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Ipv6-Based Future Iot: Discovering Possibilities For Bettering Lives

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Abstract: Internet of Things is one of the major revolutions of Internet in the recent years. Internet of Things; abbreviated as IoT; is a drastic move from a human centric network; to a network where more devices are connected to the Internet; than human beings. IoT is a new trend in connectivity which is outside the realm of laptops and smartphones. IoT is a recent communication paradigm in which the items of everyday life are embedded with micro-controllers, transceivers for digital communication, and with suitable protocol stacks that allow them to communicate with one another and also with the humans. These networks connected items or devices use unique addressing schemes and are smart enough to share information with human, with the cloud-based applications and with each other as device to device communication; hence automating our tasks by lessening efforts to almost zero and providing us with exciting possibilities for better lives. It is estimated that in near future, the number of things are going to be many; and number of internet of things that are going to be connected; are also going to be many. This explosion in the number of these connected smart devices and things to the Internet will lead to a fundamental problem of address crunch where the number of addresses that could be assigned to each of these devices would run out. So, the current Internet Protocol; Internet Protocol version 4; IPv4; is definitely not a good solution. This situation leads to the invention and migration to a new Internet Protocol named Internet Protocol version 6; IPv6; which will provide almost unlimited number of IP addresses and would be a must requirement for the success of Internet of Things. This paper discusses an immaculate solution and driving force behind IoT; namely; IPv6. Paper also focuses on how IOT is providing us exciting possibilities for better lives.

Keywords: Internet of Things, X10, Z-Wave, ZigBee, UPB, Instabus, EnOcean, Tizen, Industrie 4.0, Smart Homes, Smart Wearables, Smart Cars, Smart Cities, Smart Industries, Internet Protocol version 4, Internet Protocol version 6, Radio Frequency IDentification System, Wireless Sensor Network, Virtual Private Network, Address Resolution Protocol.

1. Introduction

Internet of Things is advancing exponentially. IoT has been identified as one of the emerging trends that are shaping the development of technologies in ICT sector. IoT is a vision of shifting from an Internet used for interconnecting end user devices; the interconnected computers; to an Internet used for interconnecting the physical objects around us; the interconnected things. These interconnected physical things could be vehicles, buildings, machines, appliances and many other things. This interconnection of things will assist humans by not only providing safety, comfort and efficiency, but also by allowing better decision making and reducing expenses. IoT permits individuals and things to be connected anytime, anyplace with anything and anyone, preferably by using any path or network and any service [1].The term; Internet of Things; was first coined by Kevin Ashton, a British technology pioneer, in the year 1999 in the Auto-ID center of MIT while he was making a research on RFID [2]. Since then rapid research is going on to make IoT as our daily life style and hence transforming the way we live, work and play. IoT can be defined as an extension of Internet which

intends to integrate the cybernetic world of information technology with the physical world of things. This integration is possible by embedding devices of everyday life with micro-controllers, transceivers and suitable protocol stacks that permit them to communicate with one another and also with the humans. Each of these network connected devices need an Internet Protocol for any type of Internet connection and need a unique addressing scheme for its identification and location definition. One of such addressing schemes was Internet Protocol Version 4; IPv4. It was the first internet protocol that was released for public use. IPv4 provided address space of 32 bits and offered 4.3 billion unique IP addresses. With the speedy growth of Internet, it became obvious that 4.3 billion addresses are not sufficient for connecting new devices in the future and far more addresses, than IPv4 address space, are needed. Moreover, the speedy and massive explosion of smart mobile devices on the Internet as well as the broadband and cloud services, already utilized much of the available IPv4 addresses. The free global pool of IPv4 address space, administered by the Internet Assigned Numbers Authority (IANA), was already exhausted in 2011. In parallel to this, IoT was also growing rapidly and so the number of connected devices. CISCO predicts that by 2020, the number of internet-connected devices will increase to 50 billion [3]. Hence, next successor which is the IPv6 was born to solve address limitation problems of IPv4. IP version 6 was designed by the Internet Engineering Task Force to deal with unavailability of addresses under IPv4. IPv6 is the most recent internet protocol and provides a perfect solution for the Internet of Things by extending the address space of 32 bits to the address space of 128 bits. IPv6 provides 2128 unique addresses, which represents 3.4 X 1038 addresses or roughly more than 340 trillion of trillion of trillion addresses. This amount of addresses will be more than sufficient for the next coming decades and to make certain that each phone, tablet, smart car, smart bike, smart watch or smart pair of shoes, that is part of the IoT, can be assigned an IP address for many, many years to come. This move from IPv4 to IPv6 will simplify the networking world and will significantly affect the future of the Internet of Things and will provide us exciting possibilities for bettering our lives.

