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A Survey on IoT Technologies, Evolution and Architecture

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***Abstract*—The Internet Of Things (IoT) was initially called as "Internet of Everything". IoT objects have identifiers which are unique. They have the ability to send the information over a network interconnecting physical and virtual things without requiring human-to-human or human-to-system interaction. It provides the effective way of learning and interaction among internet connected devices that include sensors, actuators, services and other internet connected objects. The IoT can be defined as things or objects connected to the internet than people. The IoT system's middleware can be described as intermediary software system between the IoT devices and applications. The IoT aim is to unite everything in the world under common infrastructure. The main objective of this paper is to provide an survey on Internet of Things, types of architectures, and the technologies that are used in our daily life, smart environment. However, this paper gives a good idea for new researches on Internet of Things.**

Keywords—Wireless Sensor Network; Internet of Things; Transmission Control Protocol; Internet Protocol.

I. INTRODUCTION

The common man's daily life, who works in the society became the well known concept and it has many applications. The Internet of Things is the exciting technological revolution since the internet [1],[4]. The IoT is everywhere in the world that brings the number of opportunities and impact every one. With Internet of Things, the smart cities can be built where it manages the parking spaces, street lighting, irrigation facilities, urban noise, and waste can be monitored in real time applications. We can build smart homes which are really safe and more efficient to live. We can build smart environment that can automatically monitoring the pollution from air and water and enabling the early detection of Tsunami, earthquakes, forest fires and many devastating disaster in the environment.

II. INTERNET OF THINGS

The Internet of Things is a paradigm shift in IT arena. As from the definition the internet is the computer networks that are globally interconnected and uses the Standard Internet Protocol suite (TCP/IP) for serving the billions of users among worldwide. It is a network consisting of millions of users that include various sectors like public, private, academic, business and government network consists of both local and global scope of networks as shown in Fig.1. The networks are formed by wireless, electronics, and optical networking technologies [2],[3].

While the IoT offering the exciting opportunities, it still remains challenging to manage the things that archives seamless integration of the physical world. There are two IoT communications APIs (Application Programming Interface). They are,

1. REST (Representational State Transfer) based API
2. WebSocket based API

The IoT is an umbrella term in which many technologies are involved. The following are the IoT enabling technologies.

- WSN
- Cloud Computing
- Big Data Analytics
- Embedded Systems
- Security Protocols and Architecture
- Communication Protocols
- Web Services
- Mobile Internet
- Semantic Search Engine

Among all these technologies, Wireless Sensor Network is the heart of IoT.

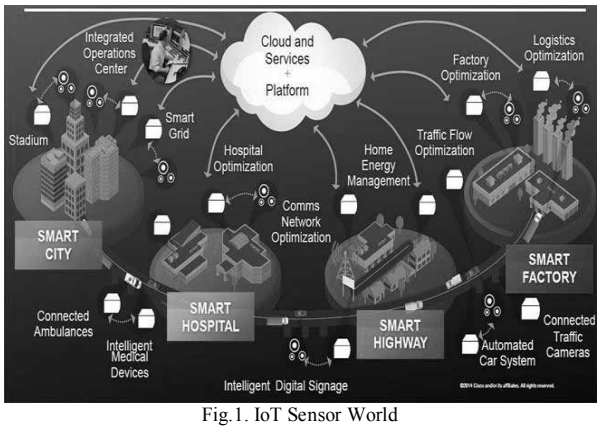

Fig.1. IoT Sensor World

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The following are the main objectives of IoT:

- To provide bridge between the poor and the rich
- To distribute the resources of the world to the needy
- To be more proactive and less reactive

The M2M communication is networking of devices, communicating or exchanging data without human interaction. The differences between M2M and IoT are listed in Table.I.

TABLE I
DIFFERENCES BETWEEN M2M AND IOT

M2M	IoT
1. Focus is on layer below the network layer	1. Focus is on layer above the network layer
2. Sensing and actuating may not be involved	2. Sensing and actuating may be involved
3. Emphasis is on hardware	3. Emphasis is on software
4. Cloud is not involved	4. Cloud is involved

III. EVOLUTION

Before the research of IoT's in depth we look at the evolution of Internet. In the early 1960s, a communication between two computers was made possible through a network called computer network. In 1980s the TCP/IP stack was introduced. The use of internet was started in 1980s. Later the (WWW) became available in 1991which made the internet to become more popular. The mobiles phones are connected to the internet where mobile internet was formed. With the use of social networking the users are getting connected via internet through connecting devices. The further step in IoT is to connect all the objects around us together and communicate via internet as shown in Fig.2.

