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IOT usage in Mobile system and Ecosystem

Dr.C.Sureshkumar, Dr.S.Prabakaran, Dr.T.Prashanth, K.Varalakshmi

[1,2]Professor, Department of Computer Science and Engineering, PERI Institute of Technology, Chennai.

[3]Associate Professor, Department of Computer Science and Engineering, PERI Institute of Technology, Chennai.

[4]Assistant Professor, Department of Computer Science and Engineering, PERI Institute of Technology, Chennai

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Corresponding Author:
K.Varalakshmi

Abstract— Mobile technology opens the door for a new kind of learning called here and now learning that occurs when learners have access to information anytime and anywhere to perform authentic activities in the context of their learning. Mobile devices, applications and services have become integrated into people's daily lives on a personal and professional level. The purpose of this study was to investigate challenges &opportunities of IoT in mobile technology. The paper is divided in 5 sections and the content of the paper covers the history, elements, challenges and opportunities along with future of IoT specific to Indian Mobile arena.

Keywords: ***IoT, M2M, Mobile technology, Smart Devices, 5G.***

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I. INTRODUCTION

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.1 The Internet of Things (IoT) also describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools.

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyper connected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate.[2]

A. IoT Progress

First coined in 1999, the term refers to the giant network of connected things and people, all of which share data amongst each other. Today, IoT objects have come to include smartphones to automobiles and everything in between. The innumerable data points that billions of IoT devices capture each day are processed into actionable insights with the help of analytics. While the reciprocity between AI and IoT is relatively well known, there are other technologies at play that enable the Internet of Things.[5]

Different people call Internet of Things with different names but the objective of IoT is same in the broad sense. The aliases of Internet of Things include Web of Things, Internet of Objects, Embedded Intelligence, Connected Devices and Technology Omnipotent, Omniscient and Omnipresent. In addition to these, it has also calling as counting

a) Cyber Physical Systems "Integrations of computation and physical processes", in which bringing the real and virtual worlds together.
b) Pervasive Computing is a computer environment in which virtually every object has processing power with wireless or wired connections to a global network
c) Ubiquitous Computing or Calm technology, where technology becomes virtually invisible in our lives
d) Machine-to-Machine Interaction means no human intervention whilst devices are communicating end-to-end.
e) Human Computer Interaction involves the study, planning, and design of interaction between people and computers.

f) Ambient Intelligence is a developing technology that will increasingly make our everyday environment sensitive and responsive.

B. IoT enabled Systems

When planning an IoT application which is the first step in designing IoT systems, the selection of components of IoT such as sensor device, communication protocol, data storage and computation needs to be appropriate for the intended application. For example, an IoT platform planned to control heating, cooling, and air conditioning (HVAC) in a building, requires utilizing relevant environmental sensors and using suitable communication technology

Sensors: These are device that generate electronic signals from physical conditions or events. IoT devices have built in sensors to see, hear and touch the world around them, and hence, turn the physical information into digital data. Sensors are used to gauge variables like images, temperature, motion, proximity, pressure and so on.Sensors are the key drivers of IoT. They are employed to collect and transmit data in real- time. The use of sensors enhances effectiveness, functionality, and plays a critical role in success of IoT. Different types of sensors exist that are developed for various application purposes. The examples of these applications include agriculture industry, environmental monitoring, healthcare systems and services, and public safety.

Networks: IoT devices are essentially networked devices. The mechanism for communicating the electronic signal can be through a variety of wireless connections such as Wi-Fi, cellular, Bluetooth, near field communication (NFC), and satellite. IoT gateways or any device that joins the cycle of data collection, transmission, and processing. For example, an IoT gateway device enables routing the data into the IoT system and establishing bi-directional communications between the device-to-gateway and gateway-to- cloud.

Standards: These are the commonly accepted prohibitions or prescriptions for process framework. IoT devices follow uniform technical and regulatory standards that ensure network security, data protection, interoperability among different devices, and so on.

Augmented Intelligence: These are the cognitive tools that provide the ability to describe, predict, and exploit relationships in database. Meaningful analysis of big data charts out the way for corrective future actions through technologies such as computer vision, natural language processing, and speech recognition so on.

Augmented Behavior: This is the carrying out of prescribed action. Augmented behavoir manifests in the form of machine-to-machine (M2M) interface and machine-to-human interface (M2H).

Cloud Computing:Cloud computing is a way of making use of virtual computer worldwide,having the same personalized experiences. The different types of Cloud computing services are:

Saas (Software as a Service): Clients can access and use software at remote location using a web browser. Ex: Google documents

Paas (Platform as a Service): Clients can install, build and **modify** or control applications. Ex: App cloud, Google App Engine

IaaS(Infrastructure as a Service): Clients can use storage to install and manage operating systems and any desired **applications**.(i.e. Virtual machines + virtual storage)

Fog Computing: Although cloud computing is one of the best computing paradigms for data processing for IoT applications.

