Jurnal Kejuruteraan dan Sains Kesihatan
Journal of Engineering and Health Sciences
Jilid 5 2021: 65 – 76

THE INTERNET OF THINGS (IOT) IS REVOLUTIONARY FOR FUTURE TECHNOLOGICAL ADVANCEMENTS

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Article history:
Received : 26 November 2021
Accepted : 7 January 2022
Published : 24.January 2022

Abstract

The internet of Things (IoT) is a new paradigm that has transformed the traditional way of life into a high-tech lifestyle. Smart cities, smart homes, pollution control, energy saving, smart transportation, smart industries are the changes caused by the IoT. Many important studies and researches have been done to improve technology through IoT. However, there are still many challenges and problems that need to be addressed to achieve the full potential of the IoT. These challenges and problems must be considered from various aspects of IoT such as applications, challenges, possible technologies, social and environmental impacts etc. The main purpose of this review article is to provide a detailed discussion from a technological and social perspective. This article discusses the various challenges and key issues of the IoT, architecture and important application domains. The article also showcases the available literature and describes their contributions in various aspects of the IoT. Moreover, the importance of big data and its analysis with respect to IoT has been discussed. This article will help researchers to understand the IoT and its application to the real world

Introduction

The Internet of Things (IoT) is an emerging paradigm that enables communication between electronic devices and sensors over the internet to simplify our lives. IoT uses smart devices and the internet to provide innovative solutions to various challenges and problems related to various businesses, government and public / private industries around the world [1] IoT is progressively becoming an important aspect of our lives that can be felt everywhere in around us.

Overall, IoT is an innovation that brings together a wide range of smart systems, frameworks and smart devices and sensors (Fiq. 1). Moreover, it utilizes and speeds of processing that were not previously understood [2]. Extensive research studies have been conducted and are available in terms of scholarly articles, newspaper reports both on the internet and in the form of printed materials to illustrate the potential effectiveness and application of IoT transformations. Maybe used in preparation before creating new innovative business plans while considering safety, security and operations.

