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A Revolutionary Impact of Internet of Things for Better Connectivity among Real World Objects

Jayashree Agarkhed*, Patil Yogita Dattatraya and Siddarama Patil*****

ABSTRACT

With development of Internet technology and communications technology, our lives are progressively led into virtual world. Internet facilitates people to chat, shop and work in the virtual world. This virtual world can be integrated with real world by Internet of Things (IoT) with its potential to identify and connect all physical objects worldwide into a unified system using sensors/actuators and wireless communication. This paper presents need to understand characteristics, features and architecture of IoT to gain future direction for better implementation of IoT applications.

Keywords: WSN, Cloud Computing, Internet of Things, RFID, Near Field Communication

1. INTRODUCTION

Wireless The IoT constructs the way between physical world and cyber. It acts as intelligent connectivity among every object like hand held phones, televisions and various types of sensors in real physical world. It provides communication among wired and wireless devices [1]. It facilitates interconnection of objects and people worldwide with ease of accessing anything, by anyone and at anyplace as in fig. 1, where objects can be identified uniquely using standard communication protocol [2].

IoT has got worldwide attention by its simple architecture and its relationship with wireless sensor network (WSN) providing variety of applications like smart homes and cities, environment monitoring, health monitoring, energy conservation systems, smart business systems, smart plant, transportation and logistics domain applications [3]-[5]. In [6] author specified current IoT tools for users, its advantage, disadvantage and challenges. In [7] author presents various approaches related to context-aware systems and self-learning techniques in IoT and need of different self-learning techniques. In [8] author has presented cloud centric vision for implementation of IoT worldwide and technology support for IoT implementation. The application domain specified motivates researchers for cloud based implementation of IoT using Aneka. Ease of implementation of IoT with advanced technology, demands better understanding of characteristics, features and architecture of IoT as discussed in next sections.

This paper is further structured to highlight importance of IoT in section 2, its different implementation ways has been discussed in section 3, applications in section 4, scope and limitations in section 5 and finally conclusion highlighted in section 6.

2. IMPORTANCE OF IOT

IoT has gained worldwide attention with its unique characteristics and features as discussed next.

* Professor, Department of CSE P.D.A College of Engineering, Kalaburagi, India, *Email: jayashreeptl@yahoo.com*

** Ph.D. Scholar, Department of CSE, *P.D.A College of Engineering, Kalaburagi, India, Email: agyogita@gmail.com*

*** Professor and H.O.D., Department of ECE, P.D.A College of Engineering, Kalaburagi, India, *Email: pdapatil@gmail.com*

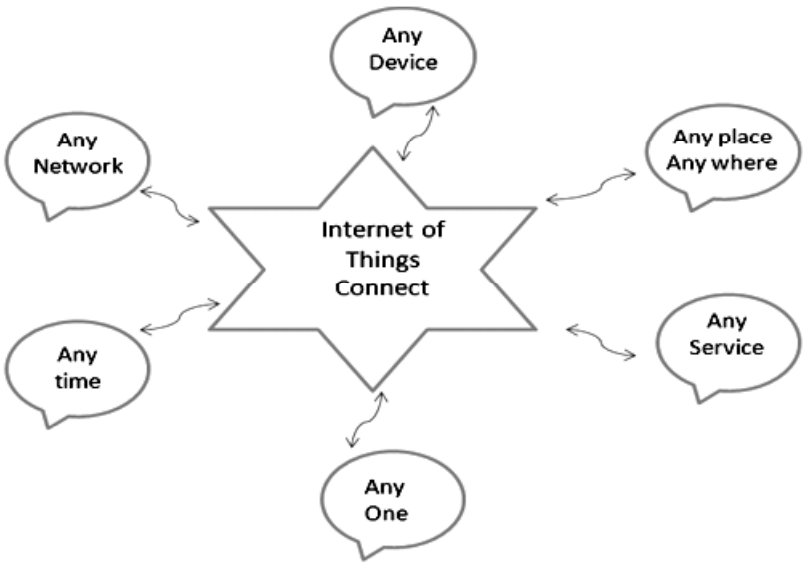

Figure 1: Abstract view of Internet of Things

2.1. Characteristics of IoT

Characteristics of IoT are classified into the following major categories [9].