In IoT, all the smart objects are connected to the internet. They communicate with each other with human intervention. Internet of things is becoming the latest and well known concept in the IT sector. It attracts the attention of users by enabling anytime, anyplace connectivity across the world and also providing unique identity to every objects [4].

IV. IOT ARCHITECTURE

The main problems of an IoT are vast and broad concept that is not proposed, uniform architecture. So, for making an IoT to work it should consist of sensors, networks, communication between the computer systems and technologies. Here we are discussing the five-layer architecture model of IoT as shown in Fig.3.

The Objects Layer is also called as perception layer that represents the physical sensors of an IoT. The aim is to collect the information from various devices and processing it. This includes sensors to perform analysis on querying location, temperature, weight, acceleration and humidity [5].

The Object Abstraction Layer Where Object Abstraction is the transferring of data from an object later to the service management by the channels. The data transferred through the channels like RFID, 3G, GSM, UTMS, WIFI, Bluetooth, etc. [5].

Service Management Layer is also called as middleware layer pairs the service based on addresses and names. This layer enabling the IoT programmers to work without the hardware platform. This layer also processes the data received and make decisions and delivers the requested data [5]

The Application Layer is used to provide the services that are being requested by the customer. The service provided to the customer should meet the customer needs. It is helpful in markets smart homes, smart cities, and home automation [6].

The Business Layer is one of the biggest responsibilities for building a business model, flow charts and graphs. It supports the designing, analyzing, implementation of IoT system related elements. It is eligible for comparing the outputs of every layer with an expected one for enhancing the user's privacy.

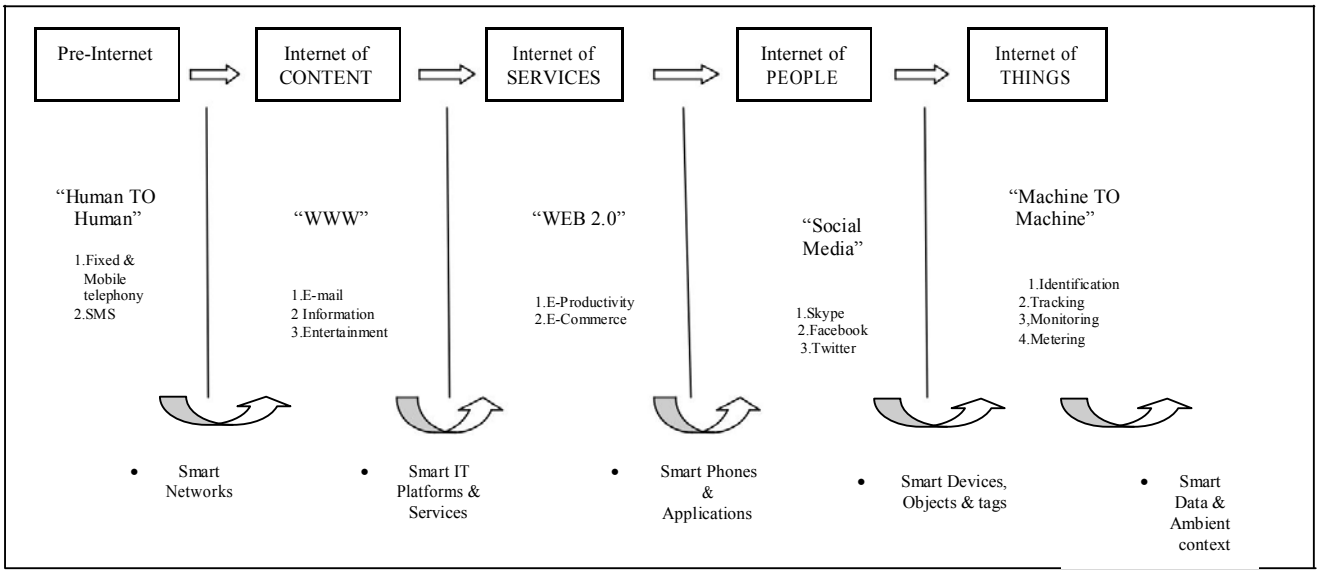

Fig.2. Evolution of IOT

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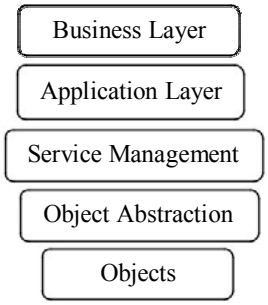

Fig.3. Five-Layer IoT Architecture Model

V. REQUIREMENTS OF AN IOT

The following are the hardware requirements that leads to the development of an IoT in infrastructure as well as in the communication networks. The main components of IoT are as follows [7].

