporation for 6 years; she published research papers in heterogeneous network, her areas of research interest included routing protocols and heterogeneous network, MANET, VANET and IOT.

Elmustafa Sayed Ali Ahmed, he received his M.Sc. degree in electronics engineering, Telecommunication in 2012, and B.Sc. (Honor) degree in electrical engineering, Telecommunication in 2008. He was a wireless networks (Tetra system, Wi-Fi and Wi-Max, and CCTV) engineer in Sudan Sea Port Corporation for five years and a head department of electrical and electronics engineering, faculty of engineering in Red Sea University for one year. He published papers, book chapters, and books in wireless communications, computer and networking in peer reviewed academic international journals. His areas of research interest include, routing protocols, MANETs, mobile networks, VANETs, image processing, and cloud computing.

References

- [1] M. A. Ezechina, K. K. Okwara, C. A. U. Ugboaja. The Internet of Things (Iot): A Scalable Approach to Connecting Everything. *The International Journal of Engineering and Science* 4(1) (2015) 09-12.
- [2] <http://www.meraevents.com/event/iot-workshop>
- [3] <http://www.nxp.com/assets/documents/data/en/white-papers/INTOTHNGSWP.pdf>
- [4] Saranya C. M., Nitha K. P., Analysis of Security methods in Internet of Things. *International Journal on Recent and Innovation Trends in Computing and Communication*, Volume 3, Issue 4; April 2015.
- [5] Sapandeep Kaur, Ikvinderpal Singh. A Survey Report on Internet of Things Applications. *International Journal of Computer Science Trends and Technology* Volume 4, Issue 2, Mar - Apr 2016.
- [6] S. Misra et al., Security Challenges and Approaches in Internet of Things. Springer Briefs in Electrical and Computer Engineering, 2016.
- [7] Suwimon Vongsingthong and Sucha Smachat. A Review of Data Management in Internet of Things. *KKU Res. J.* 2015
- [8] http://cdn2.hubspot.net/hubfs/552232/Downloads/Partner_program/Smart_Environment_s_Flyer.pdf?t=1458917278396
- [9] <http://docplayer.net/1073234-Internet-of-things-converging-technologies-for-smart-environments-and-integrated-ecosystems.html>
- [10] Jayavardhana Gubbia, Rajkumar Buyyab, Slaven Marusic, Marimuthu Palaniswami. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems* 29 (2013) 1645-1660.

- [11] <https://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-commercial-real-estate-intelligent-building-systems.html>
- [12] Grandinetti, Lucio. Pervasive Cloud Computing Technologies: Future Outlooks and Interdisciplinary Perspectives: Future Outlooks and Interdisciplinary Perspectives. IGI Global, 2013.
- [13] <http://standardsinsight.com/iot/iotworkshop>
- [14] Debasis Bandyopadhyay, Jaydip Sen. Internet of Things - Applications and Challenges in Technology and Standardization. arxiv 9 may 2011
- [15] http://www.academia.edu/3276195/Internet_of_Things_Applications_and_Challenges_in_Technology_and_Standardization
- [16] Adam D. Thierer. The Internet of Things and Wearable Technology: Addressing Privacy and Security Concerns without Derailing Innovation. 21 Rich. J. L. & Tech. 6 (2015).
- [17] Patrick Guillemin, et al., Internet of Things Position Paper on Standardization for IoT technologies. European research cluster on the internet of things; January, 2015.
- [18] Patrick Guillemin et al., Internet of Things standardization - Status, Requirements, Initiatives and Organizations. Conference: Internet of Things - Converging Technologies for Smart Environments and Integrated Ecosystems 2013.
- [19] <http://www.standardsuniversity.org/e-magazine/march-2016/security-and-iot-in-ieee-standards/>
- [20] Dr Ovidiu Vermesan, Dr Peter Friess. Internet of thing from research and innovation to market deployment, 2014 River Publishers.
- [21] Sophia Antipolis. New ETSI specification for Internet of Things and Machine to Machine Low Throughput Networks. 30 September 2014; <http://www.etsi.org/news-events/news/827-2014-09-news-etsi-new-specification-for-internet-of-things-and-machine-to-machine-low-throughput-networks>
- [22] Building the future; <http://www.etsi.org/images/files/WorkProgramme/etsi-work-programme-2015-2016.pdf>
- [23] <https://www.ietf.org/proceedings/91/overview.html>
- [24] <http://www.ipv6forum.com/iot/index.php/homepage>
- [25] http://iot6.eu/iot6_main_achievements
- [26] Isam Ishaq et al., IETF Standardization in the Field of the Internet of Things (IoT): A Survey. *J. Sens. Actuator Netw.* 2 (2013) 235-287, doi: 10.3390/jsan2020235
- [27] Nicola Accettura. Optimal and Secure Protocols in the IETF 6TiSCH communication stack; <http://telematics.poliba.it/publications/2014/Accettura ISIE2014 .pdf>
- [28] Gérald Santucci. Internet of things: an early reality of the future internet. May 2009. http://cordis.europa.eu/pub/fp7/ict/docs/enet/iot-prague-workshop-report-vfinal-20090706_en.pdf