2. Amalgamation of Ipv6 with the Internet Of Things

IPv6 provides such a vast addressing space that every person on the Earth could utilize around 4000 usable IP addresses; which is more than enough to sustain the expected growth of IoT and for the generations to come. IPv6 provides an innovative solution to compensate the unexpected expansion of the Internet and acts as an innovative player for IoT including Smart Cities, Smart Grid, Mobile Internet, eGoverment, eEducation, eHealth and sensor networks services. IoT is envisioned as a network of billion individuals interacting with million e-businesses, using a trillion intelligent devices interconnected [4]. But an increased number of IP address is not the only advantage of IPv6 over IPv4. In addition to this large address space facility, Ipv6 in IoT makes it more secure and invulnerable to various kinds of attacks. With billions of different smart products being produced each day, security is a significant thought in the back of all IoT engineer’s minds. According to HP's Fortify security software unit, the Internet of Things, even as it leads in a new eon of luxury and automated convenience, may turn out to be a web of threat and exposure [5] [6]. Devices on the IoT usually converse through the use of unencrypted data, sometimes via a Wi-Fi network that can easily be hacked. So, IoT devices are greatly dependent upon robust and secure communication as the data gathered by device sensors can contain sensitive information. This is possible with the implementation of IPv6 in IoT. IPv6 has the ability that it can run end-to-end encryption. One of the primary components in IPv6 is the encryption and integrity-checking that is used in present virtual private networks (VPNs) and is offered for all connections and sustained by all compatible devices and systems. Extensive acceptance of IPv6 will hence make “man-in-the-middle” attacks considerably extra tough. In addition to this, IPv6 also provides more protected name resolution scheme [7]. The SEcure Neighbor Discovery (SEND) protocol is able to allow cryptographic authorization that a host is who it claims to be at the time of the connection. This reduces Address Resolution Protocol (ARP) poisoning and other naming based attacks become tougher. And since the IPv6 is not a replacement of application or service layer authentication, it still provides a better level of confidence and belief in the connections [8]. Moreover, with IPv6, it is very difficult for an attacker to redirect traffic between two legitimate hosts and modify the conversation or at least view it; unlike as with IPv4. In addition to this, in most of the cases, each interface has three types of addresses: an IPv4 address, a link-local IPv6 address and a global IPv6 address. This complicates the problem; and since complexity is the enemy of security, this complication increases security [9]. In addition to this, IPv6 can deliver end-to-end connectivity with a further distributed routing mechanism, thus, network mediators such as gateways are

eradicated and thus the network concentrates more towards routing and switching units. This leads to the reduction of security vulnerabilities, as security is not wrecked by middle entities; such as NAT-Network Address Translation routers in case of IPv4.Moreover, IPv6 is maintained by a huge community of users and researchers; including IPSec-Internet Protocol Security; that examines on-going improvement of IPv6 security features. These features of IPv6 including its larger capacity of addresses makes it a perfect solution for the growth of IoT [10]. Without the extensive global acceptance and successful deployment of IPv6 as the primary version of the Internet Protocol, the IoT would not be possible. In fact, the future of the Internet itself is at stake.

3. Subset of IOT Applications in Day-to-day Lives

The Internet of Things (IoT) is an extension of Internet which aims to integrate the virtual world of information technology with the real world of things. Internet of Things is characterized by diverse technologies, which coincide to provide several innovative services in various application domains. These domains can considerably improve our lives in various environments that are presently equipped with 'things' having only primitive intelligence. By permitting these things or objects to interact and share information, numerous applications can be deployed in several service fields including cultural, educational, medical, transportation, personal and working areas. Based on the type of network availability, heterogeneity, involvement of user, impact, repeatability, scale and coverage, the application domains can be classified into various categories [11]. The major three classifications of application domain are Personal and Home; Utilities; and Enterprise.

