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Internet of Things (IoT) : Challenges and Future Directions

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Abstract: The growth potential for the embedded industry is enormous. And the path forward is becoming clearer every day. It's time that we start building IOT systems, and provide value to our customers.[1]. The IoT is expected to connect 28 billion "things" to the internet by 2020, ranging from wearable devices such as smart watches to automobiles, appliances, and industrial equipment [3]. In this paper , we will take a look at different IOT solutions developed so far, their functionalities and technology used and thus conclude the various challenges to be focused on to give way to better solutions that will help the community.

Keywords: Internet of things ,RFID , IPv6,Wireless Sensor Network ,Smart home.

I. INTERNET OF THINGS (IOT) : INTRODUCTION

The term of Internet of Things (IoT) was first invented in 1998 which is a network of networks where typically, a large number of objects or sensors are connected through communications and information infrastructure to provide value-added services. It assured in creating a world where all the objects around us are connected to the internet and therefore the communication to each other with minimal human intervention. The ultimate aim is to create a better world for human beings, where the objects around us understand our desire and hence act accordingly without any explicit instructions.[4]

According to another definition, The Internet of Things (IOT) has been defined in a variety of ways. Generally Speaking, it refers to a global, distributed network (or networks) of physical objects that are capable of sensing or acting on their environment, and able to communicate with each other, other machines or computers. Such 'smart' objects come in a wide range of sizes and capacities, including simple objects with embedded sensors, household Appliances, industrial robots, cars, trains, and wearable objects such as watches, Bracelets or shirts[2].

All these things have certainly changed the entire look of the word 'connectivity'. Internet of Things is highly on the rise and it can be observed from the areas that are completely under its effect. From smart cities, environment, health, energy, vehicle, transport, public safety to our daily essentials, Internet of Things has completely revitalized these areas.

II. FUNCTIONALITY OF IOT SOLUTIONS

IoT is sometimes understood as being synonymous with "smart" systems: smart wearable, smart homes ,smart city, smart environment, smart enterprises and so on.

This Section discusses the functionality review of IoT solution available in different sectors.

1. Smart Wearable: Smart wearable are networked devices that can collect data, track activities, and customize experiences to users' needs and desires.

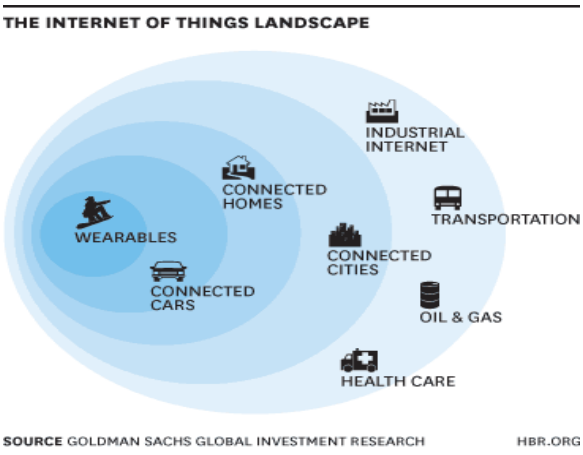

Figure 1 [3]

Wearable solutions are designed for a variety of functions as well as for where on a different of part of body such as the head, eyes, wrist, waist, hands, fingers ,legs or embedded into different element of attire. [4].Wearable devices can be classified according to two standards. One standard is based on product forms, including head-mounted (such as glass and helmet), body-dressed (such as coat, underwear, and trousers), hand-worn (such as watch, bracelet, and gloves), and foot-worn (such as shoes and socks). Another standard is based on product functions, including healthy living (such as sport wristband and smart bracelet), information consulting (such as smart glass and smart watch), and somatosensory control (such as somatosensory controller). [5]

2. Smart Homes: Smart Home is the integration of technology and services through home networking for a better quality of living. A Iot technologies related to Smart

Home are emerging.[6]. Solutions in this category make the experience of living at home more convenient and pleasant for the occupants. Some smart home solutions also focus on assisting elderly Hand (Gloves), Finger(Rings), Wrist(Watch/Bands), Eyes(Glasses), Legs(Socks), Foot (Shoes), Head (Helmet), Body(Cloth), Waist(Band), Chest(Band) people in their daily activities and on health care monitoring. Due to the large market potential, more and more smart home solutions are making their way into the market. From the academic point of view, smart energy and resource management, human–system interaction, and activity management have been some of the major focus.[7]

