A Survey: Internet of Things (IOT) Technologies, Applications and Challenges

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***Abstract*—The main aim of this paper is to discuss the Internet of things in wider sense and prominence on protocols, technologies and application along related issues. The main factor IoT concept is the integration of different technologies. The IoT is empowered by the hottest developments in RFID, smart sensors, communication technologies, and Internet protocols. Primary hypothesis is to have smart sensor dealing directly to deliver a class of applications without any external or human participation. Recently development in Internet and smart phone and machine-to-machine M2M technologies can be consider first phase of the IoT. In the coming years IoT is expected to be one of the main hub between various technologies by connecting smart physical objects together and allow different applications in support of smart decision making. In this paper we discuss IoT architecture and technical aspect that relate to IoT. Then, give over view about IoT technologies, protocols and applications and related issues with comparison of other survey papers. Our main aim to provide a framework to researcher and application developer that how different protocols works, over view of some key issues of IoT and the relation between IoT and other embryonic technologies including big data analytics and cloud computing.**

Keywords-internet of things (IoT); IoT gateway M2M

I. INTRODUCTION

The term Internet of Things (IOT) has been known for last few years. In recent time, it's getting more attention due to the advancement of wireless technology. The basic idea is due to variety of object- such as RFID, NFC, Sensors, actuators, mobile phones, etc. which can interact with each other by having a distinct address. The IoT empowers substantial objects to see, hear, think and per- form jobs by having them "talk" with each, to share information and to synchronize pronouncements. The IoT transforms these objects from being conventional to smart by manipulating its underlying technologies such as omnipresent and pervasive computing, embedded devices, communication technologies, sensor networks, protocols and applications. When, IoT was introduced, Radio frequency (RFID) seemed to be necessary for it. There are various technologies similar to RFID, Near Field communications (NFC), Machine to Machine (M2M) and vehicular to vehicular communications (V2V), which can be used to implement the modern idea of IoT [1]. The life of potential user can become easy and comfortable by adopting various technologies based on IoT. In addition, IoT has dramatic effect on domestic sphere, such as assisted living, smart homes, smart cars, etc. In business sector, IoT has noticeable advancement in manufacturing and service industry such as better services, more production and superior quality. The worldwide adaption of above mentioned technologies does appear smooth but involves lots of issues, that needed to be solved before it worldwide acceptance. The major issues that IoT is of security because of Internet hackers. Some other problems of IoT are standardization issues, addressing problems and scalability problems etc. Therefore, research is needed to resolve these complicated issues. This paper will enable the reader to have basic understanding of IoT, its technologies and applications and the open issues that IoT is facing which needed to resolve for near future. Cisco approximations the IoT will consist of 50 billion devices connected to the Internet by 2020. Achievement deeper insight with analytics using Cisco IoT System to enhance productivity, create new business models, and generate new revenue streams. [2]

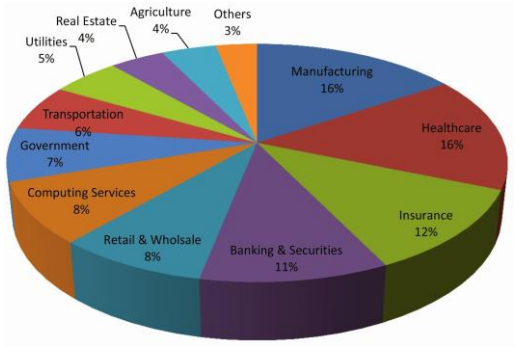

Figure 1. Projected market share of dominant IoT applications by 2020 [3].

"INTERNET OF THINGS connected devices to almost triple to over 38 billion unites by 2020" [4]. The fame of different models varies with time. The web search popularity, as measured by the Google search trends during the last 6 years for the terms Internet of Things, Wireless Sensor Networks and Ubiquitous Computing are shown in Figure 2. As it can be seen, since IoT has come into subsistence, search volume is consistently increasing with the falling trend for Wireless Sensor Networks. As per Google's search forecast (dotted line in Figure 2), this trend is likely to continue as other enabling technologies converge to form a

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genuine Internet of Things [5]. The smart gird is the assimilation of the 20thcentury conventional electrical power grid with the most recent 21sttelecommunication and information technologies. Such integration enables proficient resource utilization to optimize energy consumption, install and manage distributed energy sources, as well as to exchange the generated power. In other words, the power flow and communications will be in two-ways [6], [7]. Many utility companies around the globe started to install renewable energy sources such as solar and wind energy nearby the depletion sites. Also, residential homeowners started to install smart home appliances and renewable energy re- sources in their premises to generate and consume electrical power efficiently [8] [9]. As the smart grid developed, many endeavors started to introduce the IoT as enabling technology to the grid. Each device in the grid can be considered as an object.