- [29] <http://www.itu.int/en/ITU-T/techwatch/Pages/internetofthings.aspx>
- [30] <https://www.thingworx.com/ecosystem/markets/smart-connected-systems/smart-cities/>
- [31] Eiman Al Nuaimi¹ et al., Applications of big data to smart cities. *Journal of Internet Services and Applications* 2015.
- [32] <http://www.7wdata.be/article-general/how-big-data-and-internet-of-things-builds-smart-cities/>
- [33] A. Murray, M. Minevich, and A. Abdoullaev. Being smart about smart cities. KM World, October 2011.
- [34] Farheen Fatima, et al., Internet of things: A Survey on Architecture, Applications, Security, Enabling Technologies, Advantages & Disadvantages. *International Journal of Advanced Research in Computer and Communication Engineering* Vol. 4, Issue 12, December 2015.
- [35] http://www.connected-living.org/content/4-information/4-downloads/4-studien/20-mind-commerce-smart-homes-companies-and-solutions-2014/mind-commerce_smart-homes-companies-and-solutions-2014_glo_12-2014.pdf
- [36] <http://www.gsma.com/connectedliving/wpcontent/uploads/2012/03/vision20of20smart20home20report.pdf>
- [37] Jukka Suhonen. Experiences and Future Plans for WSN-enabled Service Development in Home Environment. Realin white paper 2013
- [38] Amrita Sajja, D. K. Kharde, Chandana Pandey. A Survey on efficient way to Live: Smart Home - It's an Internet of Things. *ISAR - International Journal of Electronics and Communication Ethics*, Volume 1. Issue 1, 2016.
- [39] Gabriele Lobaccaro, Salvatore Carlucci and Erica Löfström (2016). A Review of Systems and Technologies for Smart Homes and Smart Grids. www.mdpi.com/journal/energies
- [40] Tiago D. P. Mendes et al., Smart Home Communication Technologies and Applications: Wireless Protocol Assessment for Home Area Network Resources. *Energies* 2015.
- [41] [http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages\(1\).pdf](http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf)
- [42] Smart Grid enabling energy efficiency and low-carbon transition, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/321852/Policy_Factsheet_-_Smart_Grid_Final__BCG_.pdf
- [43] Ramyar Rashed Mohassel et al., A survey on Advanced Metering Infrastructure. *International Journal of Electrical Power & Energy Systems* 63 (2014) 473-484.
- [44] Rosario Miceli. Energy Management and Smart Grids. *Energies* 2013
- [45] David Niewolny. How the Internet of Things Is Revolutionizing Healthcare. https://cache.freescale.com/files/corporate/doc/white_paper/IOTREVHEALCARWP.pdf

