A Review Paper on Internet of Things (IoT)

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Abstract— The next wave in the era of computing will be outside the realm of the traditional desktop. The proliferation of devices with communicating-actuating capabilities is bringing closer the vision of an Internet of Things (IoT). Fuelled by the recent adaptation of a variety of enabling wireless technologies and embedded sensor and actuator nodes, the Internet of Things (IoT) has stepped out of its infancy and is the next revolutionary technology in transforming the Internet into a fully integrated Future Internet. The Internet of Things (IoT) has the potential to deliver solutions that dramatically improve energy efficiency, security, health, education and many aspects of daily life. It is the idea of automating the technology via which we can command and control systems. This paper presents vision and motivation for Internet of Things (IoT). It briefly describes the building blocks of Internet of Things (IoT) and puts light towards the integration of cloud and IoT. The paper even highlights the technological challenges and future directions in order to make IoT a reality.

Key words: Internet of Things, RFID, WSN, Cloud Computing

I. INTRODUCTION

The era of computing aims to reach the pinnacle of automation through the advancement in technology by Internet of Things (IoT). Internet of Things as the name says is the wireless network of large number of interconnected devices (things) that can communicate with each other without human intervention. This will happen when our environment will be embedded with sensors and technologies such as RFID (Radio Frequency Identification), WSN (Wireless Sensor Network) etc. will help us meet this challenge.

The term Internet of Things was first coined by Kevin Ashton in the year 1999 in the context of supply chain management. Although the definition of things has been changed as technology evolved the main aim of making computer sense information without the aid of human intervention remains same. As per GSMA, Internet of Things (IoT) refers to the use of intelligently connected devices and systems to leverage data gathered by embedded sensors and actuators in machines and other physical objects [4]. The data that will be gathered will require huge amount of storage space resulting in its dependability on cloud computing. A subset of IoT known as Machine to machine (M2M) communication already uses wireless network to connect devices to each other over the internet with minimal human intervention. The idea is to make everything smarter so that we can command and control the objects in our surrounding. The creativity of this new era is boundless with amazing potential to improve our lives.

This paper is a review paper on Internet of Things. The elements of IoT are summarized in section II. The relation between cloud computing and IoT has been specified in section III. The humongous applications of IoT have been described in section IV. Future of IoT in section V and challenges faced by IoT have been given in section VI.

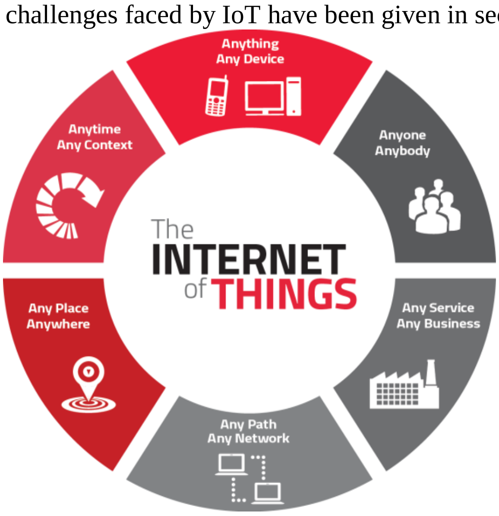

Fig. 1: Internet of Things

II. ELEMENTS OF INTERNET OF THINGS (IOT)

The Internet of Things encompasses many aspects of our life from connected homes and cities to connected cars and roads, roads to devices that track individual behaviour and use the data collected to push services [1]. The Internet of things in the near future will be used to refer to the general idea of things, especially everyday objects that are readable, recognisable, locatable, addressable, controlled via internet irrespective of the communication means as shown in figure 1. In this section, we discuss some enabling technologies that will aid IoT become a reality.

A. RFID (Radio Frequency Identification)

RFID is a wireless technology of transferring data by using electromagnetic fields in order to automatically identify and track tags attached to objects that contain electronically stored information as shown in figure 2. They aid in automatic identification of anything they are attached to acting as an electronic barcode. RFID is used to identify objects from a distance of few meters with a stationary reader typically communicating wirelessly with small battery free transponders attached to objects. It provides two basic and quintessential functions for an IoT i.e. identification and communication. The passive RFID tags are not battery powered and use the power of reader's interrogation signal to communicate the ID to the RFID reader. The passive cards are being used in many bank cards and road roll tags. A typical RFID microchip merely consists of hundred thousand transistors, contains no microcontroller and has minimal storage capacity usually just a few bytes. Instead of using a battery, passive RFID microchips are supplied with power from a reading device. Active RFID readers have their own battery supply and can instantiate communication as shown in figure 3. The RFID technology has not only contributed towards technical progress but also towards cost reduction and standardization and hence it is widely used.