- *Complex system*: IoT systems are complex system as they embrace huge number of different links and interactions between autonomous devices, with capability to integrate new devices.
- *Size consideration*: Size is an important consideration as many manufacturers start testing IoT by modifying their existing products and designs to add networking technologies. There should be compact modules available for networking technologies that will fit in existing products.
- *Time consideration*: Since IoT made up of billions things that recognizes parallel and simultaneous events, time consideration depends on each entity.
- *Space consideration*: In an IoT, the precise geographic location and dimensions of a thing will be critical information. Therefore, facts about a thing, such as its location in time and space, will be less critical to track because the person processing the information can decide whether or not that information is important to the action being taken, and if so, add the missing information.

2.2. Features of IoT

The various features of IoT as listed next have improved the use of IoT in today's world [10].

- *Connection of Things to the Internet*: From the name IoT we can also learn that the "Things" are connected by means of Internet.
- *Uniquely Identifiable Things*: An IoT system is composed of things that are uniquely identifiable.
- *Ubiquity*: Ubiquity is a major feature of an IoT system, indicating a network which is available anywhere and anytime. The "anywhere" mainly refers to the concept where it is needed and the "anytime" refers to when it is needed.
- *Uniquely Identifiable Things*: An IoT system is composed of things that are uniquely identifiable.
- *Ubiquity*: Ubiquity is a major feature of an IoT system, indicating a network which is available anywhere and anytime. The "anywhere" mainly refers to the concept of where it is needed and the "anytime" similarly refers to when it is needed.

- *Sensing/Actuation capability*: There is the involvement of sensors/actuators in the IoT System. The sensors/actuators are connected to the "Things" and perform the sensing/actuation to get a hold of the smartness of the "Things."
- *Embedded intelligence*: Smart and dynamic objects, with emergent behavior, embed Intelligence and knowledge, functions as tools and act as an extension to the human body and mind.
- *Interoperable Communication Capability*: The IoT system has a good communication capability that depends on standard and interoperable communication protocol used.
- *Self Configurability*: The one best feature of IoT system is self configurability. Due to the heterogeneity of devices like sensors, actuators, storage devices, monitoring devices, mobile, computers and network elements that are being connected to the Internet, demand manageability of IoT devices, both in terms of their software/hardware configuration and their resource utilization. Self configuration primarily consists of the actions of neighbor and service discovery, network organization and resource provisioning.
- *Programmability*: The "Things" of an IoT system support a programmability feature and opt variety of behaviors at a user's Command without need of physical changes.

These features of IoT have enthralled the interest of researchers for creation of world of smart objects.

3. IMPLEMENTATION OF IOT

Architecture in fig. 2 and protocol stack in fig. 3 assist ease of implementation of IoT with numerous technologies.

3.1. Architecture of IoT

IoT can be divided into three important layers like Perception, Network and Application layer. As shown in Fig. 2 perception layer called as recognition layer is responsible for gathering information from physical environment like brightness, temperature, humidity etc and identifies the physical world objects in terms of their state, energy level and identity. Network layer is the middle one called as WSN which is accountable for the initial processing of data, broadcasting of data and assortment of data by using appropriate routing protocols [11, 12]. The topmost application layer offers all these services for all industries. Among these layers, the middle one network layer takes care of providing global services in the IoT's [13].