1) Power source and Power Management
2) Sensors or Actuators
3) Processor and memory storage
4) Wireless communication
5) UI/UX

VI. COMPONENTS OF IOT

The following are the functional components of IoT. It is shown in Fig.4.

- Component for interaction and communication with other IoT.
- Component for Processing and analysis of operations.
- Component for internet Interaction.
- Component for handling Web services of applications.
- Components to integrate application services.
- User interface to accessIoT.

A. Device (The Thing)

The IoT devices have unique identies. It is a physical device that is embedded with sensors, actuators, electronics, software, network connectivity enabling the objects collecting and exchange of data. It performs remote sensing, actuating and monitoring capability. The term “Things”, in IoT refer to variety of devices that can collect and transfer the data to other devices. In general, there are two groups: constrained and standard devices. The IoT devices have on board or attached sensors. The data can be exchanged with other connected devices and applications. They also send the data to centralized servers or cloud based application backends for processing the data. Constrained devices are very small whose computing capabilities (such as power, storage, and so on) are low. The Bluetooth Low Energy (BLE) networks are unable to reach cloud platform directly. Standard devices are similar to small computers and route data directly to cloud platform via network. These Constrained devices need to go through some kind of gateway device to reach cloud platform.

B. Local Network

The IoT is an interconnected devices as we mentioned above and the huge amount of data will be generated. We are well known that networks are used to transmit the signals that are collected by the sensors with all the different components routers, bridges, LAN, MAN, WAN. The connecting of networks over the sensors can also be done with technologies including Wi-Fi, Wi-Max, Ethernet, LTE (Long Term Evolution). The wide spread network adoption in IoT is as follows.

1) High data rate
2) Low prices if data usage
3) IPV6 deployment

C. Internet

The internet is the system of globally interconnected computer networks by using the internet protocol suite for linking of devices worldwide. This network consists of public, private, government, business networks of local to global scope. Nowadays communications like media, telephony, radio, television, paper mail and newspapers have been overcome by the internet and giving birth to new services such as internet telephony, internet television, emails, etc. The newspapers and books are adapting to website technology in colleges. So the internet enabled and accelerated to new forums of personal interactions by instant messaging, internet forums and social networking.

D. Backend Services

The services offered are, devices monitoring, device control services, data publishing services and services for data discovery. According to the definition, backend services is a set of cloud based services that helps to build your app backend. It features a fast data storage, easy to manage user management. A pretty final product is an obvious goal of every IoT enterprise strategy. The front end of an IoT solution ensures end-users that will add value or increase security in their lives. Once the product collects data, it sends to the cloud. The data in cloud will be running on servers that allow you to store, views perform computation on your data.

E. Applicaions

The inter-connected devices share all the collected information with people, to the cloud applications and also to other devices. The connected devices capture and utilize every bit of data in daily life. The connectivity is going beyond laptops and mobile phones, its going towards connected cars, smart homes, smart cities, wearable’s, health care, etc. The following are the real most applications of an IoT [8].

1. Smart Home

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With the creation of IoT, the functions of smart home are switching of lights after you left home, unlocks the door for others for temporary access [8].

2. Wearables

Wearables have been experiencing the greatest demand in markets all over the world. Wearables may be worn or carried on the body. They sense and transfer the information about the users. These devices cover information about fitness, health and entertainment [8].

3. Connected Cars

The connected car is equipped with Internet access,and allows the car to share internet access with other devices both inside and outside the vehicle. Cars will exchange data with other cars and alerting drivers. They communicate with sensors on signs on road signals, bus stops. They also get traffic updates and rerouting alerts. And they'll communicate with your house, office, and smart devices, acting as an digital assistant, gathering information you need to go about your day.

4. Smart Cities

It is another important application of IoT generating curiosity among world's population. The smart cities have integrated sensors and monitoring devices connected through internet. The collected data can be analyzed to manage sewage system, power plant etc., The examples of smart cities is energy management, water distribution, urban security and environmental monitoring. It uses IoT to collect and analyze data in order to interact directly with city infrastructure.

5. IoT in Agriculture

Smart farming is quickly arising in agriculture business. The ioT sensors deployed in field provides data about crops, rain fall, nutrition of soil and so on.