3.1 Personal and Home

3.1.1 SMART HOMES

'Smart home' is the term generally used to describe a home that has appliances, lighting, heating, air conditioning, television, computers, entertainment audio and video systems, security, and camera systems that are proficient of interacting with one another and can be managed remotely by an application from any site in the world by phone or internet. The IoT connected smart products assists in saving time, energy and money. The smart home technology also provides great benefits to the elderly citizens who live alone. They could be notified regarding the time to take their medicine, hospitals could be notified automatically if the resident falls or gets injured. A survey discovered that installing smart home technologies would be less expensive as compared to placing a senior citizen into a residential care or providing them 24/7 nursing [12]. This technology is also a great help for handicapped people or people with disabilities. The smart product are installed with one of the available protocols; namely; X10, Z-Wave, ZigBee, UPB, Instabus and EnOcean. The key concept behind smart home is that any device in the home that consumes electricity can be put on in the home network. The owner can then give commands to devices by using voice or a remote control or a tablet or using a smartphone. The most famous smart home to date is the home of Microsoft Chairman Bill Gate, Seattle, Washington. Each and every appliance of this home is pinned with an electronic tracking chip. These chips keep track of all the activities done and make adjustments according to the preferences. It is expected that in future the smart homes will be as common as our smartphones. Companies including Amazon, Apple and Google released their IoT enabled smart home products such as Amazon Echo, Apple HomeKit, and Google Home. Other companies such as Nest, August, Ring, Ecobee and many more are focusing on manufacturing IoT enabled household products. Table 1 illustrates examples of some of the smart products and their functions. Figure 1 shows some of the IoT enabled smart home devices.

Smart Product	Function
Camera	Track home exterior even in dark.
Dish Washer	Sends text message alerts when their cycle has ended.
Door Locks	Opens automatically as the authenticate person enters the home.
Irrigation System	Waters the lawns automatically as and when needed by exact amount of water.
LED Light	Lights are switched on as one enters the room and switched off as one leaves.
Motion Sensors	Sends alert message if there is a motion in the home.
Refrigerators	Creates dinner recipes based in the ingredients stored inside them.
Thermostat	The temperature of home could be set from anywhere in the world.

Table 1: Smart products and their functions (sorted alphabetically)

Figure 1: Some of the IoT enabled smart home devices

3.1.2 SMART WEARABLES

'Smart Wearables' are the electronic body-borne computational and sensory devices which can sense the person who wears them or may be their surroundings. Wearables can interact in two ways; either directly through embedded wireless connectivity or through another device such as a smartphone [13]. IoT connected wearables are in great demand all over the world. IoT enabled wearable technology is a hallmark of the Internet of Things and the most ubiquitous of its applications to date. According to the European Parliament Scientific and Technology Options (STOA) assessment panel, wearables are identified as one of the ten technologies which will change human lives. IoT enabled wearables can be either worn as an accessory as glasses or watches; or as fabric as smart jackets or gloves; or as patches on fingers, arms or foot; or can be implanted inside the body [14]. These sensors could measure heart rate, temperature, hydration and other body metrics in a more granular way. Companies including Fitbit, Pebble, Google and Apple have designed IoT enables smart wearables namely, Fitbit health monitor, Pebble smartwatch, Google glass and Apple watch. Figure 2 shows various product categories available for different requirements discussed above.

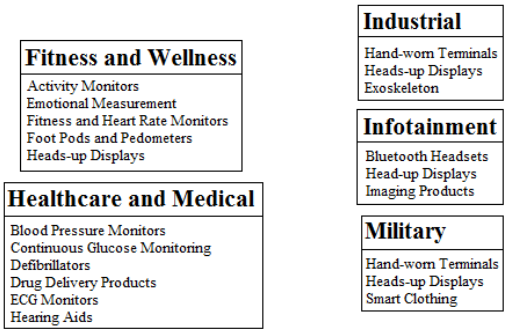

Figure 2: Wearable requirements with product categories

Figure 3 shows the three-level architecture of smart wearable devices. The first layer namely; wearable layer; consists of electronics that are placed closest to the body and that measure various body parameters such as temperature, heartbeat, pulse, movement etc. The second layer is the connectivity and control layer that consists of smartphones that act as an intermediate between the gadgets and the cloud and transfers information between them. The third layer is the cloud layer where the device supplies and reads data specific to the use case. Figure 4 shows some of the IoT enabled smart wearables.

