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IoT: Pillars and Technology

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Abstract

Objectives: This paper is to understand what Internet of Things (IoT) is? What are the technologies that enable it and how these technologies work? How IoT is different from internet. **Methods/Statistical Analysis:** It is a review paper. The literature has been studied comprehensively. Based upon the findings of different surveys by various organizations and work of various authors from various esteemed journals, the Technologies have been analyzed. **Findings:** IoT network need to be made highly secure and safe, to avoid eavesdropping, illegal access of data etc. Low power consuming compact size sensors are essential need for the IoT. All the sensors need to be placed at secure place. There is need to upgrade tools and processes which we are using to develop smart algorithms to gain useful information at real time. IoT is needed for vehicle to vehicle communication which will lead to driverless cars and safer ride. IoT is making life style smatter in every aspect like Smart cities, Smart vehicles, and smart agriculture. **Novelty /Improvement:** To make IoT safe and secure advanced Encryption and Decryption methods are required. Hybrid M2M communication is required to spread the network of IoT across the globe. Big Data is emerged as the upmost potentially troublesome technological revolution of this era IoT.

Keywords: Big Data, Cloud Computing, IoT, M2M, 5G

1. Introduction

IoT is an upcoming technological advancement which is creating a buzz around the world. IoT work as a network among the individual networks. IoT is used to make connect all the devices via internet for Machine To Machine communication (M2M) technology.

IoT work as a network among the individual networks. IoT is used to make connect all the devices via internet for M2M technology. Smart system with communication capabilities can be connected to each other as well as to the internet giving rise to a network of smart things called IoT.

Computer although a machine is expected to outrun human being in thinking in coming future. Automation and control of machines and devices from a remote location is a concept known since the early 1990's. But it has not come into being in vogue till now. This concept of IoT is to connect each and everything i.e. any device any gadget on the earth with each other with the help of Internet. It would reduce the human interference in managing functions as the interactions of computers with other machines would be on a very large scale for the exchange of information[1].

The IoT and internet are different from each other in the aspect of communication system. As the communication with the help of Internet contains only two dimensions that is it includes only Time and Place in other words it may be established at any time and at anyplace. On the other hand IoT contains third dimension Thing as well. So the whole purpose of IoT is to connect Any Thing on Any Place in this world at Any Time[2].

From these conceptual definitions, the IoT is such a network of the devices that is intelligent and enables these devices to communicate the data and information by connecting them with the help of Internet via information sensing devices. The sole purpose of this is to make the automation of various functions easier by improving

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the monitoring and management of these. It would be improved as IoT will help in intelligently identification and tracking of these devices and operations separately[2].

In this paper, we have discussed History of IoT in section II. In section III, we have discussed some important pillars of IoT. In section IV, how Internet of Vehicle (IoV) playing vital role. In section V, the technologies that enables IoT. In section VI, some of the key applications of IoT, in last section VII, we have given the conclusion.

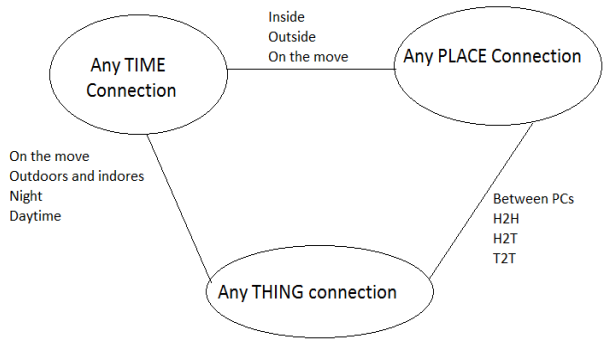

Figure 1. Dimensions of internet of things[1].

2. History of IoT

In 1999, Kevin Ashton a British visionary used the term/ documented IoT for the first time. He used the term to explain a system in which the Internet and the real world unite with the help of a ubiquitous network of data sensors. Of course, the use of this term has grown somewhat beyond the original intention, and today it means many things to many people. But to get back to the root of it all, we should also consider the Internet itself to understand the full context of the IoT[3]. In general, ATM's might be treated as the first IoT items which gone online as back as 1974.

