Understanding Architecture of Internet of Things

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ABSTRACT – Now a day's everything is in an era of Information Technology where each one must become IT incumbent and resource oriented. Our day to day life activities revolve around technology, from last few decades it was observed that technology is providing the generation with at most benefit and ease. Therefore, Internet of Things has emerged in the latest trends of technology. The future of computing and communications is depend on this new technological revolution where it contains some distinguishing features and also the features of both the Internet and the Telecommunications Network in such a specified and wide domain which helps people to understand the real world applications, where each object can perform multiple tasks while communicating with other different objects using IoT which makes human life far better and easier than ever with full of devices, sensors and other objects which allows each other to communicate in a network environment. This paper explores the current research work on IoT as Three-layer traditional architecture, and how it relates with architecture of Internet and Telecommunications Management Network. After review it was observed that there is a requirement to reform a technical framework of the Internet and the Logical Layered Architecture of the Telecommunication Management Network because three-layer architecture doesn't provides all features and significance of the Internet of Things, for this purpose only a new five-layer architecture of IoT was established. Finally, at the end a new improved architecture to the internet of things (IoT) was proposed that takes into consideration the basic concept of IoT and its working.

Keywords- Internet, Telecommunications, Internet of Things, IoT Architecture.

1.0 INTRODUCTION

The Internet of Things is considered as a collection of interconnected and distributed networks of embedded system where all the wired or wireless communication technologies are communicating and interconnecting in a network connectivity with different physical objects, devices. The other items empowered with electronics, circuits, software, sensors connected in a network that allows correlation of data in terms of collection and exchange of data. Whereas objects that has functionality of readability, recognizing, locating, addressing, are to be controlled via the Internet in terms of RFID, wireless LAN, wide-area network, and to be recognized and controlled by existing network infrastructure, remotely across the world. It also provides the opportunities for more direct integration of the physical system into computer-based system to improve efficiency and accuracy of the system [1]. Some of the well-developed domains of IoT applications are Medical, Automobile industries ,etc. where the objects that have not represented electronically at all are started to become online with the help of electronic devices, embedded systems, microprocessors, communicating with each other via the Internet without the knowledge of human intervention. As IoT technologies are booming; around the world with many new developments are happening in terms of the integration of objects with sensors via the Internet. But there are certain issues while development of IoT represented in terms of commuting and communication technology, interfaces, protocols, and standards, security and privacy, etc. [2].

Internet of Things can be categorized into two terms: one is Internet, which is defined as networks of networks where billions of users are connected in a network with some standard internet protocols [3].while using different technologies one can connect several different sectors, departments, different devices like mobile, personal systems and business organizations all are to be connected via the Internet. The second term is Thing, which basically means devices or objects that are converted into intelligent objects [4] where all objects represents to real world instead of physical world. Where interaction between physical world and real world with the help of different embedded systems such as connectors, actuators, sensors [5]. The development of dynamic world is depend on the reformation of commuting and communication technology in a number of important fields, from wired environment to wireless sensors in terms of network of smart objects that has the functionality to auto-organize, correlate data ,resources and sudden changes in the environment.[3,6] Technically, it was reviewed that the IoT architecture is based on the functionality of different communication tools, primarily RFID-tagged items (Radio Frequency Identification), Which provides the main functioning of the loT to facilitate exchange of information among other things, sharing of data in networks, i.e. It has the responsibility to provide information about "things" in a more secure and stable manner to extend the applications at their early stage of implementation and also act as backbone for universal computing, permitting the devices to retrieve information from the Internet to facilitate their robust functionality and allows smart environments to identify and recognize other objects for interaction [1].