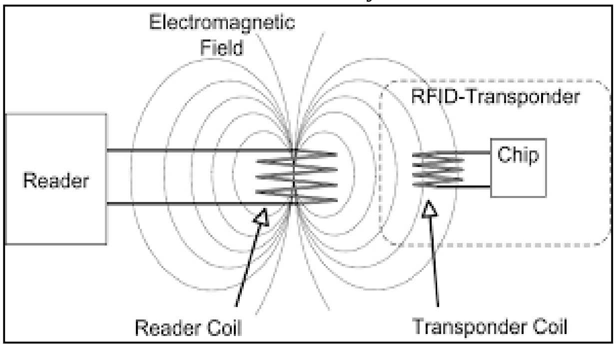

Fig. 2: RFID Basic Functioning

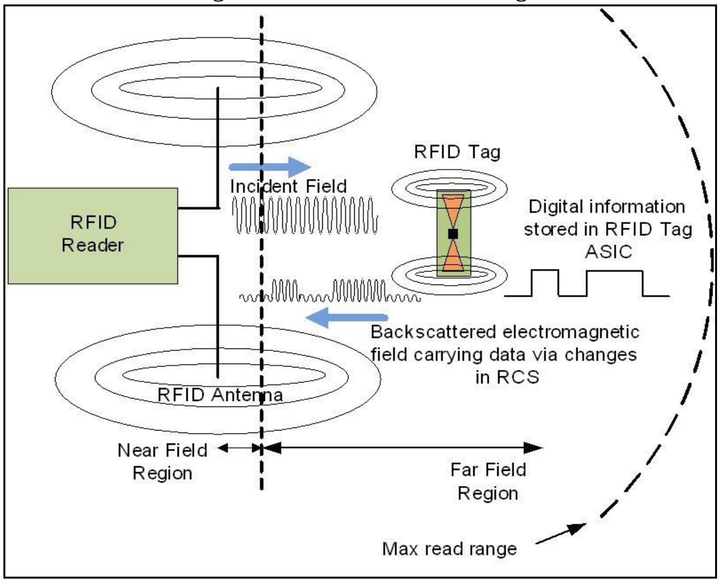

Fig. 3: RFID Communication

B. WSN (Wireless Sensor Networks)

The advancement and convergence of micro electromechanical systems (MEMS) technology, wireless communications and digital electronics has led to the development of miniature devices having the ability to sense, compute and communicate wirelessly over short distances. These miniature devices called nodes interconnect to form wireless sensor networks as shown in figure 4 and find wide ranging applications in environmental monitoring, infrastructure monitoring, and traffic monitoring etc. the components that make up the WSN monitoring network include:

1) WSN hardware: It contains sensor interfaces, processing units, transceiver units and power supply.
2) WSN communication stack: Nodes in WSN need to communicate among themselves in order to transmit data in single or multi-hop to a base station. The communication stack at the sink node must be able to interact to the outside world through the internet to act as a gateway to WSN subnet and internet.
3) WSN Middleware: It is a mechanism to combine cyber infrastructure with Service Oriented Architecture (SOA) and sensor networks to provide access to heterogeneous sensor resources in a deployment independent manner. It is based on isolating resources that can be used by several applications.

4) Secure Data Aggregation: In order to extend the lifetime of networks as well as reliable data collected from sensors, an efficient and secure data aggregation method is required. Ensuring security is critical as the system is linked to actuators and protecting systems from intruders is very important.

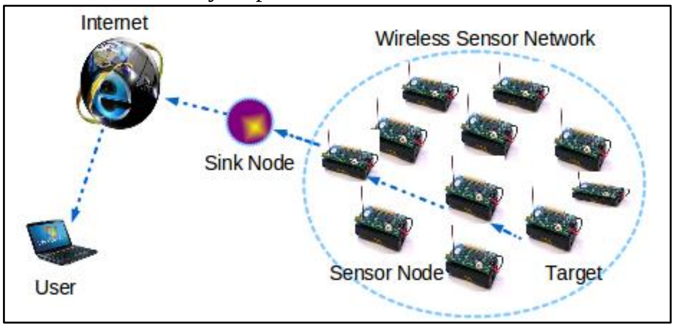

Fig. 4: WSN Communication

III. CLOUD COMPUTING AND INTERNET OF THINGS (IOT)

The two worlds of cloud and IoT have seen an independent evolution. On one hand, IoT can benefit from the virtually unlimited capabilities and resources of Cloud to compensate its technological constraints (e.g., storage, processing, and energy). Specifically, the Cloud can offer an effective solution to implement IoT service management and composition as well as applications that exploit the things or the data produced by them [2]. On the other hand, the Cloud can benefit from IoT by extending its scope to deal with real world things in a more distributed and dynamic manner, and for delivering new services in a large number of real life scenarios [3]. The complementarity and integration of Cloud and IoT has been given in the table1 below:

IoT	Cloud
Pervasive (things placed everywhere)	Ubiquitous (resources usable from everywhere)
Real world things	Virtual resources
Limited computational capabilities	Virtually unlimited computational capabilities
Limited storage or no storage capabilities	Virtually unlimited storage capabilities
Internet as a point of convergence	Internet as service delivery
Big data source	Means to manage big data

Table 1: Complementarities and integration of IoT

IoT involves a large amount of information sources that includes non-structured or semi-structured data having three typical characteristics of big data i.e. volume, variety and velocity. Hence it implies collecting, accessing, storing, sharing, archiving and searching large amount of data making cloud the most convenient and cost effective solution, offering virtually unlimited, low cost and on demand storage capacity to deal with data produced by IOT. Secondly, IoT devices have limited processing resources that do not allow on-site data processing. Data collected is usually transmitted to more powerful nodes where aggregation and processing is possible, but scalability is challenging to achieve without a proper infrastructure [6]. The unlimited processing capabilities of Cloud and its on-demand model allow IoT processing needs to be properly satisfied and enable analyses of unprecedented complexity. Thus a novel IT paradigm in which cloud and IoT are two complementary technologies merged together is expected to disrupt both current and future internet.

IV. APPLICATIONS OF INTERNET OF THINGS (IOT)

There are several application domains that will be impacted by the emerging internet of things as shown in figure 5. The applications can be classified on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact [5]. The Internet of Things will enable organizations in every industry to offer new services or change their business models. Some of the typical applications of IoT are given below:

- Smart Home and Smart Metering: IoT has large application in home environments, where heterogeneous embedded devices enable the automation of common in-house activities. Several smart-home applications proposed in literature involve (wireless) sensor networks and implement smart metering solutions to provide recognition of appliances, intelligent management of energy consumption, lighting, heating, and air conditioning.
- Healthcare: Smart devices, mobile internet and cloud services contribute to the continuous and systematic innovation of healthcare and enable cost effective, efficient, timely and high quality ubiquitous medical services. The services provided include chronic disease management, elderly care, wellness and fitness programs etc.
- Utilities (energy, water, gas): The application of IoT in this field include real time collection of usage data, local balancing, demand supply prediction, dynamic tariff generation etc. consumers connected to these smart networks have seen significant cost and resource savings.
- Manufacturing: Remote monitoring and diagnostics, production line automation, equipment handling and diagnostics through sensors located on the production floor etc. are some of the solutions provided by IoT. The outcome ranges from reduced field support costs, lower breakdowns to improved operational efficiency.

- Smart City: IoT can provide a common middleware for future oriented smart city services acquiring information from different heterogeneous sensing infrastructure accessing all kinds of geo-location and IoT technologies. A number of recently proposed solutions suggest to use Cloud architectures to enable the discovery, connection, and integration of sensors and actuators, thus creating platforms able to provision and support ubiquitous connectivity and real-time applications for smart cities.
- Automotive and smart mobility: As an emerging technology, IoT is expected to offer promising solutions to transform transportation systems and automobile services (i.e., Intelligent Transportation Systems, ITS). A new generation of IoT-based vehicular data Clouds can be developed and deployed to bring many business benefits, such as increasing road safety, reducing road congestion, managing traffic, and recommending car maintenance or fixing as shown in figure 6. The huge number of vehicles and their dynamically changing number make system scalability difficult to achieve. Vehicles moving at various speeds frequently cause intermittent communication impacting performance, reliability and Quality of Service.