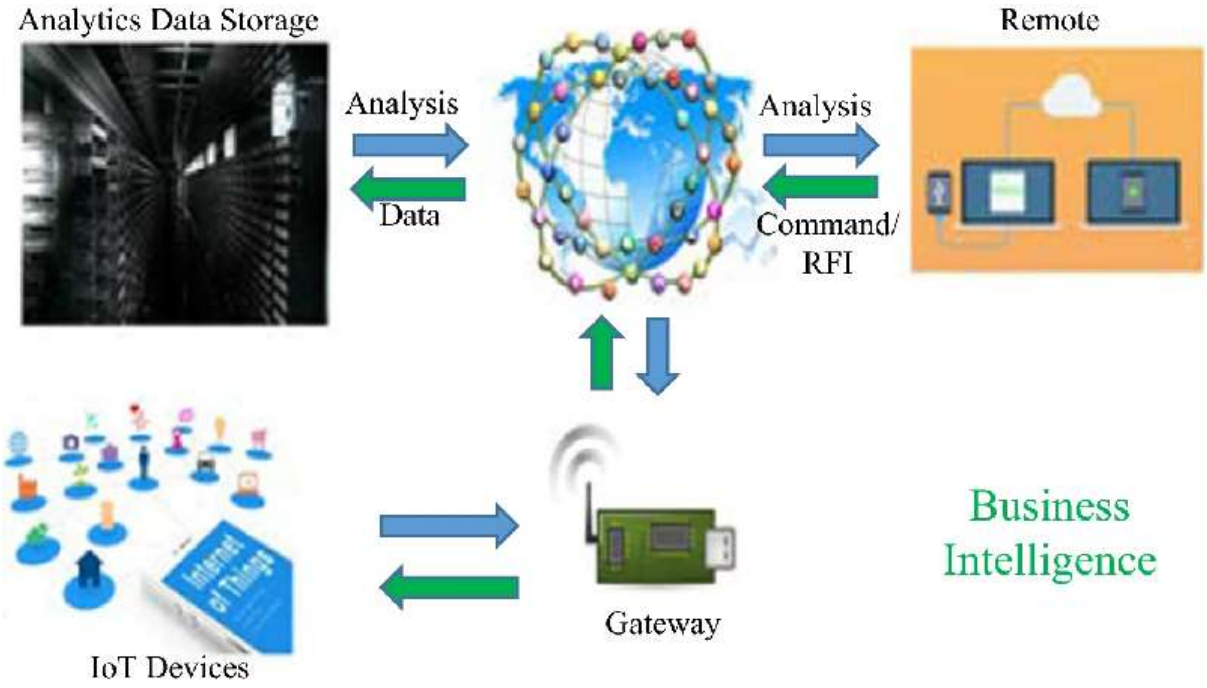


Figure 1: Analytics Data Storage

General architecture of IoT

A great transformation can be observed in our daily routine life along with the increasing involvement of IoT devices and technology. One such development of IoT is the concept of Smart Home Systems (SHS) and appliances that consist of internet based devices, automation system for homes and reliable energy management system [3]. Besides, another important achievement of IoT is Smart Health Sensing system (SHSS). SHSS incorporates small intelligent equipment and devices to support the health of the human being. These devices can be used both indoors and outdoors to check and monitor the different health issues and fitness level or the amount of calories burned in the fitness centre etc. Also, it is being used to monitor the critical health conditions in the hospitals and trauma centres as well. Hence, it has changed the entire scenario of the medical domain by facilitating it with high technology and smart devices [4, 5]. Moreover, IoT developers and researchers are actively involved to uplift the life style of the disabled and senior age group people. IoT has shown a drastic performance in this area and has provided a new direction for the normal life of such people. As these devices and equipment are very cost effective in terms of development cost and easily available within a normal price range, hence most of the people are availing them [6].

Thanks to IoT, as they can live a normal life. Another important aspect of our life is transportation. IoT has brought up some new advancements to make it more efficient, comfortable and reliable. Intelligent sensors, drone devices are now controlling the traffic at different signalized intersections across major cities. In addition, vehicles are being launched in markets with pre-installed sensing devices that are able to sense the upcoming heavy traffic congestions on the map and may suggest you another route with low traffic congestion [7]. Therefore IoT has a lot to serve in various aspects of life and technology. We may conclude that IoT has a lot of scope both in terms of technology enhancement and facilitate the humankind.

IoT has also shown its importance and potential in the economic and industrial growth of a developing region. Also, in trade and stock exchange market, it is being considered as a revolutionary step. However, security of data and information is an important concern and highly desirable, which is a major challenging issue to deal with [5]. Internet being a largest source of security threats and cyber-attacks has opened the various doors for hackers and thus made the data and information insecure.

However, IoT is committed to provide the best possible solutions to deal with security issues of data and information. Hence, the most important concern of IoT in trade and economy is security. Therefore, the development of a secure path for collaboration between social networks and privacy concerns is a hot topic in IoT and IoT developers are working hard for this. The remaining part of the article is organized as follows: "Literature survey" section will provide state of art on important studies that addressed various challenges and issues in IoT. "IoT architecture and technologies" section discussed the IoT functional blocks, architecture in detail. In "Major key issues and challenges of IoT" section, important key issues and challenges of IoT is discussed. "Major IoT applications" section provides emerging application domains of IoT. In "Importance of big data analytics in IoT" section, the role and importance of big data and its analysis is discussed. Finally, the article concluded in "Conclusions" section.

Literature survey

IoT has a multidisciplinary vision to provide its benefit to several domains such as environmental, industrial, public/private, medical, transportation etc. Different researchers have explained the IoT differently with respect to specific interests and aspects. The potential and power of IoT can be seen in several application domains. Figure 2 illustrates few of the application domains of IoTs potentials.