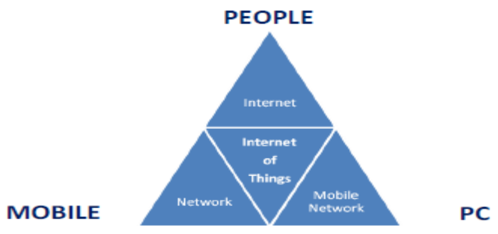

Fig.1: Basics of Internet of Things

Since single architecture is not enough to suit all the requirements therefore, a modular scalable reference model that supports different additional or suppressing of existing capabilities, also supporting many requirements across a wide variety of these areas is inherently possible. Therefore, there is a necessity to design the Reference model that provides an entry point for architects looking forward to creating IoT solutions and a strong basis for further development of existing reference models designed by industries like CISCO, INTEL and IBM. Therefore, it is suggested that the outlook of IoT's components should not be restricted by the Reference Model. i.e. from a physical point of view, every device in the IoT could reside in a single environment or it could be distributed across the world. As Internet of things composed from Internet, the study and the design of it should be from data generated by devices perspective rather than data generated by people. The internet data transmission follows the seven-layer OSI model. Where it can be compared with internet model as devices are replaced by people in internet [7]. Based on different protocols initially IoT architecture was deigned to have Three-layer architecture and 5- layer architecture, then finally Seven-layer architecture. According to the early stages of research the three-layer architecture mention the basic minimal things required for the devices to be connected to the internet. [8, 9]. Hence there will be a research in the field of finer things in the model and resulted as an output in terms of five-layer [9-10] and then to seven-layer.

The term Internet of Things (IoT) according to the 2020 conceptual framework is expressed in terms of:

IoT= Services+ Data+ Networks + Sensors [11]

2.0 Three LAYER ARCHITECTURE

After Static web pages and social networking's based web the Internet of Things is considered as the third wave of the World Wide Web (WWW) where it connects different types of objects at anyplace, anytime and anywhere via a popular internet protocol (IP).In the initial phase of research the traditional architecture was introduced [5], which have three layers the perception, network and application layers.

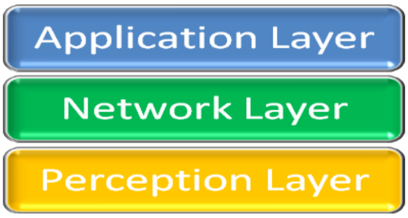

Fig. 2: Three-Layer Architecture

2.1) Perception Layer - This layer also called as physical layer, whose main functionality is to collect data, information and recognizes the usage of data in the physical world. where all the actuators work according to the information that is collected by the sensors of different object in order to perform specific operations by the corresponding objects with 2-D bar code labels and readers, RFID tags and reader-writers, camera, GPS, sensors, terminals, and sensor network [12].It acts like the facial skin and the five sense organs of loT, which is mainly identifying objects, gathering information.

2.2) Network Layer - It is the middle layer in architecture; where it acts as an interface between application layer and perceptual layer. Its functionality is to process data and information obtained from perception layer and also broadcasting of data and connecting devices in a network [5].It is functioning similarly to the neural network where it includes a convergence network of communication and Internet network, network management center, information center and intelligent processing center, etc.

2.3) Application Layer – It is a layer where in actuality different applications are to be deployed with the usage of IoT services It provides the personalized based services according to user relevant requirements, also creates a link between the users and applications which combines the industry to provide high-level intelligent applications type solutions such as the disaster monitoring, health monitoring, transposition, etc.

This model layers represents the structure of loT from the technical level, it is reasonable at the initial stage of development but it is observed that various technologies mentioned in this structure basically have varying degree of development and application, but it has not been large-scale applied into our work and life, and even many scholars think the IoT is a visionary cloud-castle because it is lack of good management methods and business models. Just as the Internet, its booming development not only depends on the technology progress, more on various new applications and successful business models. Therefore, there is a requirement not only breakthrough technology problems constantly; at the same time should also pay more attention to its management mode and business models. However, different from the Internet, which can't be managed and controlled, the things in IoT needs to be managed and operated. It is more like the communication network, because both need to be controlled and operated. To understand the Internet of Things' system structure correctly, there is a necessity to analyse these two-network structure, the Internet and communications network, and combine the features of Internet of Things, finally obtain a better and more reasonable architecture of IoT.