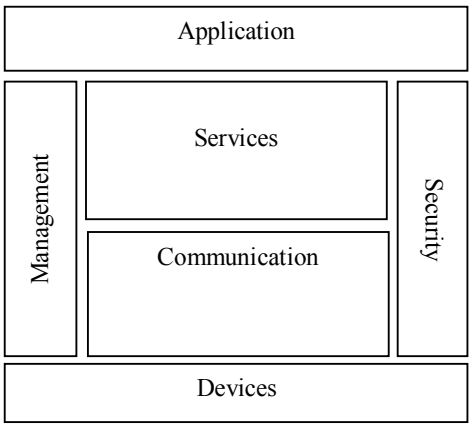

Fig.4. IoT Functional Blocks

VII. SENSORS

The Sensors play major important role in IoT. It is the tiny battery operated device with low power, less energy and limited storage capabilities.

A. Sensor Types

The following are the various types of sensor which are widely used for many applications.

1) Light Sensor
2) Temperature sensor
3) Force Sensor
4) Position Sensor
5) Speed Sensor
6) Sound Sensor
7) Chemical Sensor

B. Sensor Classes

There are two types of classes on sensors based on Output and Data type. In output, there are analog and Digital. In Data type, there are scalar and vector.

1. Analog Sensors

Analog sensors produces continuous output signal. The various types of analog sensors are accelerometers, pressure sensors, light sensors, sound sensors, temperature sensors, and so on. It finds changes in vibration, position, velocity and sensing motion are called accelerometers. All these are analog quantities and they tend to be continuous in nature. The thermometer can measure temperature of liquid and continuously responds to temperature changes as the liquid is heated up or cooled down.

2. Digital Sensors

Digital sensors are often used for analytical measurements Digital sensors produce a binary output signal in the form of a logic "1" or a logic "0. Theses digital sensors are replacing the drawbacks of analog sensors. They produce discrete values, which may be a single "bit" (serial transmission), or by combining bits to produce a single "byte" output (parallel transmission).

3. Scalar Sensors

Scalar Sensors produce output signal or voltage which is proportional to magnitude of quantity being measured. Physical quantities such as temperature, color, pressure, strain,, etc. are all scalar quantities as only their magnitude is sufficient to convey on information.

For example, the temperature of a room can be measured using a thermometer, which responds to temperature changes irrespective of the orientation of the sensor or its direction.

4. Vector Sensors

Vector sensors produce output signal or voltage which is proportional to magnitude as well as orientation of the quantity being measured. Physical quantities such as sound, image, velocity, acceleration, orientation, etc. are all vector quantities, as only their magnitude is not sufficient to convey the complete information.

For example, the acceleration of the body can be measured using an accelerometer, which gives components of acceleration of the body with respect to the x, y, z coordinate axes.

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VIII. IOT CATEGORIES

The following are the two categories of IoT.

A. *Industrial IoT*

1) IoT device connects to an IP network and the global internet.
2) Communication between the nodes done using regular as well as industry specific technologies.

B.Consumer IoT

1) IoT device communicates within the locally networked devices.
2) Local communication is done mainly via Bluetooth, Zigbee or Wi-fi.
3) Generally limited to local communication by a gateway.

IX. IOT PROTOCOLS

The dimensions of selecting an IoT protocol are as follows: Transmission range, Privacy, Battery power, QOS, Addressing, Application, Architecture and Capabilities. The top 10 IoT protocols are listed below. They are.

1. BT (BlueTooth)
2. BTE (BlueTooth Low Energy)
3. RFID (Radio Frequency Identification)
4. Wi-Fi (Wireless Fidelty)
5. Cellular
6. Near Field Communication (NFC)
7. SigFox
8. Wireless HART
9. REST
10. Ingenu

The data can be transmitted in an energy efficient secure manner for Smart Home Systems (SHS). It is secured by secret key which has been generated by chaotic system. Message integrity and authenticity is addressed by message authentication codes [9]. The multimedia transmission via IoT is achieved by dividing the large multimedia versions into simpler sessions [10]. Omar Said et al., proposed adaptive version of real-time transport protocol (RTP) and real-time control protocol (RTCP) which outperform other protocols. energy-efficient centroid based routing protocol (EECRP) is proposed which evenly distribute the energy load in the network by calculating the centroid's position. It is mainly suitable for those network types that need long lifetime [11].

X. CONCLUSION

The idea of Internet of Things providing a special path for our modern life. It is aiming to prove quality of life by connecting smart devices, technologies and applications. It is bringing many technologies in our day to day life and making a life simpler and easier. There are still various applications that IoT can implement in domains including transport, governance, medical, education, etc. In this paper, we finally presented the overview on enabling technologies and need for IoT in industrial and business sector. The main focus of this paper is tracking a person using sensors with transfer of data.

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