Due to the delay and bandwidth limitation of centralized resources that are used for data processing, more efficient ways are required. Fog computing is a distributed paradigm and an extension of the cloud, which moves the computing and analytic services near to the edge of the network. Fog computing is a paradigm that expands the cloud at a greater scale and can support larger workload. In fog computing, any device with computing, storage, and network connection capability works as fog node.

The examples of these devices include, but are not limited to, personal computers, industrial controllers, switches, routers, and embedded servers. In this computing paradigm, fog provides IoT data processing and storage locally at IoT devices instead of sending them to the cloud. The advantages of this approach include enhanced secure services required for many IoT applications as well as reducing network traffic and latency. Therefore, in contrast to the cloud computing, fog offers processing and computing services with faster response with higher security. This enables faster decision-making and taking appropriate actions.

Communication Protocols: It is the Backbone of IOT system which allows devices to exchange data over networks. It Defines data exchange formats, Data encoding, Addressing Schemes, Routing of packets from source to destination. It has other functions like - Sequence control (ordering data packets),Flow control (controlling transfer rate), Retransmission of lost packets.The communication protocols enable the different devices to communicate and share their data with the controllers or the decision making centers. IoT platforms offer the flexibility to select the type of the communication technologies (each having specific features), according to the needs of the application. The examples of these technologies include Wi-Fi, Bluetooth, ZigBee and cellular technology such as LTE-4G and 5G networks.

Big Data Analytics: It refers to the Collection of data whose volume, velocity or variety is too large and difficult to store, manage, process and analyze the data using traditional databases. Big data Analytics involves Data cleansing, Data munging (Data Wrangling), Data Processing and Data Visualization, Correcting, Removing, Replacing, Converting data from one format to other.The data analytics can be performed off-line after storing the data or it can be in form of real-time analytics. The data analytic is performed for decision making about the operation of the application. Based on the need, the data analytics can be performed off- line or real-time. In off-line analytics, the stored data is first collected and then visualized on premises using visualization tools. In case of real- time analytics, the cloud or edge servers are used to provide visualization, e.g. stream analytics.

II. IOT IN THE MOBILE NETWORKS

IoT can connect via 2G, 3G, 4G, or 5G networks. Depending on the needs of the IoT device and application, there are primarily two types of Cellular IoT connections, namely, LTE-M and NB-IoT which are the recent IoT specific variables. 2G and 3G are no longer used for mobile connectivity. According to a recent Gartner reporter by 2022, half of the Communication Service Providers (CSP) that have completed commercial 5G deployments will fail to monetize their back-end technology infrastructure investments, due to systems not fully meeting 5G use case requirements. Most CSPs will only achieve a complete end-to-end 5G infrastructure on their public networks during the 2025-2030 time frames. A 5G platform will impact many industries including automotive, entertainment, agriculture, manufacturing and IT.

More than 500 billion IoT devices, from sensors, to actuators, to devices, will be connected to the internet by 2030, according to research from Cisco. The data collected, aggregated, and analyzed by IoT devices will deliver insights across a wide variety of platforms and services, from health care to artificial intelligence innovations. 5G networks will be needed to meet the requirements of these data-intensive IoT devices and related cloud services.

A. 5G and IoT

The development of faster and more reliable networks, especially with the extensive rollout of 5G, accelerates the pace with which IoT deployment occurs. Due to this development, many vehicles are becoming increasingly connected, a trend that is forecast to continue both in the commercial and consumer connected car markets. Numerable studies that are trying to quantify and predict the material impact of Fifth Generation (5G) and the Internet of Things (IoT). Some of these focus on the cost aspect and others on the value to society. 3 However, even as these studies are ongoing, it is evident that 5G will spur innovation across many industries and provide a platform enabling emergent technologies such as the IoT to become an integral part of our economy and lifestyle.

5G is the foundation for realizing the full potential of IoT. While 5G is set for commercial availability sometime around 2020, the industry is already working to develop new global standards and pre 5G products to benefit industries everywhere. Ericsson AB's latest Mobility Report points out that there will be 550 million 5G subscriptions in 2022 and Asia Pacific will be the second- fastest growing region with 10% of all subscriptions being 5G in 2022.[4].