There are three ways to integrate sensors with IoT. It can be achieved by Front-end solution, Gateway solution or TCP/IP solution. In Front end solution the WSN is independent of the internet and freely

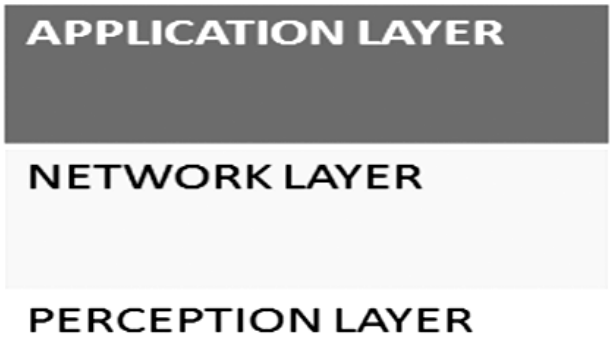

Figure 2: Architecture of Internet of Things

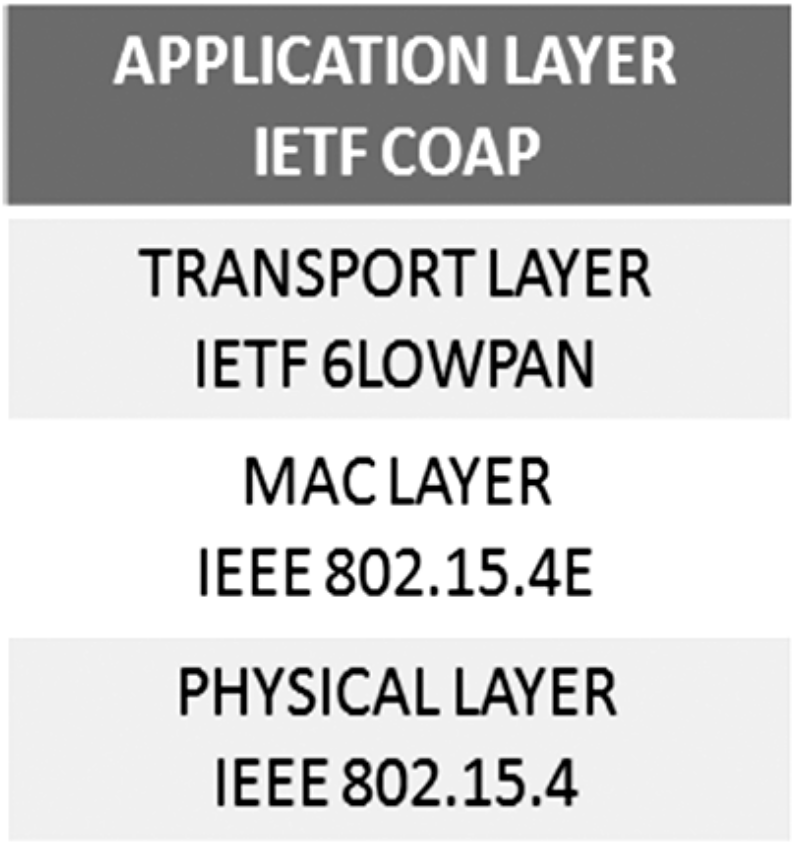

Figure 3: IOT Protocol Stack

implements its own set of protocols. Interactions among the sensor nodes and the internet host are managed by base station. The base station stores all the data coming from the nodes and sends across to the centralized device. In Gateway solution the base station performs translation of the lower layer protocols and the routing information. Front-end solution and the Gateway solution do not find as much benefits in emergency scenarios and disaster recovery. In TCP/IP solution the sensor nodes are embedded with the TCP/IP stack, acting as internet elements themselves. The WSNs can connect directly to the web, paving way to total integration with the IoT [1].

3.2. Protocol stack

The protocol stack as shown in Fig. 3 referred from [13], specifies various protocol standard used in each layer and the description of each is discussed as next.

- *Physical Layer*: The IEEE 802.15.4 2006 standard is used and it mull over energy efficiency. This layer allows ultra low rate transmission over very narrow frequency and thus enhances range for transmission.
- *MAC Layer*: IEEE 802.15.4E standard is used as suitable standard for IOT protocol stack. It is the reliable and low power MAC protocol.
- *Network Layer*: The IETF 6LOWPAN is used for connecting low power radio to the internet and to achieve universal connectivity.
- *Transport and Application Layer*: The introduction of IETF Constrained Application Protocol (COAP) in both the layer is to ensure that applications themselves do not need to be re-engineered to run over low-power embedded networks.