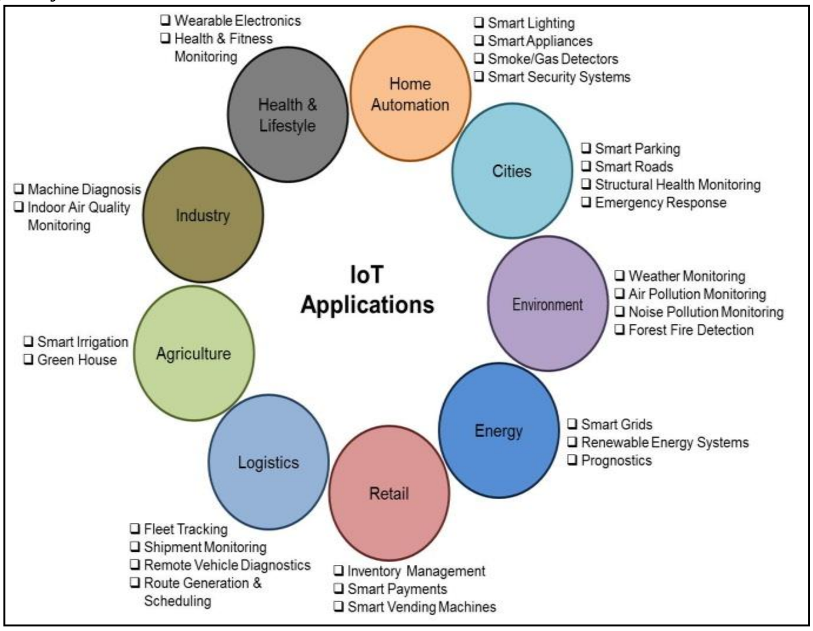

Fig. 5: IoT Applications

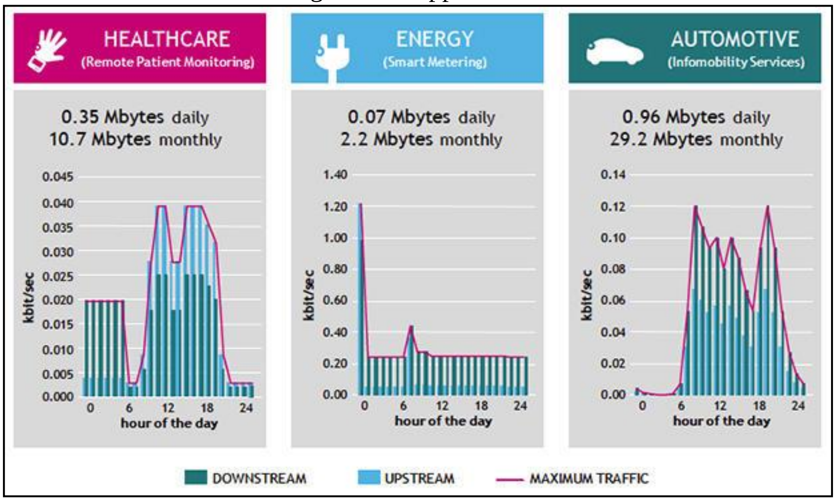

Fig. 6: Traffic Patterns for IoT Applications

V. TECHNOLOGICAL CHALLENGES AND FUTURE OF INTERNET OF THINGS (IOT)

A. Technological Challenges in IoT

While the possible applications outlined above may be very interesting, the demands laid on underlying technology may be substantial. In addition to the expectation that the technology must be available at low costs, if a large number of objects are actually to be equipped we are also faced with many other challenges such as:

- Scalability
- Interoperability
- Discovery
- Software Complexity

- Data Interpretation
- Security and Personal Privacy
- Fault tolerance
- Power supply
- Energy efficient sensing
- Integration of data from multiple sources
- Flexibility and evolution of applications

B. *Future of Internet of Things (IoT)*

- Quality of Service: Quality of Service in Cloud computing is another major research area which will require more and more attention as the data and tools become available on clouds. Dynamic scheduling and resource allocation algorithms based on particle swarm optimization are being developed. For high capacity applications and as IoT grows, this could become a bottleneck.
- New Protocols: The protocols at the sensing end of IoT will play a key role in complete realization. They form the backbone for the data tunnel between sensors and the outer world. For the system to work efficiently, an energy efficient MAC protocol and appropriate routing protocol are critical.
- GIS based Virtualization: As new display technologies emerge, creative visualization will be enabled. The evolution from CRT to Plasma, LCD, LED, and AMOLED displays has given rise to highly efficient data representation (using touch interface) with the user being able to navigate the data better than ever before. With emerging 3D displays, this area is certain to have more research and development opportunities.
- Cloud Computing: Integrated IoT and Cloud computing applications enabling the creation of smart environments such as Smart Cities need to be able to (a) combine services offered by multiple stakeholders and (b) scale to support a large number of users in a reliable and decentralized manner.

VI. CONCLUSION

The Internet of Things promises to deliver a quality change in an individual's life in the near future through widely distributed and locally intelligent network of smart devices. This paper presents a brief introduction of Internet of Things describing its elements such as RFID and WSN that would aid in making it a reality. Moreover the need for integration of cloud and IoT has been explained in this paper. The paper also focuses on wide ranging applications of IoT as well as the technological challenges and the future directions of IoT. Just as the internet phenomenon happened not so long ago and caught a wildfire, Internet of Things will soon touch every aspect of our lives in less than a decade.

ACKNOWLEDGEMENTS

I, express my sincere gratitude to all the contributors of this paper. Special thanks to all the authors of the papers mentioned in references section.

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