There is a sense of eagerness and urgency with respect to the arrival of 5G in India. The industry is likely to witness a timely arrival of 5G in line with global launches unlike 2G, 3G and 4G technologies. In order to understand the economics and performance, operators are taking intermediate steps to evolve from LTE to LTE-A and LTE-A pro in preparation for 5G. Some of the network suppliers have already commenced 5G trials with Indian operators. With 5G, operators can empower their entire facility, on and off-premises, seamlessly with one network for near-wireless operations and quicker adoption of new technologies.[6]

B. Communication Technologies

Wireless communication systems play the major role in activating IoT. Wireless systems connect the sensor devices to IoT gateways and perform end-to-end data communications between these elements of IoT. Wireless systems are developed based on different wireless standards and the use of each one depends on the requirement of the application such as communication range, bandwidth, and power consumption requirements. The short range wireless technology, e.g., Wireless Fidelity (Wi-Fi) for IoT applications in the energy sector has been widely studied. Low power wide area network (LPWAN) communication technologies suchas narrowband IoT (NB-IoT); ZigBee; Bluetooth low energy (BLE) technologies; as well as the emerging LPWAN technologies such as LoRa, Sigfox, and LTE-M operating in unlicensed band are better solutions to be used in the mobile sector. Because,these emerging LPWAN technologies enable establishing a reliable, low-cost, low- power, long-range, last-mile technology for smart solutions. A brief understanding of these short range wireless technologies is provided below:

Bluetooth Low Energy (BLE) is a short range wireless communication technology for IoT that enables exchanging data using short radio wavelengths BLE is less costly to deploy, with a typical range of 0 to 30 m, which enables creating an instant personal area network . BLE targets small-scale IoT applications that require devices to communicate small volumes of data consuming minimal power. Industries in the mobile sector with a well-designed IoT strategy can create new forms of machine-to-machine and machine-to-human communication using this technology.

Zigbee is a communication technology, which is designed to create personal area network and targets small scale applications. Zigbee is easy to implement and planned to provide low-cost, low-data rate and highly reliable networks for low-power applications. Zigbee also utilizes a mesh network specification where devices are connected with many interconnections. Using the mesh networking feature of Zigbee, the maximum communication range, which is up to 100 m, is extended significantly. In the energy sector, the example IoT applications of Zigbee include lighting systems (buildings and street lighting), smart grids, e.g., smart electric meters, home automation systems and industrial automation. These applications aim to provide approaches for consuming energy in an efficient way. In literature, aiming to minimize the energy expenses of the consumers, the research in evaluates the performance of home energy management application through establishing a wireless sensor network using Zigbee. It has been noticed that smart home interfaces to allow interoperability among ZigBee devices, electrical equipment, and smart meters to utilize the energy more efficiently.

Long Range (LoRa) is a wireless communication technology designed for IoT. LoRA is a cost-effective communication technology for large deployment of IoT, it can add many years to battery life. LoRa is also used to establish long-distance broadcasts (more than 10 km in rural areas) with very low power consumption.

Sigfox is a wide area network technology which uses an ultra-narrow band Sigfox allows devices to communicate with low power for enabling IoT applications. A study reviews the technological advances and presents Sigfox as one of the best low power candidates for smart metering for enabling real-time energy services for households. In addition, the study in compare different low power wide area network technologies and conclude that Sigfox is a suitable solution to be used with electric plugs sensors alert in smart buildings.

Narrowband IoT (NB-IoT) is a LPWAN communication technology that supports large number of IoT devices and services with a high data rate with very low latency. NB-IoT is a low-cost solution that has long battery life and provides enhanced coverage. Due to the latency features of NB-IoT, this technology is a potential solution for smart energy distribution networks by providing low-cost communications for smart meters.

Long Term Evolution for Machine-Type Communications (LTE-M) is the 3GPP (the third-generation partnership project) standardization, which is designed to reduce the device complexity for machine- type communication (MTC). LTE-M supports secure communication, provides ubiquitous coverage, and offers high system capacity. LTE-M also offers services of lower latency and higher throughput than NB-IoT.

Weightless is LPWAN open wireless standard that is developed to establish communication among great number of IoT devices and machines. Weightless is a suitable wireless technology can be used in smart home IoT applications for smart metering and smart grid communications.

Satellite is another communication technology that has a very wide-area coverage and can support low data rate applications in machine-to-machine (M2M) fashion. Satellite technology is suitable for supporting IoT devices and machines in remote places. A study presents an IoT-based machine-to-machine satellite communication that is applicable to the smart grid, particularly for the transmission and distribution (T&D) sector.

III. IOT ECOSYSTEM

M2M/IoT is an emerging area in the field of telecom technologies. In M2M communications, machines can be interconnected through a host of media like indoor electrical wiring, wired networks (Ethernets), WPANs (Bluetooth, Zigbee etc.), WiFi, PLC, PSTN/DSL, 2G/3G/4G and even satellites.