3. Smart City : A 'smart city' is an urban region that is highly advanced in terms of overall infrastructure, sustainable real estate, communications and market viability. It is a city where information technology is the principal infrastructure and the basis for providing essential services to residents. There are many technological platforms involved, including but not limited to automated sensor networks and data centers. Though this may sound futuristic, it is now likely to become a reality as the 'smart cities' movement unfolds. Urban IoTs, in fact, are designed to support the Smart City vision, which aims at exploiting the most advanced communication technologies to support added-value services for the administration of the city and for the citizens. The application of the IoT paradigm to an urban context is of particular interest, as it responds to the strong push of many national governments to adopt ICT solutions in the management of public affairs, thus realizing the so-called Smart City concept [8].

4. Smart Environment: The Smart Environment in a city comprises of Smart Governance, Smart Mobility, Smart Utilities, Smart Buildings.[9].Services enabled by the IoT paradigm in smart city environment might ranges from Monitoring health building, Management of waste, Monitoring air quality, Monitoring noise, Traffic congestion ,smart parking , smart lightning, water quality monitoring, ntural disaster monitoring ,smart farming and many more. For instance, Airqualityegg[10] is a community led sensor system that helps the community to have better air quality. AmritaWNA[11] is a wireless landslide detection system that is capable of releasing alerts about possible landslides caused by torrential rain in the season. There are many more solutions available providing diverse solutions in different areas mentioned above.

5. Smart Enterprise: Enterprise IoT solutions are designed to support infrastructure and more general purpose functionalities in industrial place. Current enterprise strategies already acknowledge a few interfaces to smart items, but with increased computational and communication capabilities of these items, the power shifts towards the edges of the network. Intelligent mechanisms for data aggregation, filtering, fusion and conversion can be deployed to and executed at the network edge, or within the network, as appropriate.

Software is already the key innovation driver in many industries and many new business models of the future will heavily rely on the use of such items. We see with the expanded definition of the Internet of Things many other interesting application domains. Some of the most promising ones are Manufacturing, supply chain integrity, energy and production, health, transportation and logistics. For Instance , Wattics[12] is a smart metering solution that manages energy consumption at the individual appliance and machine level. Canatalouspesys[13] allows the user to keep track of stocks in vending machine remotely. Timely and optimal replenishment strategies are determined from context info related to usage patterns. Engaugeinc[14] is a remote fire extinguisher monitoring system.

III. IoT : TECHNICAL BACKBONE

There are three IoT components which enables seamless pervasive computing : a) Hardware - made up of sensors, actuators and embedded communication hardware b) Middleware - on demand storage and computing tools for data analytics and c) Presentation - novel easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications.[15.The IoT covers a huge scope of industries and applications.

This Section focuses on some of the technologies that are driving the IoT, from popular communication options to the different software and data brokerage platforms managing the data exhaust from these systems.

1. Radio Frequency Identification (RFID)

A radio-frequency identification system uses tags, or labels attached to the objects to be identified. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response. The readers generally transmit their observations to a computer system running RFID software or RFID middleware. RFID tags can be either passive, active or battery assisted passive. An active tag has an on-board battery and periodically transmits its ID signal. A battery assisted passive (BAP) has a small battery on board and is activated when in the presence of a RFID reader.[16] It is more reliable, efficient, secured, inexpensive and accurate. RFID has an extensive range of wireless applications such as Road tolls, Building Access, Inventory, tracing, patient monitoring, military apps etc.

2. Wireless Sensor Networks (WSN)

A wireless sensor network (WSN) is a collection of distributed sensors that monitor physical or environmental conditions, such as temperature, sound, and pressure. Data from each sensor passes through the network node-to-node.[1].