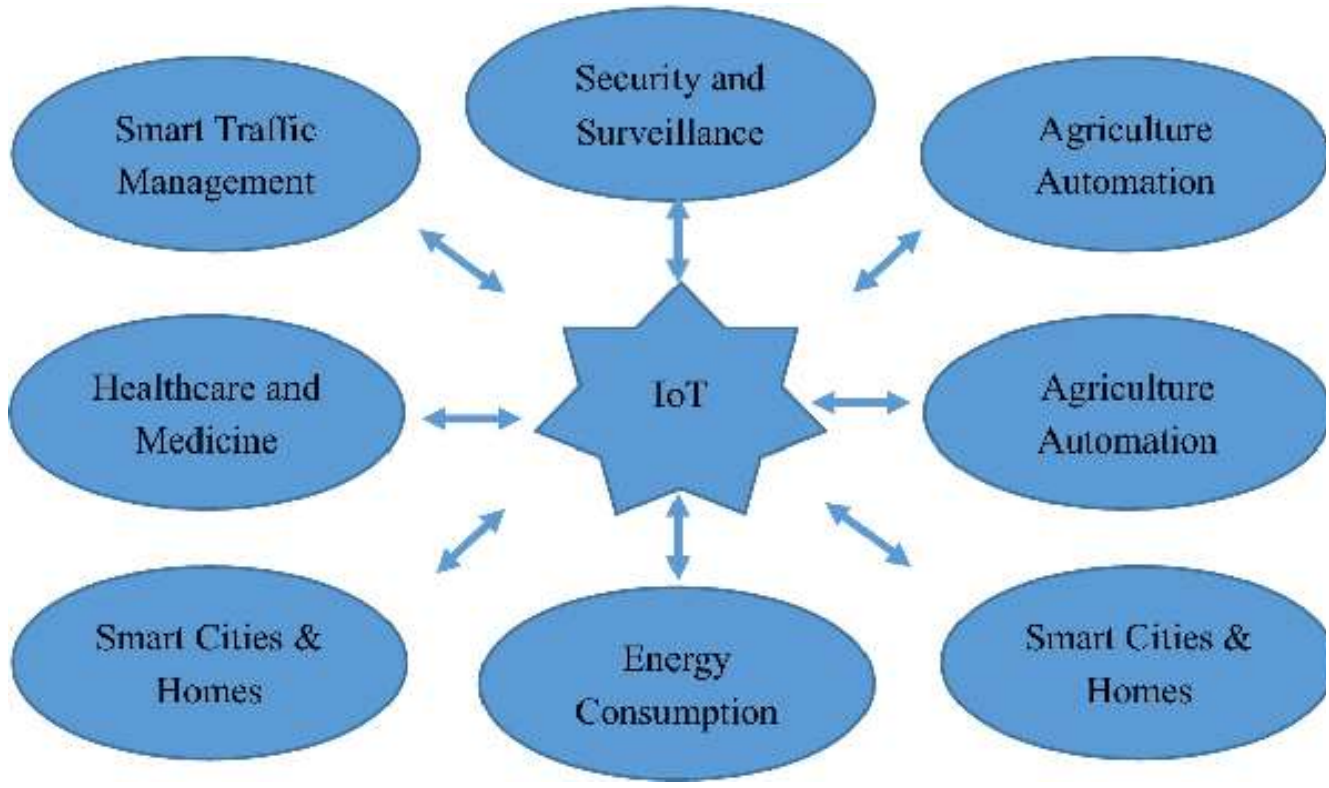


Figure 2: illustrates few of the application domains of IoTs potentials

Some of the potential application domains of IoT

Various important IoT projects have taken charge over the market in last few years. Some of the important IoT projects that have captured most of the market are shown in Fig. 3. In Fig. 3, a global distribution of these IoT projects is shown among American, European and Asia/Pacific region. It can

be seen that American continent are contributing more in the health care and smart supply chain projects whereas contribution of European continent is more in the smart city projects [8].

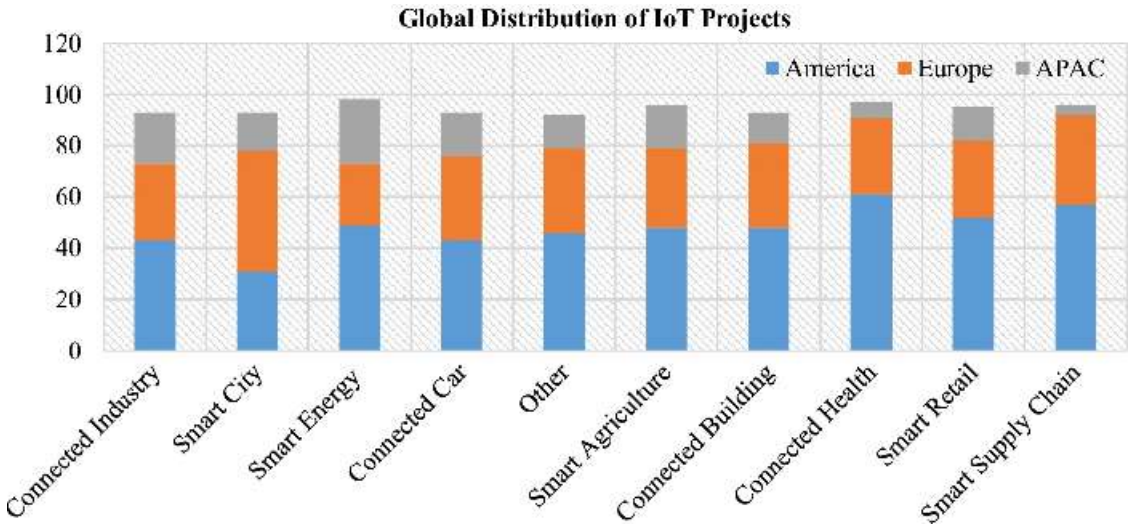


Figure 3: Global Distribution of IoT Project

Global distribution of IoT projects among America (USA, South America and Canada), Europe and APAC (Asia and Pacific region) [8]

Figure 4, illustrates the global market share of IoT projects worldwide [8]. It is evident that industry, smart city, smart energy and smart vehicle based IoT projects have a big market share in comparison to others.