TABLE I. MART GIRD APPLICATIONS BANDWIDTH AND LATENCY REQUIREMENTS [10]

Smart Grid Application	Bandwidth	Latency
Substation Automation	9.6-56 kbps	15-200 ms
WASA	600 – 1500 kbps	15-200 ms
Outage Management	56 kbps	2000 ms
Distribution Automation	9.6-100 kbps	100 ms-2 sec
Distributed Energy Resources	9.6-100 kbps	100 ms-2 sec
Smart Meter Reading	10-100 kbps/meter 500 kbps/concentrator	2000 ms
Demand Response	14 – 100 kbps	500 ms-min
Demand Side Management	14 – 100 kbps	500 ms-min
Assets Management	56 kbps	2000 ms

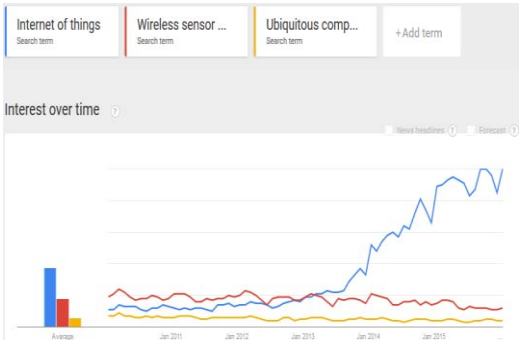

Figure 2. Google search trends since 2011 for terms internet of things, wireless sensor networks, ubiquitous computing.

There are three ways enterprises can manages Internet of Things using modern techniques.

- Use automated methods for organizing and retaining data based on the content.
- Securely consolidate IoT data regardless of where it came from or where it's kept.
- Offer new ways to access information, be productive and add value.

In this paper we discuss that many new technologies have been applied and many drawbacks have been overcome for IoT. But still there are some problems (mention in IOT Challenges section of the paper) would come in the future when the Internet of Things will get expand on large scale industry and these problems can be consider as future research area for researcher.

II. INTRICATE TECHNOLOGIES

Various technologies are involves implementing the idea of IOT. In this paper we will focus on these.

- Radio frequency Identification (RFID)
- Near Field Communication (NFC)
- Machine-to-Machine Communication (M2M)
- Vehicle-to-Vehicle Communication (V2V)

A. Radio frequency identification (RFID)

RFID system comprise of one or more readers and several RFID tags. It uses radio frequency electromagnetic fields to send data attached to it. The tags that are attached to it, stored data electronically which can be read by RFID when it comes in the proximity of the reader comments. RFID allows monitoring objects in real time, without the need of being in line of sight comment RFID tag or label is very small microchip attached to an antenna in a compact package. These tags antenna receive signal from RFID and return it with some extra information [11]. Hitachi has developed a tag with dimension. The RFID tag comes in three configurations, Passive Reader Active Tag (PRAT), Active Reader Passive Tags (ARPT) and Active Reader Active Tag (ARAT). In ARAT, reader is passive and receives the signal from the battery operated tag and its transmission range is from 1-2000 feet depends upon architecture. Secondly, most commonly used configuration, ARPT does not have onboard supplies, so it consumes the energy required to send data from the query signal sent by the RFID reader [11]. Last one, ARAT have both the reader and tags active, and tags only awoken by the reader when it comes under the domain of reader. Transmission may appears in different frequency bands spanning low frequency (LF) at 124-135 KHz up to ultra- high frequency (UHF) at 860-960 MHz. An Electronic Product Code (EPC) is one common set of data stored in a tag. The objects can be tracked uniquely because EPC's are coded on RFID tags. It contains 96-bit string of data. The first bits of this string are known to identify the version of the Protocol [12]. The next 28 bits are fixed to identify the organizations that are handling this tag and this organization id is assigned by EPC global consortium. The next 24 bits are an object class, identifies the kind of product. Further last 36 bits are a unique serial number of a particular tag. As compare to URL, the entire electronic product code number can be used as a key into a global database to uniquely identify a particular code.