3.3. IoT Technology

There are several technologies that can be used to implement the concept of Internet of Things as [14].

3.3.1. Radio frequency identification (RFID)

RFID system consists of one or more readers and several RFID tags. Tags have a specific address and objects are applied WITH these tags. A tag uses radio-frequency electromagnetic fields to transfer data from an object. When RFID reader comes in the proximity of the object, it reads electronically stored information available with tag.

The RFID tags are available in three configurations

- Passive Reader Active Tag (PRAT): In this the reader is passive and receives the signal from the battery operated active tags. The transmission range of the RFID tag and the reader is from 1-2000 feet based on the architecture.
- Active Reader Passive Tag (ARPT): It is most commonly used tag. It does not have power supplies, so it harvests the energy required for data transmission from the query signal sent by the RFID reader.
- Active Reader Active Tag (ARAT): In this both the reader and the tags are active, but tags are awoken only by the reader.

An Electronic Product Code (EPC) is stored in a tag. EPC's are coded on RFID tags because of which objects can be tracked and identified uniquely. The RFID tags are used in many applications like Monitoring the life cycle of a product, inventory management in the warehouse, tracking of animals and goods, airport baggage mobile payment, etc. [3]

3.3.2. Radio frequency identification (RFID)Near field communication (NFC)

NFC is a radio communication between NFC enabled mobile devices. NFC operates within the unlicensed Radio Frequency band of 13.56 MHz with the operating range of NFC device is 20 cm [15].

The operating range is directly depended on the size of the antenna. NFC is a short range, low power wireless link evolved from RFID that can transfer small amounts of data between two devices. Unlike Bluetooth, no paring is required before the actual transfer of data. NFC enabled communication between the smart objects is safe as this cannot be done from a remote location, so one with NFC enabled device should be present there for the application. The NFC technologies significantly contribute to the future development of IoT. It provides the necessary tool for wireless connection to any smart objects.

3.3.3. Machine-to-Machine communication (M-to-M)

M-to-M communication means communications between computers, embedded processors, smart sensors, actuators and mobile devices [16]. The use of M2M communication is increasing in the scenario at a fast pace. M-to-M is a five-part structure and defined as follows:

- *M-to-M Device*: Is a device with capability to respond quickly to request for data contained with it.
- *M-to-M Area Network (Device Domain)*: Connect several M-to-M Devices among themselves and M-to-M Gateways.
- *M-to-M Gateway*: Use M-to-M capabilities to ensure M-to-M devices inter-working and interconnection to the communication network.
- *M-to-M Communication Networks (Network Domain)*: Provide communications between the M-to-M Gateway(s) and M-to-M application.

- *M-to-M Applications*: Data goes through various application services and is used by the specific business-processing engines. M-to-M has several applications in various fields like healthcare, smart robots, cyber transportation systems (CTS), manufacturing systems, smart home technologies.

3.3.4. Vehicle-to-vehicle (V2V) communication

In this, vehicles act as a node in a network and communicate with each other with the use of sensors connected to it. V2V network infrastructure is complicated due to frequent change in the topology by vehicles movement. Applications of vehicular networks can be divided into four broad categories, namely safety and collision avoidance, traffic infrastructure management, vehicle telemetric, and entertainment services and Internet connectivity Vehicles communicate with each other within a 1000 m of range. Two types of communication are possible; first one is vehicle-to-vehicle and the other one is the vehicle with the road-side infrastructure. Vehicular communication system is developed as a part of Intelligent Transport System [14, 17].