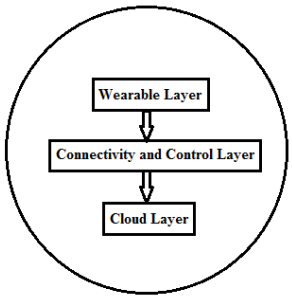

Figure 3: Three layer architecture of smart wearables

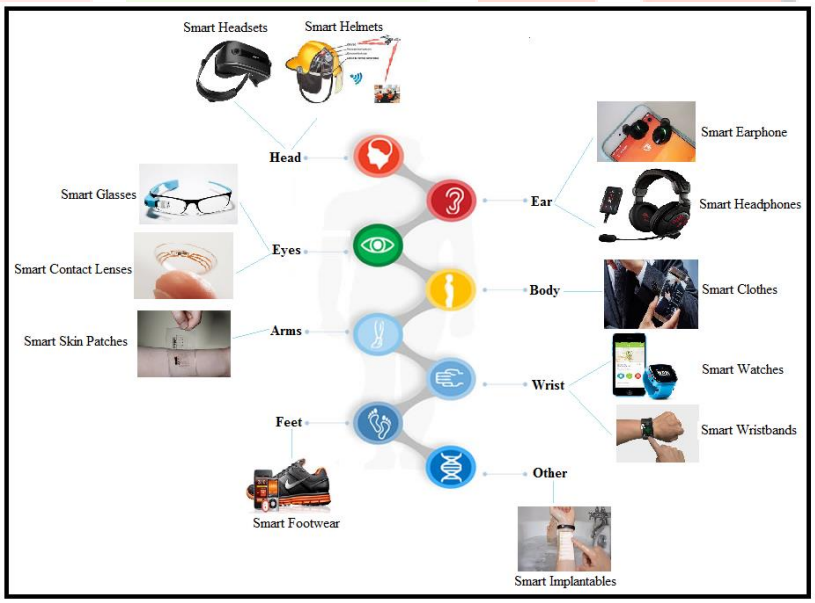

Figure 4: Some of the IoT enabled smart wearables

3.2 Utilities

3.2.1 Smart Cars and Vehicles

Companies are investing money into the Internet of Things, and one field of specific interest to financiers is IoT connected cars. Beyond the elementary perception of a connected vehicle equipped with Internet access, novel markets have emerged, such as Vehicle-to-Infrastructure (V2I), Vehicle-to-Vehicle (V2V), Vehicle-to-Cloud (V2C), Vehicle-to-Pedestrian (V2P), and Vehicle-to-Everything (V2X). The Internet of Things is

enabling a transformational change in automotive companies that are in a process of manufacturing cars known as connected cars. Connected cars are modernizing the automotive industry, car dealerships and the transportation policies. A connected car or a smart car is a vehicle which is able to enhance and optimize its own operations and maintenance keeping in view the comfort of passengers. This is achieved by the use of the onboard sensors embedded within the vehicle and internet connectivity that directs useful information regarding the vehicle to the automotive companies. The automotive companies, with the collaboration of software developers, use the information received from the vehicle to examine its performance and acquire valuable data on how the drivers are using their vehicles. Figure 5 shows various internal sensors that would be embedded inside connected vehicles.