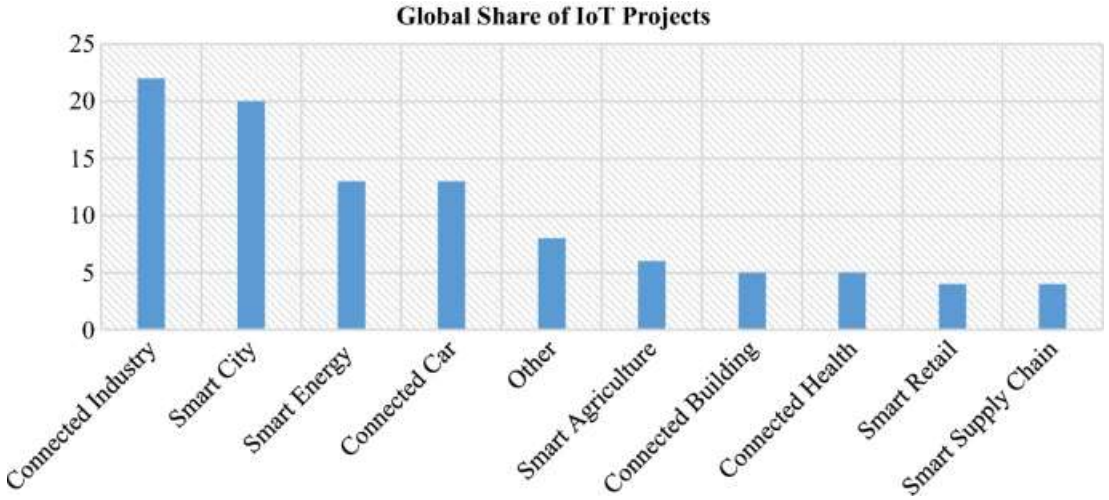


Figure 4: Global Share of IoT Projects

Global share of IoT projects across the world

Smart city is one of the trendy application areas of IoT that incorporates smart homes as well. Smart home consists of IoT enabled home appliances, air-conditioning/heating system [8], television, audio/video streaming devices, and security systems which are communicating with each other in order to provide best comfort, security and reduced energy consumption. All this communication takes place through IoT based central control unit using Internet. The concept of smart city gained popularity in the last decade and attracted a lot of research activities [9]. The smart home business economy is about to cross the 100 billion dollars by 2022 [10]. Smart home does not only provide the in-house comfort but also benefits the house owner in cost cutting in several aspects i.e. low energy consumption will results in comparatively lower electricity bill. Besides smart homes, another category that comes within smart city is smart vehicles. Modern cars are equipped with intelligent devices and sensors that control most of the components from the headlights of the car to the engine [11]. The IoT is committed towards developing a new smart car systems that incorporates wireless communication between car-to-car and car-to-driver to ensure predictive maintenance with comfortable and safe driving experience [12].