4. APPLICATIONS OF IOT

IoT plays a vital role in abundant of applications. In the future, there will be numerous applications using IoT. As the world is growing with a technological revolution, more objects will use the technology of RFID, NFC, M-to-M communication and V2V communication for automation as shown in Fig. 4 [18].

4.1. Transportation and logistics application

The various applications in this domain are as follows

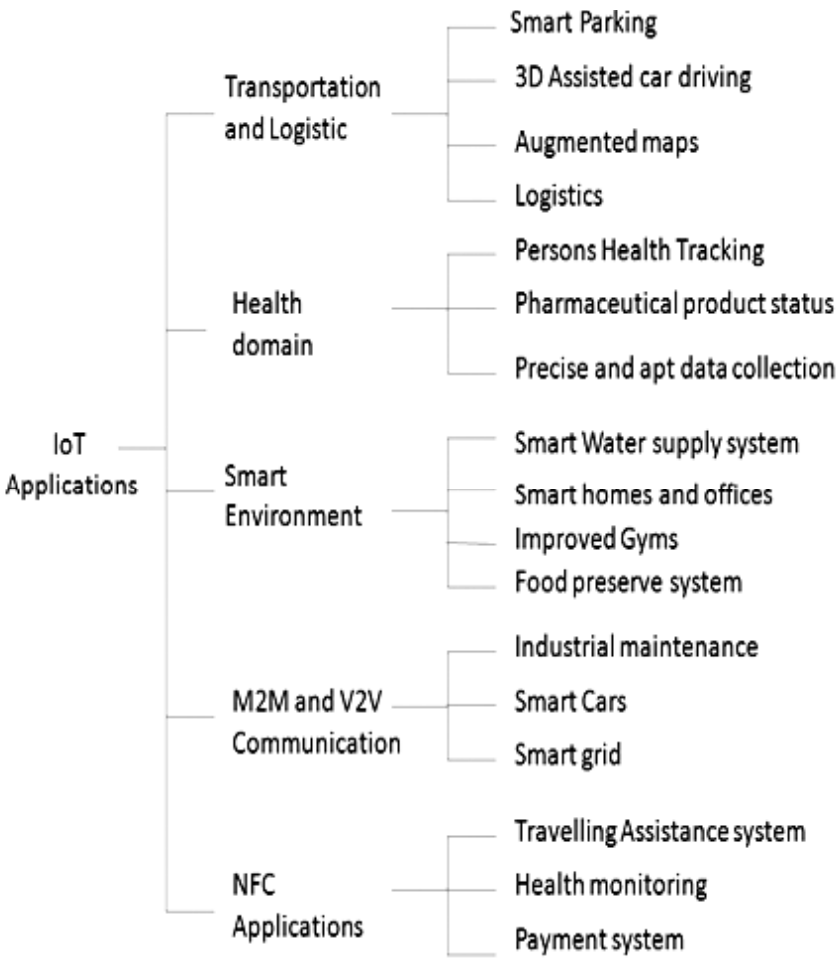

Figure 4: Applications of IOT

- *Smart parking*: The new Smart Parking sensor are buried in parking spaces to detect the arrival and departure of vehicles. The Smart parking provides easy parking management and helps motorists to save their time and fuel in finding free parking space.
- *3D Assisted car driving*: Vehicles like cars, buses and trains along with the roads and rail are equipped with sensors to assist driver for better navigation and safety.
- *Augmented maps*: Augmented maps with tags assist NFC-equipped devices to browse the information about the places and quickly get connected to the web services providing instant information about restaurants, hotels, monuments, theater.
- *Logistics*: RFID and NFC both can be used to monitoring almost every link of supply chain, ranging from commodity details, purchasing of raw materials, storage, production, transportation, and sale of product.