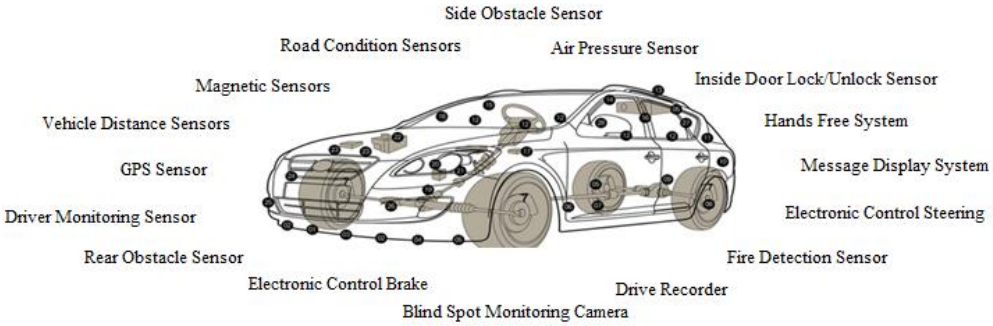

Figure 5: Sensors embedded inside IoT enabled cars

According to Sven Hammar, founder and chief strategy officer at Aprica, with the IoT the vehicles could be accessed remotely by the owners with the use an app to perform various functions such as adjusting vehicle temperature, checking the mileage or even starting the car. The major reason behind the advancement in smart cars is to provide a safer driving environment. It is expected that once cars start driving by them, traffic fatalities could be decreased 90% by 2050. Major brands like Tesla, BMW, Apple, Microsoft, Uber, Amazon, Mercedes, Bosch, Nissan, Audi and Google are working on bringing the next revolution of totally driverless vehicles. According to a survey conducted by Global Automotive Executive for 200 automotive executives in 2017, BMW is found to be the champion in manufacturing IoT enabled vehicles [15]. Not only the cars, but the public transportation including buses and trains will also be IoT connected in near future.

3.2.2 SMART CITIES

Another leading manifestation of the Internet of Things (IOT) is the smart cities. The world is entering a new era, where smart cities will play a significant role in solving the big challenges to meet objectives regarding socio-economic development and quality of life. With the use of sensors; either standalone or embedded into physical devices; data generated can be communicated, integrated and analysed to assist some aspect of city life to function better in some way. It is foreseen that in the near future the maximum world's population will live their lives in smart cities. The application of the IoT model to an urban perspective will thrust many national governments to implement ICT solutions to control public affairs and hence developing the so called Smart City concept [16]. The major goal here is efficient utilization of public resources, enhancing the quality of the facilities provided to the residents while decreasing the operational costs of the public administrations. IoT will assist in resolving key difficulties faced by the people living in cities like pollution, transportation overcrowding and scarcity of energy supplies etc. Internet of Things when applied to cities generates smart investigation, mechanized transportation, smarter energy management systems, smart water supply system, smart urban safety mechanisms and smarter environmental monitoring system. For example, by mounting sensors and using web applications, residents can find free available parking slots across the city. Also, the sensors can discover meter damaging issues, common malfunctions and any installation problems in the electricity system. Products like cellular communication enabled Smart Belly trash will send alerts to municipal services when a bin needs to be emptied. Figure 6 shows some of the application areas of smart cities.

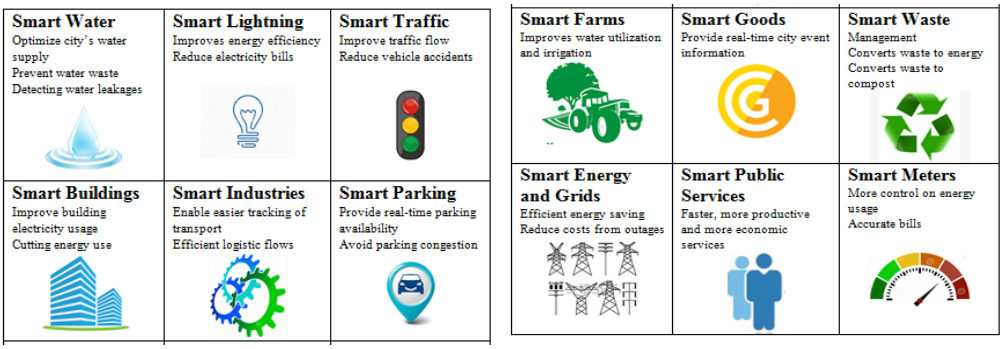

Figure 6: Areas of smart city applications

According to a survey, the Amsterdam is leading the world in smart city development. With the use of IoT in Amsterdam, the traffic on the roads has been decreased to great extent. Moreover, IoT has enabled energy savings and increased safety level of the people. Another city; Barcelona; implemented sensor technology and used the data analysis of traffic flows to design a novel bus traffic network. Santa Cruz used IoT technology to analyze the data of crimes in order to forecast the needs of police and to maximize the presence of police in required places.