3.0 ARCHITECTURE OF INTERNET AND TELECOMMUNICATIONS MANAGEMENT NETWORK

3.1. TCP/IP Model Layer

The TCP/IP (Transmission Control Protocol Internet Protocol) model uses four layers that logically related to the top six layers of the OSI (Open System Interconnect) model. This model does not contain the physical layer, where hardware devices are to be used. The remaining three layers-network interface, internet and (host-to-host) transport correspond to layers 2, 3 and 4 of the OSI model. Figure 3 shows the relationship between TCP/IP and, OSI/RM[1].

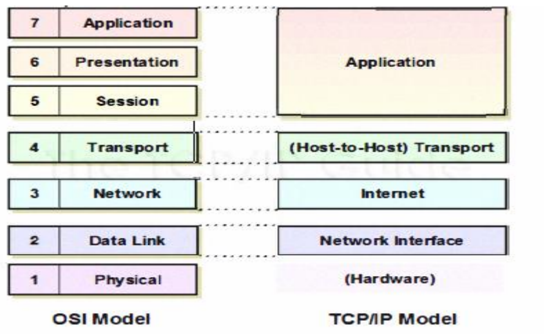

Fig .3: OSI Reference Model and TCP/IP Model Layers

3.1.1) Internet Layer: This layer is like the network layer in the OSI Reference Model and sometimes called the network layer even in TCP/IP model. Its main functionality with three responsibilities such as logical device addressing, data packaging, manipulation and delivery, and most importantly routing of data. It is core component of TCP/IP, as well as support protocols for Internet Control Message Protocol (ICMP) and the different routing protocols (RIP, OSFP, BOP, etc.) In the coming years the future version of IP, called as IPV 6, will be used.

3.1.2) Transport Layer: This layer facilitates device to device communication over an internetwork. Where logical connections are to be established between devices to transfer of data either reliably where it keeps track of the data sent and reached successfully to the destination and re- sends it if necessary or unreliably with no guarantee that it forwarded and arrived to the end Point. The protocols used at this layer are the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP). The TCP/IP transport layer corresponds same as OSI model (layer four) with certain elements that are part of the OSI session layer. Where it establishes a connection between end devices that can persist for a long period of time, which is in some cases called as session instead of connection by researchers.

3.1.3) Application Layer: This is at the top position in the TCP/IP model that provides the interfaces and corresponding protocols needed by the users. It is used to develop network-based applications. It is also concerned with error handling and recovery of the message. It provides user services like user login, naming network devices, formatting messages, and e-mails, transfer of files etc. With the help of number of protocols reside at this layer such as HTTP, FTP and SMTP for providing end-user services, as well as administrative protocols like SNMP, DHCP and DNS. [14]

3.2. TMN Logical Layered Architecture within the TMN functional architecture

To understand the complexity of telecommunications management, it may be represented into logical layers. The LLA is responsible for the structuring of management functionality in terms of groupings called "logical layers" and describes the relationship between layers. It reflects aspects of management arranged by different levels of abstraction [15]. Figure 4 shows the Suggested model for layering of TMN management functions.

3.2.1) Element management layer: This layer manages each network element on an individual basis or group basis and supports an abstraction of the functions provided by the network element layer. It has one or more element called as Operations Systems Function to individually responsible, on a delegate basis from the network management layer, for some part of network element functions. The following are three principal roles of this layer:

a) Control and coordination of a subset of network elements on an individual NEF (Network Element Function) basis.

b) Control and coordinate a subset of network elements on collective basis.

c) To maintain statistical, log and other data about elements within its scope of control.

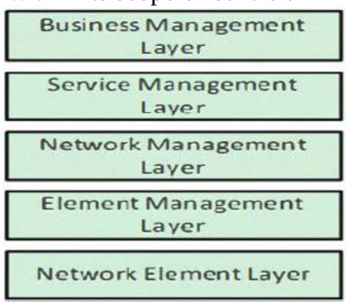

Fig .4: Suggested model for layering of TMN management

3.2.2) Network management layer: The network is supported by the element management layer and functions addressing the management of a wide geographical area. Since complete visibility of the entire network is typical hence as an objective, a technology independent view will be provided to the service management layer. It has the following five principal roles:

a) It controls and coordinates the network view of all network elements within its prescribed domain.

b) The allocation of resources or modification of network capabilities for the support of service to customers.

c) The maintenance of network capabilities.

d) It maintains statistical, log and other data about the network and interact with the service manager layer on performance, usage, availability, etc.

e) The network OSFs maintains the relationships (e.g. Connectivity) between NEFs.