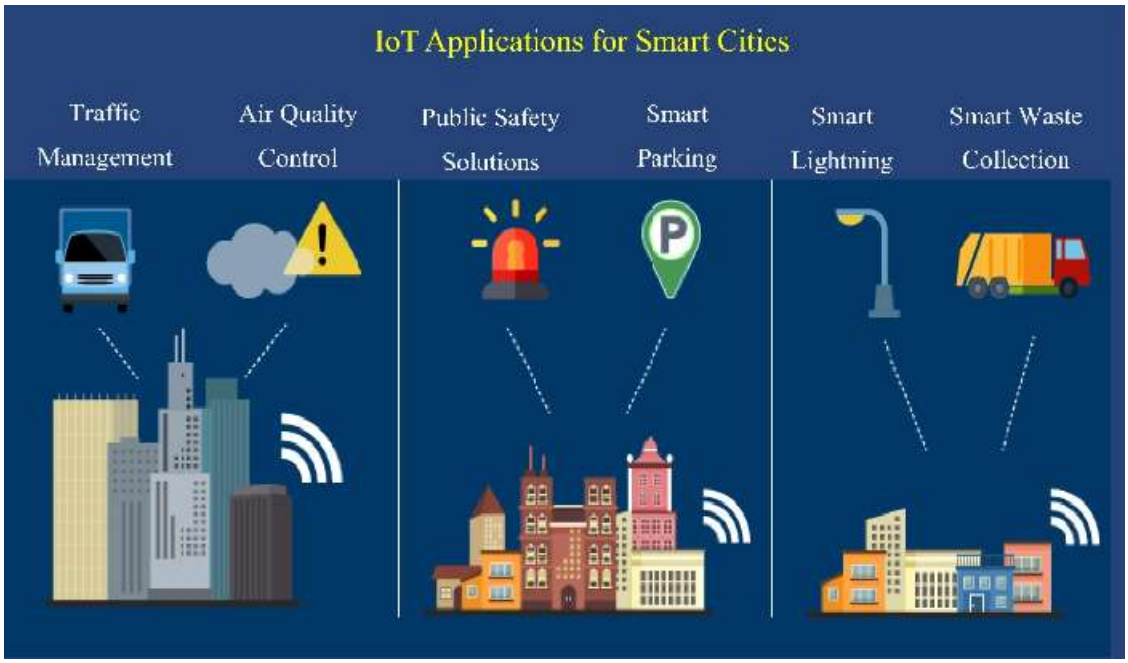


Figure 5: Applications for Smarts Cities

Potential IoT application areas for smart cities

Another important issue of IoT that requires attention and a lot of research is security and privacy. Weber [12] focused on these issues and suggested that a private organization availing IoT must incorporate data authentication, access control, resilience to attacks and client privacy into their business activities that would be an additional advantage. Weber suggested that in order to define global security and privacy issues, IoT developers must take into account the geographical limitations of the different countries. A generic framework needs to be designed to fit the global needs in terms of privacy and security. It is highly recommended to investigate and recognize the issues and challenges in privacy and security before developing the full fledge working IoT framework.

Table 1 Comparative illustration of specific research studies on evaluation factors

Search	Major directions of study	Comparison based on evaluation factors				
		RT	RL	AV	**CT**	**EC**
Zhou et al. [3]	Security and privacy	–	x	–	**–**	**x**

IoT architecture and technologies

The IoT architecture consists of five important layers that defines all the functionalities of IoT systems. These layers are perception layer, network layer, middleware layer, application layer, business layer. At the bottom of IoT architecture, perception layer exists that consists of physical devices i.e. sensors, RFID chips, barcodes etc. and other physical objects connected in IoT network. These devices collects information in order to deliver it to the network layer. Network layer works as a transmission medium to deliver the information from perception layer to the information processing system. This transmission of information may use any wired/wireless medium along with 3G/4G, Wi-Fi, Bluetooth etc. Next level layer is known as middleware layer. The main task of this layer is to process the information received from the network layer and make decisions based on the results achieved from ubiquitous computing. Next, this processed information is used by application layer for global device management. On the top of the architecture, there is a business layer which control the overall IoT system, its applications and services. The business layer visualizes the information and statistics received from the application layer and further used this knowledge to plan future targets and strategies. Furthermore, the IoT architectures can be modified according to the need and application domain [19, 20, 27]. Besides layered framework, IoT system consists of several functional blocks that supports various IoT activities such as sensing mechanism, authentication and identification, control and management [28]. Figure 6 illustrates such functional blocks of IoT architecture.