3.3 Enterprise

3.3.1 SMART INDUSTRY (IIOT)

A new buzz in the industrial sector is the Industrial Internet; also termed as Industrial Internet of Things (IIoT) or Smart Industry or Smart Factory. Today, industries are progressing from cyber physical systems to the Industrial Internet of Things. The Industrial Internet of Things (IIoT) is the use of Internet of Things (IoT) technologies in manufacturing. IIoT is enabling industrial manufacturing with the use of sensors, strong connectivity, software, big data analytics and next generation of embedded devices; to generate brilliant smart machines. The IIoT is the root for an innovative level of organization and management of industrial value chains. IIOT facilitates extremely flexible and resource saving manufacturing as well as improved individualization of products at the cost of mass production. The key driving viewpoint behind IIoT is that the smart machines are extra accurate and reliable than humans in communicating through data that can assist companies to pick inefficiencies and problems faster. IIoT holds an extreme prospective for quality control and sustainability. Moreover, the apps for tracing goods, exchanging real time data regarding inventory among suppliers and retailers and the programmed delivery will increase the supply chain efficiency. In the IoT enabled industries, the products are fairly smart that they know their own individuality, history, description, documentation, and even regulate their own manufacturing process; through information in a barcode or RFID chip. These smart products do not only assemble records during their production but also when they are installed and used by the customers. The German government defines this policy as the subsequent industrial revolution under the title 'Industrie 4.0' [17]. A comparable initiative named 'The Smart Manufacturing Leadership Coalition' is also made in US to make factories smarter [18] [19]. According to a report by McKinsey Global Institute, connecting the physical and digital worlds could produce up to $11.1 trillion a year in GDP by 2025 [20]. IIOT is not a new technology; rather it is a collaboration of existing technologies and disciplines as shown in figure 7 [21].

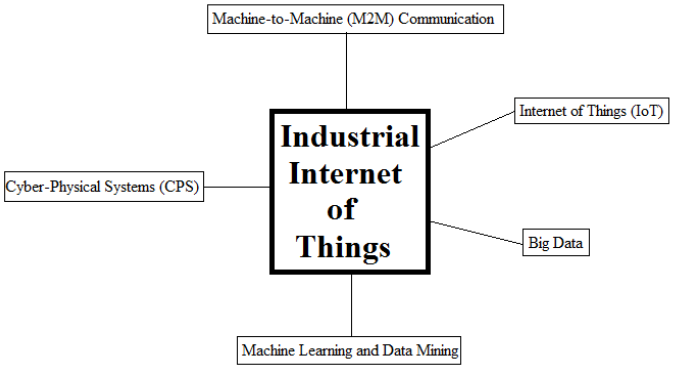

Figure 7: Existing technologies that collaborate to form IIOT [21]

4. Conclusion

The Internet of Things is considered as a new revolution of the World Wide Web. We have entered a life where electronic devices and machines are probably becoming our best friend. The IoT network not only benefits the one, but all, that is, individuals, society, stakeholders of business etc. by saving efforts, time and money. IoT can assist people with their everyday plans. The IoT, with the prospect of seamlessly integration the real and the virtual worlds through the massive deployment of embedded devices, has opened up many new domains of its applications. As the IoT world keeps on to growing at such a fast rate, its reliability on IPv6 is an obvious step in creating flawless device interoperability and communication. This paper discussed how IPv6 is an immaculate solution and driving force behind IoT. This paper included subset of domains of applications of IoT covering smart homes, smart wearables, smart cars, smart cities and smart industries. Even though IoT has not been applied according to the expectations of people, however, it is predicted that IoT with the integration of a number of innovative IT technologies, will change our societies significantly in coming 5 to 15 years.

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