3.2.3) Service management layer: This layer provides the services to the potential customers who can perform IoT operations' facilities offered by this layer are service order handling, complaint handling and invoicing. It has the following four principal roles:

a) To handle customer and interfacing with other PTOs (Public Telecommunications Operators);

b) To interact with service providers;

c) To maintain statistical data (e.g. QOS);

d) Interaction between services.

3.2.4) Business management layer: It has responsibility for the total enterprise. The business management layer comprises proprietary functionality. The business management layer is included in the TMN architecture to facilitate the specification of capability that it requires of the other management layers. This layer acts as a part of the overall management of the enterprise and many interactions are necessary with other management systems.it has the following four principal roles: [5]

a) To support the decision-making process for the optimal investment and use of new telecommunications resources;

b) To support the management of OA&M related budget;

c) To support the supply and demand of OA&M related manpower;

d) Also maintain aggregate data about the total enterprise.

4.0 Five LAYER ARCHITECTURE

As IOT is different from Internet and Telecommunications Network, the above two models are not suitable for loT directly. But they have some similar feature in common. So, through the technology architecture of the Internet and the logical structure of Telecommunications Management Network and combined with the specific features of the Internet of Things, a new architecture of loT was established. It is to be believed that this architecture would better explain the features and connotation of the Internet of Things. It divides loT into five layers, which are the Business Layer, the Application Layer, the Processing Layer, the Transport Layer and the Perception Layer. As shown in figure below.

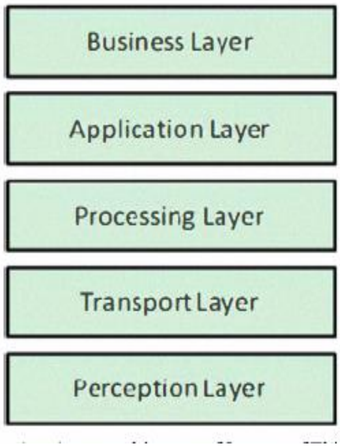

Fig .5: Five-layer architecture of Internet of Things

4.1) The Perception Layer: The main task of this layer is to perceive the physical properties of objects (such as temperature, location etc.) by various sensors (such as infrared sensors, RFID, 2-D barcode), and convert these information's to digital signals which is more convenient for network transmission. The various sensors and equipment's in the Perception Layer are like the "Network Element" in Telecommunications Management Network. The techniques used in this layer are sensing technology, RFID technology (including labels and literacy), 2-D barcode, GPS, etc.

Meanwhile, many objects cannot be perceived directly, so to perform this functionality implant microchip into their bodies. These chips can sense the temperature, speed and so on, and even process collected information with the usage of nanotechnology which makes the chips small enough to be implanted into every object, even sand. These are the key technologies of this layer.

4.2) The Transport Layer: The Transport Layer, or called the Network Layer, is responsible for transmitting data obtained from the Perception Layer to the processing center through various network, such as wireless or cable network, even the enterprise Local Area Network (LAN). The main techniques in this layer include FTTx, 3G, Wifi, bluetooth, Zigbee, UMB, infrared technology and so on. At this layer, many protocols are available, like IPv6 (Internet Protocol version 6), which is necessary for addressing billions of things. Therefore, the communication between different networks and entities is very crucial because it connects billions of things, also encompass huge amounts of various networks.[5].

4.3) The Processing Layer: The Processing Layer mainly store, analyze, process and transmits the information of objects from the transport layer. It must perform the major task because it will process all the information gathered by the perception layer. This huge amount of data will require storage space and to be stored using some techniques like cloud computing or any DBMS. Then it will analyze how to fetch data whenever required in order to complete the desired task, due to the large quantities of things and the huge information they carried, it is very important to maintain and difficult to store and process these mass data. The techniques included database, intelligent processing, cloud computing, ubiquitous computing, etc. Cloud computing and ubiquitous computing is the primary technology in this layer [16].