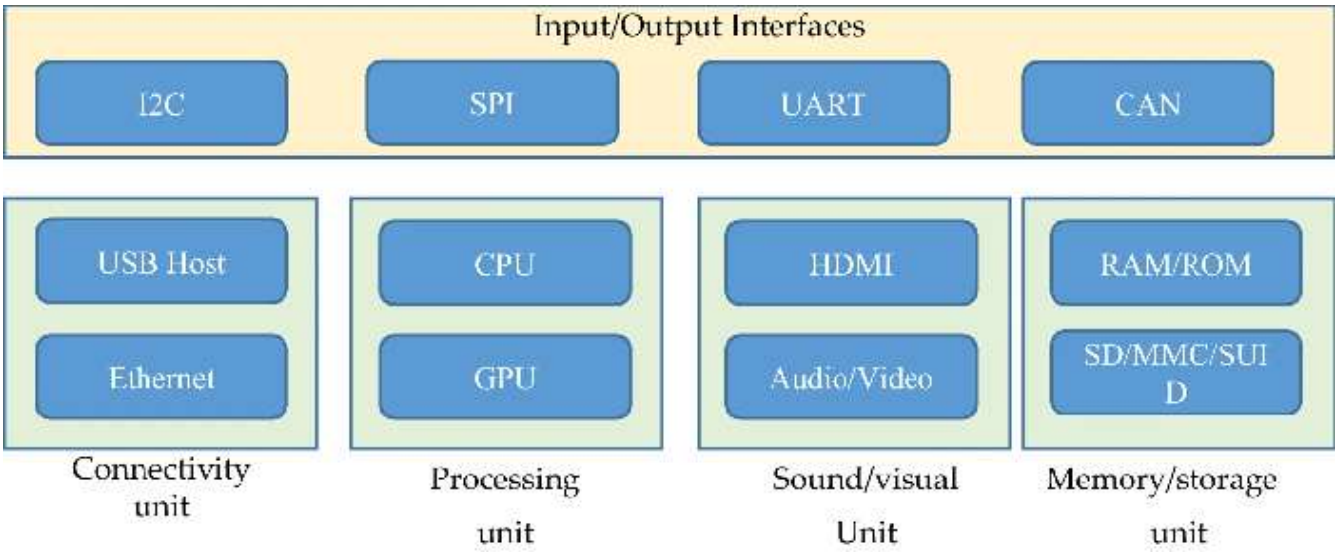


Figure 6: Input / Output Interfaces

A generic function module of IoT system

There are several important functional blocks responsible for I/O operations, connectivity issues, processing, audio/video monitoring and storage management. All these functional block together incorporates an efficient IoT system which are important for optimum performance. Although, there are several reference architectures proposed with the technical specifications, but these are still far from the standard architecture that is suitable for global IoT [29]. Therefore, a suitable architecture is still need to be designed that could satisfy the global IoT needs. The generic working structure of IoT system is shown in Figure 7 shows a dependency of IoT on particular application parameters. IoT gateways have an important role in IoT communication as it allows connectivity between IoT servers and IoT devices related to several applications [30]

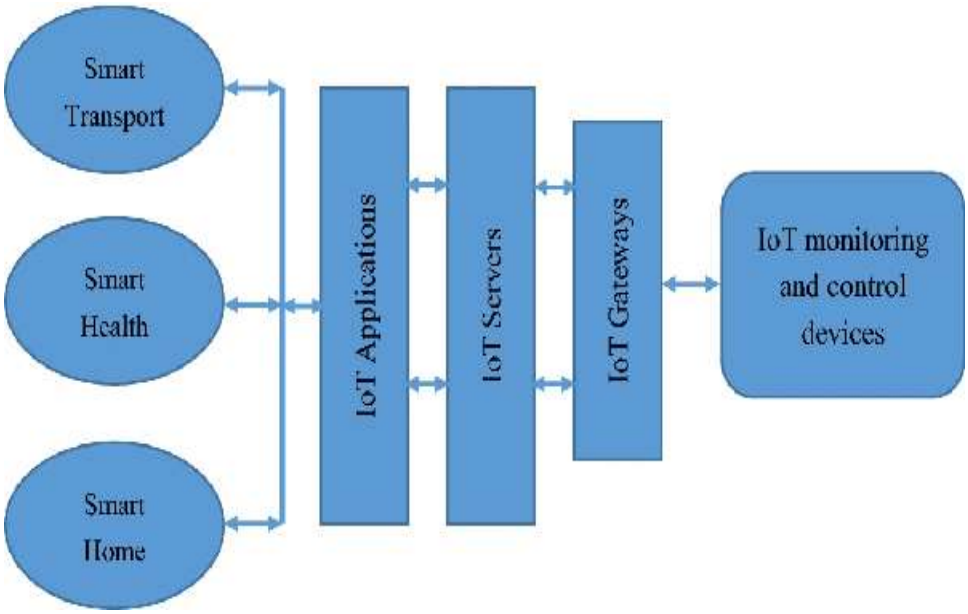


Figure 7: IoT Monitoring and Control Devices

Working structure of IoT

Scalability, modularity, interoperability and openness are the key design issues for an efficient IoT architecture in a heterogenous environment. The IoT architecture must be designed with an objective to fulfil the requirements of cross domain interactions, multi-system integration with the potential of simple and scalable management functionalities, big data analytics and storage, and user friendly applications. Also, the architecture should be able to scaleup the functionality and add some intelligence and automation among the IoT devices in the system.

Moreover, increasing amount of massive data being generated through the communication between IoT sensors and devices is a new challenge. Therefore, an efficient architecture is required to deal with massive amount of streaming data in IoT system. Two popular IoT system architectures are cloud and

fog/edge computing that supports with the handling, monitoring and analysis of huge amount of data in IoT systems. Therefore, a modern IoT architecture can be defined as a 4-stage architecture as shown in Fig. 8.