- [46] Bill Chamberlin. Healthcare Internet of Things: 18 trends to watch in 2016. IBM Center for Applied Insights. <https://ibmcai.com/2016/03/01/healthcare-internet-of-things-18-trends-to-watch-in-2016/>
- [47] Mobyen Uddin Ahmed, Mats Björkman, Aida Čaušević, Hossein Fotouhi, and Maria Lindén. An Overview on the Internet of Things for Health Monitoring Systems. <https://www.researchgate.net/publication/281062554>
- [48] Vahid Mirzabeiki. An Overview of the Freight Intelligent Transportation Systems; Division of Logistics and Transportation, Chalmers University of Technology. [http://www.bth.se/tek/intelligent_gods.nsf/bilagor/Mirzabeiki,2010,ITS%20World%20Busan_.pdf/\\$file/Mirzabeiki,2010,ITS%20World%20Busan.pdf](http://www.bth.se/tek/intelligent_gods.nsf/bilagor/Mirzabeiki,2010,ITS%20World%20Busan_.pdf/$file/Mirzabeiki,2010,ITS%20World%20Busan.pdf)
- [49] Manoop Talasila, Reza Curtmola, and Cristian Borcea. Mobile Crowd Sensing; New Jersey Institute of Technology. <https://web.njit.edu/~mt57/publications/Chapter4.pdf>
- [50] Georgios Chatzimilioudis, et al., Crowdsourcing with Smartphones. IEEE Internet Computing 2011.
- [51] Marc Benioff. Industrial Internet of Things: Unleashing the Potential of Connected Products and Services, January 2015. http://www3.weforum.org/docs/WEFUSA_IndustrialInternet_Report2015.pdf
- [52] https://www.munichre.com/site/corporate/get/documents_E352744188/mr/assetpool.shared/Documents/0_Corporate%20Website/1_The%20Group/Focus/Emerging%20Risks/CROF-ERI-2015-The-Smart-Factory.pdf
- [53] <https://atos.net/content/dam/global/documents/your-business/atos-smart-factory-ascent-thought-leadership-paper-july-2014.pdf>
- [54] Arko Djajadi, Member. Ambient Environment quality monitoring Using IoT Sensor Network. *Interworking Indonesia Journal* Vol. 8, No. 1 (2016).
- [55] D. Bhattacharjee and R. Bera. Development of smart detachable wireless sensing system for environmental monitoring. *International journal on smart sensing and intelligent systems* Vol.. 7, No. 3, September 2014.
- [56] Peng Jiang, Hongbo Xia, Zhiye He and Zheming Wang. Design of a Water Environment Monitoring System Based on Wireless Sensor Networks. *Sensors* 9 (2009) 6411-6434; doi:10.3390/s90806411
- [57] Nomusa Dlodlo. Adopting the internet of things technologies in environmental management in South Africa. International Conference on Environment Science and Engineering, IPCBEE Vol. 3 2, (2012) IACSIT Press, Singapore.
- [58] Delphine Christin, Andreas Reinhardt, Parag S. Mogre, Ralf Steinmetz. Wireless Sensor Networks and the Internet of Things: Selected Challenges. http://www.ti5.tu-harburg.de/events/fgsn09/proceedings/fgsn_031.pdf
- [59] http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/409774/14-1230-internet-of-things-review.pdf
- [60] http://senseable.mit.edu/papers/pdf/20150228_Kumar_et al_RiseLowcost_EnvironmentI nternational.pdf