The components that make up the WSN monitoring network include:

WSN nodes are low cost devices, so they can be deployed in high volume. They also operate at low power so that they can run on battery, or even use *energy harvesting*. A WSN node is an embedded system that typically performs

a single function (such as measuring temperature or pressure, or turning on a light or a motor).[1]

A WSN edge node is a WSN node that includes Internet Protocol connectivity. It acts as a gateway between the WSN and the IP network. It can also perform local processing, provide local storage, and can have a user interface.

WSN Technologies: There are multiple candidates that can be selected as WSN technologies .Few of them are discussed here**.**

• **Wi Fi -** The first obvious networking technology candidate for an IoT device is Wi-Fi, because it is so ubiquitous. Certainly, Wi-Fi can be a good solution for many applications. Almost every house that has an Internet connection has a Wi-Fi router. However, Wi-Fi needs a fair amount of power. There are myriad devices that can't afford that level of power: battery operated devices, for example, or sensors positioned in locations that are difficult to power from the grid.

• **IEEE 802.15.4 :** One of the major IoT enablers is the IEEE 802.15.4 radio standard, released in 2003. Commercial radios meeting this standard provide the basis for low-power systems. This IEEE standard was extended and improved in 2006 and 2011 with the 15.4e and 15.4g amendments. Power consumption of commercial RF devices is now cut in half compared to only a few years ago, and we are expecting another 50% reduction with the next generation of devices.[1]

3. Addressing schemes

The ability to uniquely identify Things' is critical for the success of IoT. This will not only allow us to uniquely identify billions of devices but also to control remote devices through the Internet. The few most critical features of creating a unique address are: uniqueness, reliability, persistence and scalability.

Every element that is already connected and those that are going to be connected, must be identified by their unique identification, location and functionalities. The current IPv4 may support to an extent where a group of cohabiting sensor devices can be identified geographically, but not individually. The Internet Mobility attributes in the IPV6 may alleviate some of the device identification problems; however, the heterogeneous nature of wireless nodes, variable data types, concurrent operations and confluence of data from devices exacerbates the problem further [15]
IPv6's addressing scheme provides more addresses than there are grains of sand on earth — some have calculated that it could be as high as 10^{30} addresses *per person* (compare that number to the fact that there are 10^{28} atoms in a human body!). With IPv6, it is much simpler for an IoT device to obtain a global IP address, which enables efficient peer-to-peer communication.[1]

4. Data storage and analytics

One challenge is that this highly measured world will create data at an astonishing rate, even if not all the data is or ever will be interesting or valuable. Storage, ownership and expiry of the data become critical issues. Hence data centers which run on harvested energy and which are centralized will ensure energy efficiency as well as reliability. The data have to be stored and used intelligently for smart monitoring and actuation.[15]. The primary value in an IoT system is in the ability to perform analytics on the acquired data and extract useful insights.

IV. CHALLENGES IN DEVELOPING IOT

This section discusses some of the major challenges that need to be addressed in order to build the IoT. The solutions for these issues need to be come from technological, social, legal, financial, and business backgrounds in order to receive wide acceptance by the IoT community.

1. Standards and interoperability

Standards are important in creating markets for new technologies. If devices from different manufacturers do not use the same standards, interoperability will be more difficult, requiring extra gateways to translate from one standard to another. In addition, a company that controls different parts of a vertical market (e.g. the acquisition of data, its integration with other data streams, and the use of those data streams to come up with innovative solutions or to provide services) may dominate a market, stifling competition and creating barriers for smaller players and entrepreneurs. Differing data standards can also tend to lock consumers into one family of products: if consumers cannot easily transfer their data when they replace one device with another from a different manufacturer, they will in effect lose any benefit from the data they have been accumulating over time.

2. Security. As the IoT connects more devices together, it provides more decentralized entry points for malware. Less expensive devices that are in physically compromised locales are more subject to tampering. More layers of software, integration middleware, APIs, machine-to-machine communication, etc. create more complexity and new security risks. Expect to see many different techniques and vendors addressing these issues with policy-driven approaches to security and provisioning.