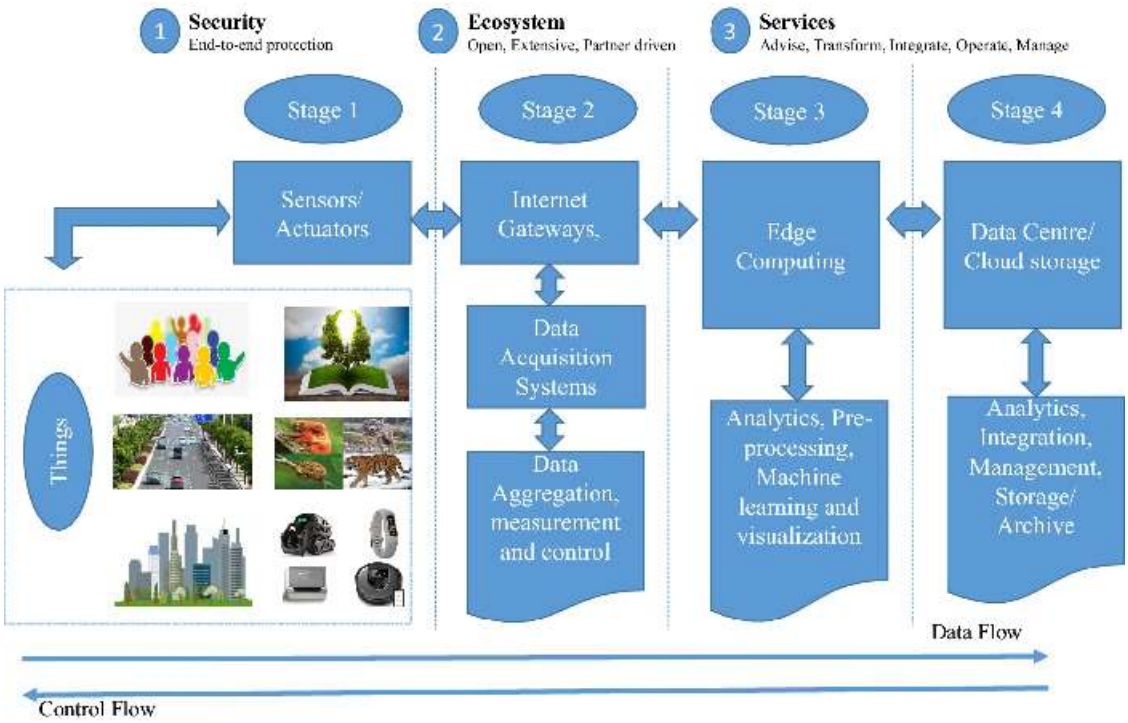


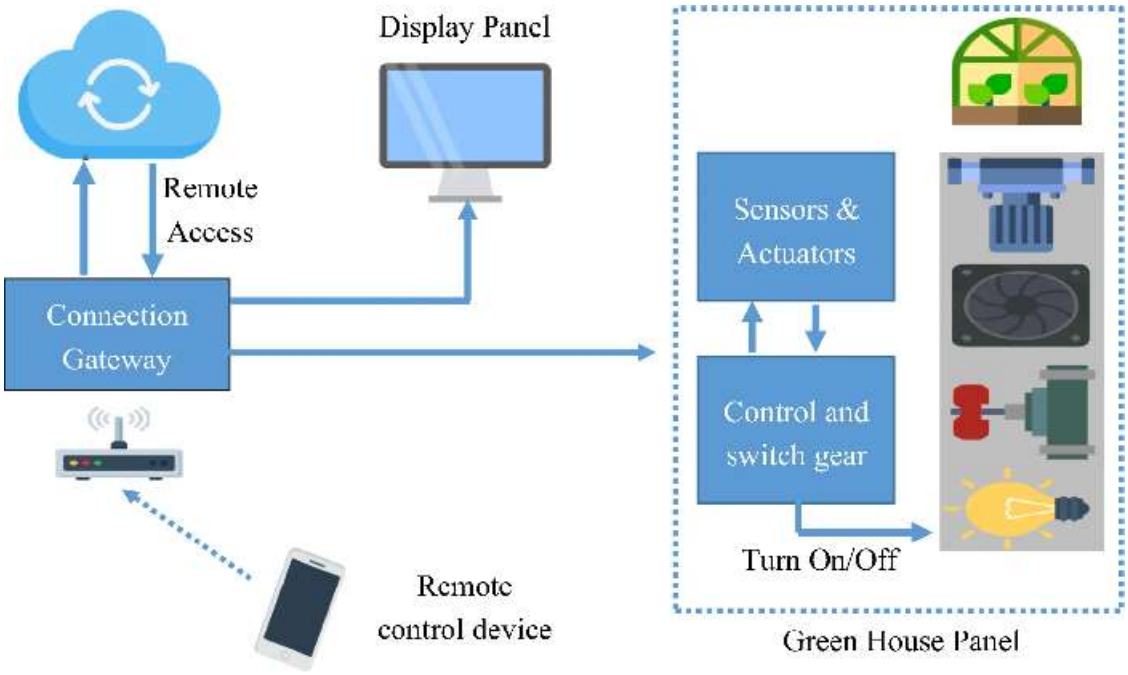
Figure 8: Stage Architecture

Four stage IoT architecture to deal with massive data

In stage 1 of the architecture, sensors and actuators plays an important role. Real world is comprised of environment, humans, animals, electronic gadgets, smart vehicles, and buildings etc. Sensors detect the signals and data flow from these real world entities and transforms into data which could further be used for analysis. Moreover, actuators is able to intervene the reality i.e. to control the temperature of the room, to slow down the vehicle speed, to turn off the music and light etc.

Agriculture and industry automation

The world's growing population is estimated to reach approximate 10 billion by 2050. Agriculture plays an important role in our lives. In order to feed such a massive population, we need to advance the current agriculture approaches. Therefore, there is a need to combine agriculture with technology so that the production can be improved in an efficient way. Greenhouse technology is one of the possible approaches in this direction. It provides a way to control the environmental parameters in order to improve the production. However, manual control of this technology is less effective, need manual efforts and cost, and results in energy loss and less production. With the advancement of IoT, smart devices and sensors makes it easier to control the climate inside the chamber and monitor the process which results in energy saving and improved production (Fig. 9). Automatization of industries is another advantage of IoT. IoT has been providing game changing solutions for factory digitalization, inventory management, quality control, logistics and supply chain optimization and management.



A working structure of IoT system in agriculture production

Figure 9: Automatization of industries is another advantage of IoT

Importance of big data analytics in IoT

An IoT system comprises of a huge number of devices and sensors that communicates with each other. With the extensive growth and expansion of IoT network, the number of these sensors and devices are increasing rapidly. These devices communicate with each other and transfer a massive amount of data over internet. This data is very huge and streaming every second and thus qualified to be called as big data. Continuous expansion of IoT based networks gives rise to complex issue such as management and collection of data, storage and processing and analytics. IoT big data framework for smart buildings is very useful to deal with several issues of smart buildings such as managing oxygen level, to measure the smoke/hazardous