The origins of the Internet go back to the Arpanet in the late 1960's. In 1974, Vint Cerf introduced TCP/IP, but it was a decade before it was broadly adopted across the network and the real growth could start. In 1984, approximately 1,000 active network nodes on the early Internet switched over to adopt TCP/ IP for their core data transmission and networking protocol, and, since then, the network has continued to grow unabated[3].

Internet is available since late 1960's, even the most electronics devices are there since early 2000's but IoT came into being later is due to following reasons:-

- The cloud has evolved a set of sophisticated infrastructures for storage, messaging, security, content, and connectivity.
- Mobile networks have driven ubiquitous connectivity.
- Smart phones provide the user interface (and a gateway for some devices) to access, manage, and control our things.
- The Internet means this new infrastructure is accessible everywhere—truly ubiquitous.

Network of IoT is changing life-style of present and upcoming generations, and is getting used in various important fields that are why is huge necessity to make IoT network highly secure and safe; otherwise hazardous output can be obtained. As shown in Figure 2. the Three plus two layer architecture of IoT, there is need to make each layer secure for the finest exploitation of the IoT.

In three layer architecture at lowest level, there is perception layer. This layer is also called physical layer because all the sensors are physically fitted at this level to sense or monitor the data. Through this layer all the data is gathered and feather processed. Network layer is responsible for the exchange of information among machines, which implements the key concept behind IoT i.e. M2M communication and due to this, it is very necessary and difficult at the same time to make it secure. There are chances of illegal access of data, eavesdropping, leakage of confidential info, manipulation of data to other attacks in this layer. So prevent all this problems to take place, we need to make communication highly secure and to stop unauthorized access. Data filtration is also important in order to stop unsafe data coming from physical layer. Data encryption can be also used to make this layer more safe and secure.

Security issues such as eavesdropping to illegal access to any data can happen, hacking of application layer can cause leak of personal data to all the confidential information and can lead to data tampering. To solve or minimize the chance of such issues we need to develop more secure protocols. Encryption and Decryption of data can also minimize such issues. And also make smart access management system to stop unauthorized user to access the data.

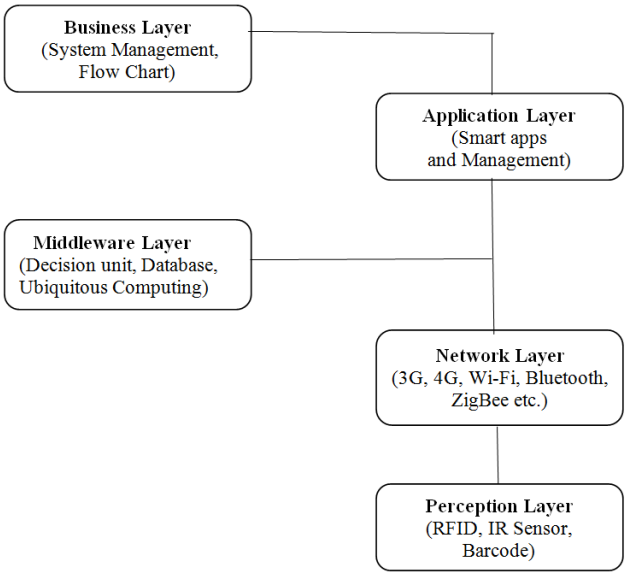

Figure 2. Architecture of IoT[4].

3. Pillars of IoT

IoTis a wide technology depends upon various factors and various networks, But IoT mainly depends upon four pillars:-

- Sensors
- Communication
- Computers
- Analysis

3.1 Sensors

Sensors are the eyes and ears of the IoT network. Sensors convert physical/non electrical signals into electrical signals. The working of IoT technology depends upon accurate measurement by sensors; inaccurate sensing can lead to negative result for a system. That is why, it is extremely important to choice sensor which is most ideal for a particular task.