3. Trust and Privacy. With remote sensors and monitoring a core use case for the IoT, there will be heightened sensitivity to controlling access and ownership of data. (Note that two recent high-profile security breaches at Target and Home Depot were both achieved by going through third-party vendors' stolen credentials to gain access to payment systems. Partner vetting will become ever more critical.) Compliance will continue to be a major issue in medical and assisted-living applications, which could have life and death ramifications. New compliance frameworks to address the IoT's unique issues will evolve. Social and political concerns in this area may also hinder IoT adoption.

4. Complexity, confusion and integration issues. With multiple platforms, numerous protocols and large numbers of APIs, IoT systems integration and testing will be a challenge to say the least. The confusion around evolving

standards is almost sure to slow adoption. The rapid evolution of APIs will likely consume unanticipated development resources that will diminish project teams' abilities to add core new functionality. Slower adoption and unanticipated development resource requirements will likely slip schedules and slow time to revenues, which will require additional funding for IoT projects and longer "runways" for startups. [17]

5. Evolving architectures, protocol wars and competing standards. With so many players involved with the IoT, there are bound to be ongoing turf wars as legacy companies seek to protect their proprietary systems advantages and open systems proponents try to set new standards. There may be multiple standards that evolve based on different requirements determined by device class, power requirements, capabilities and uses. This presents opportunities for platform vendors and open source advocates to contribute and influence future standards. [17]

6. Concrete use cases and compelling value propositions. Lack of clear use cases or strong ROI examples will slow down adoption of the IoT. Although technical specifications, theoretical uses and future concepts may suffice for some early adopters, mainstream adoption of IoT will require well-grounded, customer-oriented communications and messaging around "what's in it for me." Detailed explanations of a specific device or technical details of a component won't cut it when buyers are looking for a "whole solution" or complete value-added service. IoT providers will have to explain the key benefits of their services or face the proverbial "so what." [17]

V. IoT FUTURES

The acceleration of IoT from lofty concept to reality is predicated on the projected exponential growth of smart devices and the confluence of low-cost infrastructure, connectivity and data. Declining device costs, widespread and pervasive connectivity, and an ever-increasing focus on operational efficiency and productivity is leading to wide deployment of IoT solutions.[18] This rapid growth is based on expectations that the IoT will bring tangible benefits to businesses and consumers. Those benefits can take different forms for citizens, for businesses and for governments.

Consumers can get more personal product or service offers, based on what they actually do or where they are. They can travel more efficiently by avoiding traffic jams when their connected car suggests an alternative route ,based on traffic reported by other vehicles. They can save money by reducing energy usage or by paying lower car insurance premiums based on verified safe driving practices. They can be healthier, safer and more independent due to wearable devices that provide feedback on health or that monitor the elderly in the home.[2]

Businesses can provide better products and services by studying how customers behave; they can also discover needs for new products or services. They can protect buildings via remote security; secure assets like cars and machinery with location trackers and remote locking devices; and ensure that sensitive products (e.g. pharmaceuticals) are consistently stored in correct conditions. They can become more efficient, as in the case of utilities using smart meters to eliminate waste or loss, or in the case of equipment sellers providing just-in-time preventive maintenance.[2] Farmers can be more productive with smart irrigation that provides water just where and when needed. New business models based on selling final outcomes rather than just equipment may boost business revenues.[2]

Governments and public authorities can also benefit from the IoT. For example, health and long-term care costs can be reduced with better remote support for the elderly in their own homes. Road safety can be improved based on data from thousands of drivers. The efficiency of street lighting can be improved by dimming lights on empty roads[2]. As **governments** work to deliver quality services in increasingly complex environments, devices that have already begun to make life easier and more efficient for companies and consumers can also help create greater public value.

VI. CONCLUSION

The potential of the IoT appears to be great, despite the range of issues that need to be Addressed. This paper has sought to highlight the IoT concept in general through the four sections namely; section I, reviewed an overview about the IoT concept. Section II reviewed a set of the popular applications which are offered by IoT namely in the domain of Smart Homes, Smart Wearable ,Smart Environment, Smart Enterprises. Section III focuses on technical backbone for the realization of IoT. Section IV and V reviewed a set of challenges faced and future impact of Internet of things. Based on above ,It can be considered that new research problems arise due to the large scale of devices, the connection of the physical and internet worlds , the openness of the systems of systems, and continuing problems of privacy and security.

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