B. Near Field Communication

It is similar to RFID configuration. NFC can be made customer-oriented by integration of RFID reader into mobile phones. In addition it is type of radio communication between NFC mobile devices by connecting them together in the domain of other phone. It is short range, low power

wireless link that can send small amounts of data between two devices within the range of lying in the specific domain [13]. No paring is needed before the actual sending of data in comparison to Bluetooth [14][25]. NFC operates within the unlicensed Radio Frequency band of 13.56MHz. The typical range of NFC is 20m and mostly it depends on the size of the antenna in the device.The NFC technology can play a significant role in the future progress of IoT. It will enable to provide necessary tool to be wirelessly connected to other smart objects [15]. For example by using NFC mobile a user will be able to transfer the mobile set into other various objects like mobile set will be able to used as a credit card.

C. Machine to Machine (M2M)

It refers to the communications between computers, embedded processors, smart sensors, actuators and mobile devices. This sort of communication is increasing these days. There are four components of M2M, that are sensing, heterogeneous access, information processing and applications & processing. In actual, M2M is a five-part structure that is as followsM2M Device: A device capable of replying to request for data contained within that device [16]. M2M Area Network (Device Domain): Provide connectivity between M2M Devices and M2M Gateways. M2M Gateway: Use M2M capabilities to ensure M2M Devices inter-working and interconnection to the communication network. M2M Communication Networks (Network Domain): Communications between the M2M Gateway(s) and M2M application [17].M2M Applications: Contains the middleware layer where data goes through various application services and is used by the specific business-processing engines. M2M Applications: Contains the middleware layer where data goes through various application services and is used by the specific business-processing engines. It has applications in different sectors like healthcare, smart robots, cyber transportation systems (CTS), manufacturing systems, smart home technologies, and smart grids [18].Example of M2M area network typically includes personal area network technologies, such as Ultra-wideband and Bluetooth or local networks.

D. Vehicle-to-Vehicle Communications (V2V)

V2V communications involve a vehicle, which acts as a node in a network and communication is done by the use of various sensors connected in an ad-hoc network. The infrastructure of this network is quite complicated because there is no any fixed topology to be followed as vehicle is moving from one place to another all time. There are four wider categories of this network, namely safety and collision avoidance, traffic infrastructure management, vehicle telematics, and entertainment services and Internet connectivity [19]. Vehicles communicate with each other within the range of 1000m. Two types of communications are there: first one is called vehicle to vehicle and other is related to road infrastructure. Intelligent transport system (ITS) is related to vehicular communication system. According to architectural aspect, it focuses mainly on routing protocols that are Physical layer (PHY), Medium Access Control MAC layer, and broadcasting [19].

III. APPLICATIONS

Applications of IoT are very diversify. Applications ofIoT are increasing every day in many domains. Every day individual /industrial changes our needs and as per need we use the Internetand hence Internet-of-Things. There are plenty of applications of IOT. In coming years, IOT will be more revolutionized because of the RFID, NFC, M2M and V2V communications.

A. Radio frequency Identification (RFID)

1) Smart parking

In recent time, smart parking sensors are attached in parking space to detect the arrival and departure of vehicles. It provide an efficient management solution which help motorist to save time and fuel. It provides motorists with accurate information about parking spaces and keeps the traffic system smooth. It also enables the facility of deployment to book parking space directly from vehicle. It can also help to reduce CO2 emission and lessen the traffic jams [20].

2) Augments maps

Tourists augmented maps with tags allow NFC tag would enable the phones to search the information about places by connecting to web service. By this one will be able to search required information about hotels, restaurants, monuments, theater and the local attractions. This can be by hovering your mobile phone over the tag within its reading range so that the additional information about the marker can be displayed on the screen [21].

3) Logistics

By implementing IoT in retail chain monitoring has many advantages: RFIC and NFIC can be used to monitor every detail such as commodity details, purchasing of raw materials, production and sales of product after sale service. With the help of IoT, one can track the inventory in the warehouse so that one can have information about stock, customer's satisfaction etc. and result in increased sales [21].

4) Data collection

If doctor become enable of having collection and transfer of data then it would help in reducing the them, minimizing the data collection error, automated care and routine auditing. It will also enable to transfer the previous health record of patients, which would result in accuracy of the medication given by doctor [20].

5) Smart water supply

Wireless network system will enable to monitor the water supply and will help to ensure that there is adequate water supply for the resident and business use. It will also help to discover if there is any water loss. In this way water leakage problem would be discover and help in water saving. Tokyo, for example, has calculated they save $170 million each year by detecting water leakage problems early [22].

The system can report pipe flow measurement data regularly, as well as send automatic alerts if water use is outside of an estimated normal range. This allows a smart city to determine the location of leaking pipes and prioritize repairs based on the amount of water loss that could be prevented.