- [61] <http://auskogroup.com/how-iot-is-changing-the-waste-industry>
- [62] P. Susmitha, G. Sowmyabala. Design and Implementation of Weather Monitoring and Controlling System. *International Journal of Computer Applications* Volume 97, No. 3, July 2014.
- [63] <http://iotworm.com/internet-of-things-technology-weather-forecasting/>
- [64] Curioni, F. Murtas, M. Silari. Internet of Sensors. Politecnico di Milano, Milano, Italy. https://indico.cern.ch/event/470460/attachments/1303283/1948255/P10_TWD2016_Curioni.pdf
- [65] M. Dragusin, D. Stanga, D. Gurau, E. Ionescu. Radiation monitoring under emergency conditions. *Rom. Journal. Phys.* Vol. 59, Nos. 9-10 (2014) 891-903.
- [66] IAEA Safety Standards for protecting people and environment; Environmental and Source Monitoring for Purposes of Radiation Protection; Safety Guide No. RS-G-1.8, IAES international atomic negry agency. <http://www.ns.iaea.org/standards/feedback.htm>
- [67] <http://www.undp.org/content/dam/mozambique/docs/Community%20based%20BP.pdf>
- [68] <http://www.esciencecentral.org/ebooks/smart-agriculture-an-approach-towards-better-agriculture-management/smart-agriculture-an-approach-towards-better-agriculture-management.pdf>
- [69] Ron Davies. The Internet of Things Opportunities and challenges. May 2015. [http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/557012/EPRS_BRI\(2015\)557012_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/557012/EPRS_BRI(2015)557012_EN.pdf)
- [70] Friedemann Mattern and Christian Floerkemeier. From the Internet of Computers to the Internet of Things. <https://www.vs.inf.ethz.ch/publ/papers/Internet-of-things.pdf>
- [71] Alessio Botta, Walter de Donato, Valerio Persico, Antonio Pescap'e. On the Integration of Cloud Computing and Internet of Things. http://wpage.unina.it/walter.dedonato/pubs/iot_ficloud14.pdf
- [72] Yu Liu, Beibei Dong, Benzhen Guo, Jingjing Yang and Wei Peng. Combination of Cloud Computing and Internet of Things (IOT) in Medical Monitoring Systems. *International Journal of Hybrid Information Technology* 8(12) (2015) 367-376.
- [73] Isna Khan, Prof S.D. Sawant. A Review on Integration of Cloud Computing and Internet of Things. *International Journal of Advanced Research in Computer and Communication Engineering* Vol. 5, Issue 4, April 2016.
- [74] <http://www.csi-india.org/communications/SeptDec2015.pdf>
- [75] https://5g-ppp.eu/wp-content/uploads/2014/02/Advanced-5G-Network-Infrastructure-PPP-in-H2020_Final_November-2013.pdf
- [76] Payam Barnaghi, Wei Wang, CoryHenson and Kerry Taylor. Semantics for the Internet of Things. Early progress and back to the future. <http://ai2-s2-pdfs.s3.amazonaws.com/fall1/0ddb525702ebd6b501216d7f3dbce365d529.pdf>

- [77] Dr. N. Preethi. Performance Evaluation of IoT Result for Machine Learning. *Transactions on Engineering and Sciences*, Vol. 2, Issue 11, November 2014
- [78] Hele-Mai Haav. linked data connections with emerging information technologies: A survey. *International Journal of Computer Science and Applications* Vol. 11, No. 3, (2014) 21-44.
- [79] Rebecca Sawyer. The Impact of New Social Media on Intercultural Adaptation. University of Rhode Island, 2011. <http://digitalcommons.uri.edu/cgi/viewcontent.cgi?article=1230&context=srhonorsprog>
- [80] Odulaja, G.O., Security issues in internet of the things. *Computing, Information Systems, Development Informatics & Allied Research Journal*, Vol. 6, No. 1, March 2015.
- [81] P. Saichaitanya¹, N. Karthik, D. Surender. Recent trends in IoT. *International Journal of Electrical and Electronics Engineering*, Vol. 8, Issue 2, December 2016.
- [82] Shahid Raza. Lightweith security solutions for the internet of things. Mälardalen University Press Dissertations, 2013. <http://www.diva-portal.org/smash/get/diva2:619066/FULLTEXT02>
- [83] Jaydip Sen. Security and privacy issues in cloud computing. Innovation Labs, Tata Consultancy Services Ltd., Kolkata, India. <https://arxiv.org/ftp/arxiv/papers/1303/1303.4814.pdf>
- [84] <http://www.cloud-council.org/deliverables/CSCC-Cloud-Security-Standards-What-to-Expect-and-What-to-Negotiate.pdf>
- [85] https://www.ntia.doc.gov/files/ntia/publications/marcus_response_to_ietf_rfc_rin_0660xc024__0.pdf
- [86] Paula Fraga-Lamas, et al., A Review on Internet of Things for Defense and Public Safety. *Sensors* (Basel) 2016 Oct., 16(10), 1644.
- [87] Virendra Dilip Thoke. Theory of distributed computing and parallel processing with applications, advantages and disadvantages. *International Journal of Innovation in Engineering, Research and Technology*. http://www.ijert.org/admin/papers/1452798652_ICITDCEME%E2%80%9915.pdf
- [88] <https://www.rtinsights.com/what-is-fog-computing-open-consortium/>

(Received 22 January 2017; accepted 08 February 2017)