3.2 Communication

M2M (M2M) is the key technology behind IoT. Values which are sensed by the sensors are needed to be sent for the computing. With the help of ubiquitous wireless communication, it is easy to establish communication among the various networks. The more the data travels, more are the chances of corruption of data. There is need to use standard protocols of communication, so even problems like data leak cannot happen.

3.3 Computers

Computers have been transformed into tiny chips. Single chip computers are called microcontrollers. Microcontroller unit working at the speed of Giga Hertz, which usually sucks a large amount of power. Computing part is responsible for the most of the power consumption. Power source or battery is the main issue here, because any sensor or microcontroller needs power to work. Choosing less power consuming and with high frequency microcontroller unit is necessary for IoT applications.

3.4 Analysis

Data sent by the sensors will create big data, due to usage of billions of sensors. Cloud computing is need to store the data, but the difficult part is to do analysis of big data and finding useful information, it's like finding needle in haystack. There is need to upgrade tools and processes which we are using and develop smart algorithms to gain useful information at real time[5].

4. IoV

At present, some of IoT technologies already exist, but there is tons of technology which are emerging every day. IoVs is one of top most emerging IoT technology today. Vehicles today consist of up to 30% electronics components and this number is keep on increasing with the emergence of the technologies.

IoV consist of communication among various aspects/networks of Vehicle like V2V (vehicle-to-vehicle), V2I (vehicle-to-internet), V2R (vehicle-to-road), V2S (vehicle-to-sensors), V2H (vehicle-to-human). Each aspect of IoV leads to vital information. V2V communication is one of most necessary in making and development of driverless vehicles. When one vehicle rides on a route, that route get updated in all the vehicles thought V2V communication. V2S communication through various intelligent sensors embedded in different part of vehicle inform vehicle about condition of the vehicle, then through V2H communication between human and vehicle that information is passed to its driver like warning of low fuel level to maintenance of the vehicle updates. With the encompass of V2R communication it updates driver of fuel stations nearby to the traffic condition. Finally one of the most important role is played by the V2I communication; in case of accident

to breakdown of the vehicle it automatically updates dealer/showroom of the vehicle to repair it, not just this, V2I also vital for other updates of the environment of the vehicle. With the implementations of IoV, transport system is renamed as Intelligent Transport System (ITS). ITS is required to avoid problems like heavy traffic jams, no space for parking which leads to wastage of time and resources and causes pollution. ITS collects data through the sensors and by M2M communication sends it over to Cloud/server[6].

A vehicle Global Identification (GID) system is the core of IoV. GID includes of all the smart embedded sensors which ultimately gives all the information, like location of vehicle, fuel level etc. GID also behaves as communication gateway among all the networks. GID has global positioning and global online identification functionality. GID behaves as a online number plate. GID includes of GPS & GPRS, which helps in tracking the position of vehicle to keep eye on falsely registered or smuggled vehicles. IoV development has direct relation with ITS, which includes information communication, energy conservation, environment protection and safety[7].

5. Technologies that Enable with IoT:

5.1 M2M Communications:

Recently a new communication paradigm has emerged which enables ubiquitous connectivity and autonomous communication capability without any human intervention, it is called M2M. Simply enough this M2M is the base for understanding of IoT. The IoT is imagined as "*a global network of connected devices having identities and virtual personalities operating in smart spaces and using intelligent interfaces to communicate within social, environmental, and user contexts*". According to the idea in near future IoT will be contained of billions of day to day objects (devices) and surrounding environments connected and managed via different communication networks and cloud-based servers[8]. A large number of technologies and different networks will act as enablers of M2M communication. M2M can be categorized in two wide ranges:

- Capillary M2M
- Cellular M2M

Capillary M2M networks, are mainly characterized by necessities of high energy efficiency as well as dependability, high packet loss ratio etc. and mostly unplanned deployment. It also utiliozes low power link layer technologies. In the Capillary M2M networks, short range communication technologies are used to connect M2M devices such as Zigbee, Wi-Fi, Bluetooth etc. To cover wide area one can utilize a gate way. This type of network is also known as the Low power and Lossy Network (LLNs)[8]. This kind of connections is expected to reach at 27 billion in 2024 from the recent 5 billion at the start of 2015, with China and US sharing a 21% and 20% respectively. On the other hand, Cellular M2M is characterized by the device having embedded SIM card which enables it to communicate and pass information over a cellular network. But in the coming future it is bound to move upon cognitive cellular communication which will help IoT era to communicate in a manner that will efficiently utilize the Spectrum by the use of Cognitive Radio. This technology apart from enhancing spectrum efficiency will also help in better interference management, Energy efficiency and machine heterogeneity. Hence Cognitive M2M will open latest window of applications to this field[8]. Back in 2008, number of people connected with internet was less than the number of objects connected to the Internet.

M2M technology is simply a machines with ability to communicate with other machine. M2M communication can take place in following ways, (i)Wired (ii)Wireless (iii)Hybrid. Wired M2M communication in machines take place with machines are connected through wires or cables, which makes it bit complex and somewhat expensive, especially in distant communication, but it has high reliability and high transfer speed, that is why it is most traditional way of M2M communication which is taking place since ever. Universal Synchronous/ Asynchronous Receiver/Transmitter (USART), Universal Asynchronous Receiver/Transmitter (UART), Inter-Integrated Circuit (I2C) is some of the protocols of serial communication with take place via Wired communication. Whereas, Wireless M2M communication reduces many problems that we face in wired communication, there is no wire so machines become mobile, no complexity of wires, but issues of low transfer speed, bad network coverage in some areas. In short range, devices like Near Field Communication (NFC), Bluetooth, Zegbee etc are used, but for long distance Wi-Max, 4G, Global System for Mobile communications/ Code Division Multiple Access (GSM/CDMA). Hybrid M2M communication is blend of the both Wired and Wireless communication,

which provides somewhat ideal like environment for IoT network.

5.2 IoT Vs Big Data

IoT terminology encapsulates uniquely identified objects as it is the interconnection of these objects via internet it will also include their virtual representations in it. Currently data of 2.5 quintillion bytes is created by the world every day. It is when approximately 5 billion devices are connected to internet if we consider the scenario of 2024 when 27 billion devices would be there and interconnected what will be the amount of data generated? Approximately 40 Zetta bytes is the amount of data that is expected to be generated[9]. Scientific society has hailed it as the upmost potentially troublesome technological revolution of this era after the Web and mobile accessibility. It becomes even stronger with smart apps like Smart cities, Smart roads, automated factories, smart buildings structures, smart houses, and smart vehicles. On the other hand, Big Data is a wide-ranging name for data packets so bulky and confusing that conventional data processing technologies are insufficient. It has recently been considered as a technology and become a very active research area primarily involving topics related to machine learning, database, and distributed computing. It has been claimed that "the success or failure of the IoT on Big Data". Based on many years of first-hand experience, this talk will provide an overview of IoT and Big Data, including state-of-the-art and future treads, with a aim on how IoT and Big Data are linked with and applied in various industrial domains and societies[10].

5.3 IoT Vs Cloud Computing

In an ideal sense Cloud offers unlimited storage capacity, computational and networking capabilities. This can help integrate various type of IoT devices. IoT systems will also get elastic runtime infrastructure to work. In the past growth and organization of wide range IoT systems has extensively exploited Cloud computing technologies. The pay-as-you-go manner for the resources in very small IoT resources provided by utility based Cloud computing model will do following things:

- It will reduce the upfront costs.
- It will help create cross-domain application opportunities.
- It will enable new business and usage models of the IoT cloud systems.