6) Smart homes and offices

In recent time, human life is surrounded by thousands of electronic gadgets like microwave ovens, refrigerators, heaters, air conditioners, fan and lights. By installing actuators and sensors will assist to utilize the energy sufficiently and add comfort in life. These sensors will measure the outside temperature and even can determine the occupants inside the rooms and thereby control the amount of heating, cooling and flow of light etc. This practice would result in minimizing the cost and increase energy saving [23].

B. M2M and V2V Communication Domain

1) Industrial maintenance

It is necessary to monitor the temperature and vibrations of industrial motors and to detect the irregular operation in it. The sensors installed on these machines will keep industrial maintenance, by keeping the equipment running efficiently in a factory, cleaning, lubrication and repairs. This preventive maintenance is typically a vital part of industrial field. Companies waste billions due to inefficient maintenance management. This will help Companies to save money and time.

2) Smart cars

M2M communication and smart cars is a best way to minimize accidents. A pilot to operate remote control car in order to minimize car accident and reduce human error was developed by McGill University [24]. These driverless cars will provide functioning more than just safety such as they can save valuable time, reduce stress of driving etc. Some studies carried out by the Institute of Electrical and Electronics Engineers (IEEE) reveal that, by 2040, driverless cars will account for up to 75 per cent of cars on the road worldwide [22].

3) Smart grid

Smart grid is an electrical grid, which is designed to advance the efficiency of power transmission, and quality service to end-user. All the devices in this network are connected with sensor that regularly send the data related to power consumption to the central server. Central server determines the consumption pattern and amount of power. This will improve the production to achieve the transient power targets [13].

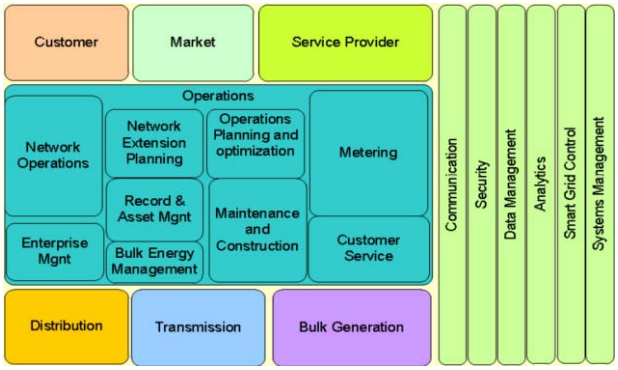

Figure 3. Smart grid conceptual model [25] NFC application domain.

4) Travelling

NFC has created a great ease in travelling; it can to minimize different checks at restaurants. For instance if a person book a room in hotel, a secret digital key would be provided to that person. By using that secret digital ticket, with NFC enable lock,a person can go to booked room without wasting time in lounges [26].

5) Health

NFC also plays a great role in monitoring personal health. It has information and data about health of patient and sends it to health monitoring center. By analyzing this data at health center, valuable information is provided to individual [26].

Figure 4. Internet of things applications and market [27].

IV. CHALENGES

TABLE II. PROJECTS AND RESEARCH ADDRESSING IOT KEY CHALLENGES [28]

IoT Challenge	Projects/Protocols
Architecture	IoT-A, IoT @ Work, EBBITS, BETaaS, CALIPSO, VITAL, SENSEI
Availability	-
Reliability	PERUM, RELY on IT
Mobility	IoT6, Open IoT, APEC IoV
Performance	Smart Santander, RELY on IT
Management	OMA Device Management (OMA-DM), LWM2M, NETCONF Light, Kura, MASHPlatform
Scalability	IoT-iCore, IoT6, SENSEI
Interoperability	IoT-iCore, PROBE-IT, Open IoT, Link Smart
Security and Privacy	IETF SOLACE, BUTLER, Codo, SVELETE

V. CONCLUSION

World has been changed completely due to Internet and Internet based application development. Interaction in all scenario becomes seems impossible without it. IoT has potential to broaden its horizon by enabling communication between smart objects. IoT will changed everything drastically if implemented successfully, But still there are

various issues which need thorough research to improve the quality of life. In this Paper, we have discussed various technologies with its specification that can result in making IoT a reality. In next section, we presented some handsome application of IoT and its comfort in life. Finally, some important issues that needed to be resolved have been discussed before wide acceptance of this technology.We finally conclude the need for new "smart" autonomic management, data aggregation, and protocol adaptation services to accomplish better integration among IoT service.

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