gases and luminosity [29]. Such framework is capable to collect the data from the sensors installed in the buildings and performs data analytics for decision making. Moreover, industrial production can be improved using an IoT based cyber physical system that is equipped with an information analysis and knowledge acquisition techniques [30]. Traffic congestion is an important issue with smart cities. The real time traffic information can be collected through IoT devices and sensors installed in traffic signals and this information can be analysed in an IoT based traffic management system [31]. In healthcare analysis, the IoT sensors used with patients generate a lot of information about the health condition of patients every second. This large amount of information needs to be integrated at one database and must be processed in real time to take quick decision with high accuracy and big data technology is the best solution for this job [32]. IoT along with big data analytics can also help to transform the traditional approaches used in manufacturing industries into the modern one [33]. The sensing devices generates information which can be analysed using big data approaches and may help in various decision-making tasks. Furthermore, use of cloud computing and analytics can benefit the energy development and conservation with reduced cost and customer satisfaction [34]. IoT devices generate a huge amount of streaming data which needs to be stored effectively and needs further analysis for decision making in real time. Deep learning is very effective to deal with such a large

information and can provide results with high accuracy [35]. Therefore, IoT, Big data analytics and Deep learning together is very important to develop a high tech society.

Conclusions

In the latest in IoT has attracted the attention of researchers and system developers around the world. IoT system developers and researchers work together to develop technology on a large scale and benefit the community to the highest good. However, improvements are only possible if we consider the various problems and shortcomings in the current technical approach. In this review article, we present some of the problems and challenges that IoT developers should consider in order to develop a better model. Also, important areas of IoT applications are also discussed where IoT developers and researchers are involved. As IoT not only provides good services but also generates large amounts of data. Therefore, the importance of big data analysis is also discussed which can provide accurate results that can be used to develop better IoT systems in the future

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