Contemporary approaches virtualize physical sensors and actuators that are used for the IoT. The convergence of IoT with cloud computing is at quite nascent stage and it has to go miles. There are numerous challenges that come while designing these large IoT systems. As most of the time these IoT network rely heavily on clouds and virtualized IoT resources. Challenges of reactive resource, custom provisioning of IoT etc. do come up on regular basis., So it becomes mandatory if a Central Management System(CMS) is configured which will take care of all these issues along with the decision on communication protocols as well. By doing virtualization of all the resources and creating a CMS one can pave the way for Dynamic management of resources. It will help in better management of resources as after the peak time that is in low demand scenario CMS scale down the IoT systems which are otherwise created to run continuously. Although theoretically a cloud have unlimited capacity of storage but in practical scenario where the IoT will generate huge amount of information, e.g. in Smart Cities, which need to be stored and processed Cloud of Things(CoT) becomes an important facility which is the pool of interconnected resources via internet[11]. This must have Virtualized IoT capabilities and must also enable: 1) encapsulating them in a well-defined API, at different levels of abstraction, 2) centrally managing configuration models and automatically propagating them to the edge of infrastructure, 3) automated provisioning of IoT resources and IoT capabilities[12].

Putting it altogether, any modern Information and Communication Technology (ICT) related infrastructure must include technologies like 5G to offer connectivity, IoT to create network, CoT and scattered Artificial Intelligence (AI). Specially, the AI branch is difficult 'cause it is fixed into the IoT environment, which gives inadequate assets. Thus, an Advanced Artificial Intelligence (AAI) system is desired for dealing with multipart IoT models. This AAI system can be applied as a scattered classification which interfaces with the AI models fixed in: Internet of Things, smart cities and CoT jobs[11].

5.4 5G in IoT

The time frame of the launch of 5G has been set at 2020. With the coming of 5G the world will be looking at a completely new era. An era where everything would be connected, every day to day device would have the communication capabilities and it could be connected

anywhere anytime. In this way this era of technology would be dominated by M2M. Computing will become pervasive and the point of view towards Internet services would be changed altogether.

The advent of Long-Term Evolution (LTE) standards provided the mobile network a whole new look. Now the connecting technology is no more circuit switched, it is replaced by all-IP mobile network. But the increasing number of users and the need of new User cases like Social aid or Disaster management services etc. paved the way for 5G. The increasing traffic need to be accommodated make some things mandatory. It has been accepted by two basics principles will serve as the base for 5G. First new band of frequencies must be used for physical layer which can be seen as the use of mm Wave technology for the same. Second the traffic load will be increased by the exponentially increasing user data (increasing users and there demand for broadband services) this makes it necessary to reduce signaling load minimum. As in most of the case the Internet services are session –based with high reliability the signalization reduction has been applied in some cases only. Although the utilization of higher frequency bands has been done for the services many times earlier. It is also a general belief that signaling as a part of the total bandwidth consumes quite small part of the resources in network[13].

Considering the case of IoT services where each and every device would be connected on the earth, this makes the number of devices need to be connected "very large". To communicate between such a large numbers of nodes may imply a high portion of the resources are used in transporting signalization. Handover is the most important process in wireless networks. Signalization plays an important role in case of reliable handover. In case of IoT, a reliable handover will require enormous amount of signaling which will increase the burden on the network. In 4G technology, handover is carried out with the help of User equipment as well as the network equipment. It increases the demand for resources as compared to previous generations or technologies. It makes it imperative to that handovers optimization or redesign will be basic in case of 5G. Good news is that addresses required to connect such a large number of devices is not a problem. 340 undecillion Internet Protocol (IP) addresses are available in IPv6 which were only 4.3 billion in case of IPv4[14].