4.4) The Application Layer: The functionality of this layer is based on the data processed in the Process Layer, and develops diverse applications of the IoT, such as authentication, intelligent transportation, logistics management, identity location-based service and safety. It is providing all kinds of applications for each industry, because the various applications promote the development of the IOT to a large scale.

4.5) The Business Layer: The Business Layer is like a manager of the Internet of Things, including managing the applications, the relevant business model and other business. It not only manages the release and charging of various applications, but also the research on business model and profit model. As everyone knows, success of a technology depends on the priority on technology, and on the innovation and reasonable of business model. Meanwhile, this layer should manage the users' privacy which is equally important in IoT [17].

5.0 PROPOSED IMPROVED LAYERED ARCHITECTURE FOR IoT

This improved layered architecture depends on seven layers, unlike the traditional layered architecture, it takes all the functions of the traditional architecture and distribute them on the seven layers, but in a more operational way. The proposed improved layered IoT architecture composed of seven layers, is illustrated in Fig.6, as follows [18]:

5.1) Application layer: This is the topmost layer of the architecture and is responsible of providing various applications to different users using IoT.The applications can vary from different industry areas such as: manufacturing, logistics, retail, environment, public safety, healthcare, food and drug etc. Also, from the RFID technology, numerous applications are evolving which all are part of IoT [19].

5.2) Application support & management layer: It focus on main functions such as**;** Qos Manager, Device Manager, Business Process Modeling, Business Process Execution – Authorization, Key Exchange & Management, Trust & Reputation, Identity Management. All actions related to the control, security and management of the application are responsibility of this layer.

5.3) Services layer: It performs the following functions such as Service storage & orchestration Service composition & organization, Virtual Entity resolution, VE services, IoT servicer resolution and service monitoring. All decisions related to the monitoring, storage, organization and visualization of the received information, including resolving virtual entities created, are responsibility of this layer.

5.4) Communication layer: It performs the following functions; such as Flow control & Reliability – Qos – Energy Optimization. Also, if applicable it performs cross platform communication. The IoT web portal is part of this layer. All decisions related to communications and measurements of the flow and its quality and energy consumed are responsibility of this layer.[20]

5.5) Network layer: The main functionality is to provide Gateway Routing & Addressing, Network Capabilities, Transport Capabilities, Error detection & Correction and also takes care of publishing and subscribing of messages. It consist of different high speed applications and services, transactional services, context-aware applications, and access protocols are all to be connected with each other in a heterogeneous configuration and are available in a wide spectrum at this layer, where these networks can be represented in terms of a private, public or hybrid models and are to be used to support the communication requirements for latency, bandwidth or security. [21]

5.6) Hardware layer: It interconnects the physical world with digital world using different devices, sensors, hardware components, embedded systems, RFID tags and readers, which allows real-time information to be collected and processed in a network. There are multiple types of sensors like environmental sensors, body sensors, home appliance sensors and vehicle telemetric sensors, for different purposes have the capacity to take measurements such as temperature, air quality, movement and electricity and also with degree of memory, allowing it to record a certain number of measurements i.e. measure the physical property and convert it into signal that can be understood by an instrument and are represented according to their unique purpose.

5.7) Environment layer: Its functionality is to detect objects and places to be observed. The detected objects can vary from physical moving objects, such as humans, cars, to environmental factors such as, temperature, or humidity. The places to observe are ranging from buildings, universities, streets and so on.