4.2. Healthcare application

The various applications in this domain are as follows

- *Persons Health tracking*: With the use of sensors and the latest technology one can track the person's body temperature, blood pressure and heart beat rate etc. In emergency cases, the individual and their personal doctor will be notified with all the data collected by the sensors.
- *Pharmaceutical products status monitoring*: We can also track the expiry of drugs with the use of sensors, thus preventing the transferring of expired drugs to the patient.
- *Precise and apt data collection*: Processing time can be reduced by automatic data collection and transfer of that data to the doctor will help in reducing he processing time, reducing the data collection errors, automated care and routine auditing.

4.3. Smart environments application

The various applications in this domain are as follows

- *Smart water supply*: Wireless Sensor Networks provide the technology for cities to monitor their water piping systems more accurately and helps to discover water loss rate. Cities that are addressing water leakage problem with sensor technology are resulting in high savings..
- *Smart homes and offices*: Various electronic devices like microwave ovens, air conditioners, heaters, refrigerators, fan and lights using actuators and sensors to be installed in these devices provide more comfort in life with power saving.
- *Improved gyms*: The gymnasium experience can be enhanced by involving new technologies like a separate exercise profile which can be installed on machines and each person can be identified from his given identification id.
- *Food preserve system*: With the use of appropriate sensors, we can prevent the food from climatic damages by monitoring humidity, temperature, light and heat etc. Sensors can measure these variations precisely and notify the concerned person.

4.4. M-to-M and V2V communication application

The various applications in this domain are as follows

- *Industrial maintenance*: The sensor fitted into the machinery, monitors the temperature and vibration in Industrial motors and also warns when irregular operation is detected. Companies waste billions due to inefficient maintenance management. This will help companies to save money and time.

- *Smart cars*: M-to-M communications and especially Smart Cars, help to prevent car accidents.
- *Smart grid*: Smart Grid is an electrical grid, designed to improve the efficiency of transmission power, and quality of service to the end user. In Smart Grid, all the devices in the network are connected with the sensors which regularly send the data related to power consumption to the central server [17].

4.5. NFC application

The various applications in this domain are as follows

- *Travelling assistance system*: NFC can augment the travelling experience to a great extent. It helps to minimize the check in time for the stay in hotels. When the room is booked in a lodge, a secure key is sent to the travelling agency. This key can be used as digital ticket, with the NFC enabled locks, and can directly go to the room without performing manual check-in lodge procedure.
- *Health monitoring system*: NFC can be helpful in monitoring personal health. It gathers information about person's health and sends the data collectively to health monitoring center. These centers can analyze health and provide the valuable report and information to the individual.
- *Payment system*: With the help of NFC technology, a user can leave his credit cards at home and can make a copy of credit cards on the mobile device. To make any payments, one can electronically make the payment by using the copy of credit cards stored on the mobile phone with NFC activated devices.

5. SCOPE AND LIMITATIONS OF IOT

The IoT encourages the communication between devices and total transparency is available with lesser inefficiencies and greater quality. Without human intervention, the machines are able to communicate with each other leading to faster and timely output. The most obvious advantage of IoT is monitoring like, monitoring the expiration of products to provide safety. Optimum utilization of resources and energy conservation achieved by adopting this technology and in turn one can save money by using this technology. Instead of repeating the same tasks every day, it enables people to do other creative jobs thereby saving lots of time. All the applications of this technology increases comfort, convenience and better management thereby improving quality of life. [19], [20]

The bad effects of IoT use are, dependency and control of person life by IoT technology. One has to decide how much of our daily routines are to be mechanized and be controlled by technology. With daily activities getting automated, will naturally lead to fewer requirements of human resources, workers and qualified staffs. This may result more unemployment rate in the society. IoT is complex network and any failure in software and hardware will have serious consequences. Even power failure can cause a lot of inconvenience [19].

6. CONCLUSION

The internet has changed the way we lived in today's world, as all the interactions are done through the internet. The IoT has the potential to add a new dimension to this process by enabling communication among smart objects. IoT has been considered as an element of future Internet that connects everything to network and facilitates every object to interact with each other using appropriate technology. To implement smart application under given constraints this paper, presents various technologies and specifications that makes IoT a reality.

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