6. Applications

Some applications of IoT are given following:

6.1 Smart Cities

The IoT occupy an important job in betterment of the smartness involve numerous functions to look for parking places accessibility, keeping eye on environment, health of building structures, noise observation in susceptible parts, observation of vehicles and walkers path, intelligent climate responsive lamps, checking the level of garbage in dustbins and garbage collection, intelligent roads, smart highways with warning boards and deviation regards to weather circumstances as well as unpredicted actions like traffic jams, accidents. Several IoT smart cities consist of smart infrastructure of buildings, planed roads to curb traffic, control on noise pollution, smart waste management system etc. The spectrum of this apps varies from small to large. By now evolved IoT apps are Aware home, Smart Santander and sense city[15]. "The IoT will be connected to most of the gadgets in houses, from smart door-locks to smart lightings. Big companies like Google and Samsung are aware of this situation. Google bought smart thermostat maker, Nest Labs, for $3.2 billion, and Samsung purchased connected home company Smart Things for $200 million".

6.2 Smart Agriculture

The IoT can assist in betterment and strengthen the cultivation field by looking for soil quality as well as stem width of crops to manage along with sustain quantity of vitamins and minerals in agricultural foodstuffs, manage environment to capitalize on the growth of crops and food items and its class, monitoring climate circumstances in area to predict temperature variations, weather, chances of rain or drought, direction and speed of wind, humidity and other information to avert contaminants and make better decision for sustainable crops. The work of IoT in the water management and control involves reading of appropriateness of water in the weal, ponds, river and sea in all nearby region for cultivation purpose along with drinking purpose. The latest cattle sheds are made based on the IoT to keep track of animals and keep monitoring over their activities.

6.3 Health Care

Several advantages handed over by the IoT technologies to the health care discipline are categorized into automatic data collection and sensing, identification and authentication of people, keeping eyes on objects, work of staff along with health of patients. In the Hospitals, Sensor machines begins work aimed on patients and specifically on recognizing patient health, giving real-time health status of patients. The automatic data gathering and relocating is designed to reduce data exchanging time, procedure computerization, automatic health care and process assessment along with the medical record list management. The recognition and verification involves people identification to diminish the events unsafe to patients, complete history and in progress medical inventory continuation in addition to newborn child detection to avoid confusion. Tracking is the done to recognize a people or a things in motion. This involves the monitoring the patients to refine the work system in hospitals. Application range involves various medical solutions, keep an eye on patient obedience with medication contingent prescriptions and watchful for patient health. The fundamentals of IoT in HealthCare are RFID, NFC, ZigBee, Wi-Fi etc. Considerably betterment of the dimensions and monitoring methodology of crucial acts such as temperature record, BP, heart beat rate, body weight, etc of the patients[15].

6.4 Smart Vehicles

IoT is now the state of art technology used for many multimedia applications, smart transport systems and smart city design and deployment issues. The smart transport system can be a part of the smart city projection for days to come. This may be because of the nature of the contents involved in applying and developing IoT applications [15]. "By 2020, a quarter of a billion vehicles will be connected to the Internet, giving us completely new possibilities for in-vehicle services and automated driving".

Just 10 percent of cars were connected to the Internet in 2012. By 2020, it's estimated that 90 percent of the cars will be connected to the internet. The popularity of IoT application in the 21st century is due to the dominance of internet users, development of smart phone technology and mobile communication standards. Clearly the internet users across the world has become a design factor decision to apply IoT in e-Governance, e-Billing for domestic applications like water and electricity facilities, e-reservation systems for bus, trains and flights. However a survey can also be done on infrastructure for IoT, Cloud computing and the services offered[16]." In fact, we already have cars that can drive on their own – Google's self-driving cars currently average about 10,000 autonomous miles per week".

7. Conclusion

The IoT technology is changing the world and making it smarter each and every day, we can see new gadgets and applications are being developed. Intelligent algorithms are under development. IoT will not just help in automation and bring ease in our life but also help in reduction of harmful gases and will be energy efficient which makes it eco-friendly. Various sub-parts of IoT like IoV are also playing crucial role in development of IoT. Technologies come and go, but IoT is here to stay.

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