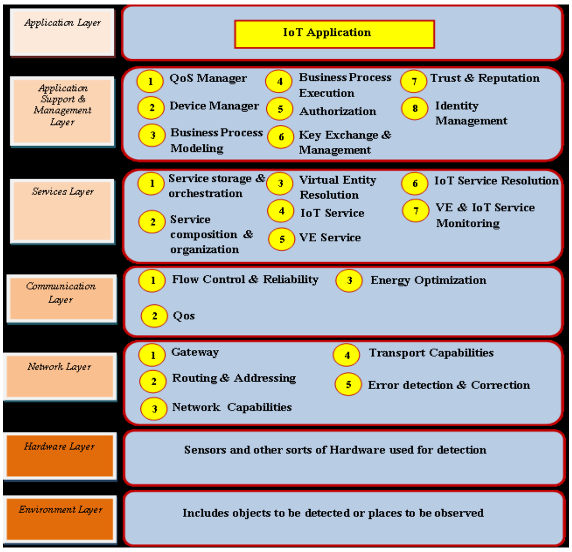

Fig.6: Improved Layered Architecture for IoT

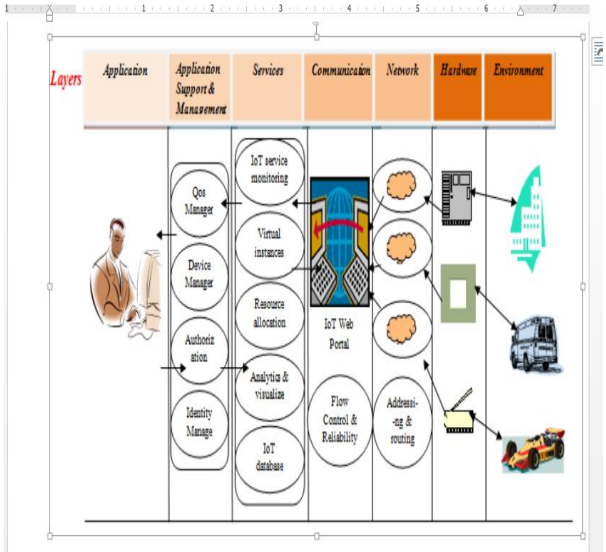

Fig 7. A model of end-to-end interaction between various layers in improved layered IoT architecture

The below figure represents how the seven layers interact with each other inside the proposed architecture of IoT. The interaction between layers can occur in both directions in some cases. First, the authorized person must provide his identity to the application, if the identity is right and registered in the IoT database in the services layer, then only one can open the application and request the information according to requirement. The detected objects are to be tracked or places to be identified by the environment layer which includes not only static, but also dynamic objects for example vehicles, places such as buildings, which contains movable objects or walking people. The hardware layer, includes the components such as; sensors, tracking devices, RFID readers and tags and others that transport live information about the tracked object or place to the network layer, with multiple networks ,various technologies and access protocols, such as, Wi-Fi, Ethernet, CDMA , GSM, Bluetooth and others. Then, the network layer takes this live information to the communication layer, where the IOT Web portal resides, and performs cross platform interaction using different protocols, such as, HTTP, FTP and others. The functionality of communication layer is to transmit this live information to the services layer, where all decisions related to the monitoring, storage, organization, resources allocation and visualization of the received information, including creating virtual entities, are to be considered.[23] Finally, the received information is transmitted from the services layer to the application support and management layer, where it goes to the authorized person to receive this information. And finally, in the application layer, when the authorized person sitting before the application user interface receives this information, he must take the required decisions and can request additional information from the application. [24,25]

6.0 CONCLUSION AND FUTURE SCOPE

IoT connects billions of devices and enables machine-to-machine communication. It can transform daily life with everyday objects connected to each other via the Internet. The existing three-layer structure has certain significance to understand technical architecture of IoT at the initial stage of its development, but it cannot completely explain its structure and the connotation, because of this, five-layer architecture of IoT was established by developers to better understand the Internet of Things. Later, a more reliable IoT architecture is proposed in this paper. The proposed improved layered architecture of IoT is consist of seven layers and the environment layer is included in this architecture, and there is a sort of functions distribution on each layer. This proposed architecture differs from the traditional architecture by its reliability and feasibility to all sorts of applications, also, it is more flexible. In the future, there will be a focus on building new model applications for internet of things (IoT) based on this proposed internet of things (IoT) architecture. The future research should focus on standardized protocol stack and networking technologies used for a seamless flow of data between different devices. Streamlined data analytics for the huge amount of data generated by IoT and how to secure data must also be an area of emphasis.

7.0 ACKNOWLEDGEMENT

The author is very much thankful to Dr.Hiren Dand sir for giving this opportunity to publish research paper for this particular conference and all the other members of the conference team for their valuable suggestions.

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