M2M ecosystem comprises of:

a) Telecom service providers

b) M2M application service providers

c) Sensors/hardware OEMs

d) Supply chain

e) Middleware

f) Deployment & asset management

Various Fixed and Mobile connectivity solutions are available as per the need for mobility and geographical spread to be covered.

The M2M architecture by oneM2M partnership depicts three layers:

a) Network services layer

b) Common services layer

c) Application layer: It comprises of Application entity (AE), Common services entity (CSE) and underlying Network services entity (NSE) functions. The data storage, applications and actuation may reside on the physical network entities, captive data center or cloud or in a hybrid mode.

A. Opportunities in IoT

M2M opportunities can be across many industry verticals/segments:

a) Transportation & Automotive

b) Utilities

c) Financial transactions in Retail

d) Home/Buildings

e) Security & Surveillance

f) Manufacturing

g) Healthcare

h) Consumer Electronics

i) Others - agriculture, mining, conservation of wild life/forests etc.

To realize any M2M based smart network. M2M communication is a key building block. A typical M2M network consists of the following building blocks:

GEOGRAPHICAL SPREAD →	NEED OF MOBILITY → FIXED	NEED OF MOBILITY → MOBILE
DISPERSED	**Applications** Smart Grid, Smart Meters, Smart City Remote Monitoring **Technology** PSTN Broadband 2G/3G/4G Power Line Communication	**Applications** Car Automation eHealth Logistics Portable Consumer electronics **Technology** 2G/3G/4G Satellite
CONCENTRATED	**Applications** Smart Home/ Smart Building Factory Automation eHealth **Technology** Wireless Personal Area Network Wired Network Indoor Electrical Wiring Wi-Fi	**Applications** On Site Logistics **Technology** Wi-Fi WPAN

Source: https://www.bisinfotech.com/wp-content/uploads/2017/12/Indian-telecom-getting-ready-for-M2M-IoT_- whitepaper.pdf

a) Wide area network

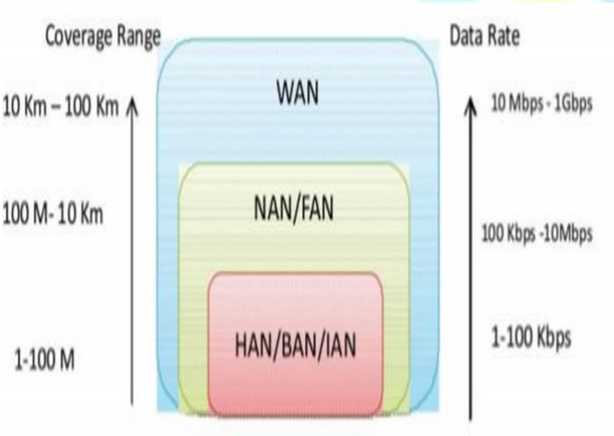
b) Field area network

c) Neighborhood area network

d) Home/Building area network

e) Local area network

All of the above are depicted below:



Source: https://www.bisinfotech.com/wp-content/uploads/2017/12/Indian-telecom-getting-ready-for-M2M-IoT_- whitepaper.pdf

B. Challenges of IoT

Building M2M network - In the Indian context, massive investment is required to build infrastructure along with better co-ordination and planning amongst various agencies. For e.g.: a) While planning/building roads, build ducts alongside b) While planning/constructing buildings, build communication ducts c) M2M network designs to be based on standards including selection of the communication technology. d) Ensure security & privacy

Integration of IoT with Subsystems: A main challenge includes the integration of an IoT system in subsystems of the energy system. Because subsystems of each sectors are unique employing various sensor and data communication technologies. Therefore, solutions are needed for managing the data exchange among subsystems of an IoT-enabled system. An approach for finding solutions for the integration challenge, taking into account the IoT requirements of a subsystem, pertains to modeling an integrated framework for the energy system .Other solutions propose designing co-simulation models for systems to integrate the system and minimize synchronization delay error between the subsystems .

User Privacy: Privacy refers to the right of individual or cooperative energy consumers to maintain confidentiality of their personal information when it is shared with an organization. Therefore, accessing to proper data such as the number of users as well as the number and types of appliances which use IoT becomes impossible. Indeed, these types of data which can be gathered using IoT enables better decision-making that can influence the energy production, distribution and consumption . However, to decrease the violation of users' privacy, it is recommended that the providers ask for user permission to use their information, guaranteeing that the users' information will not be shared with other parties. Another solution would also be a trusted privacy management system where consumers have control over their information and privacy is suggested.

Security Challenge: The use of IoT and integration of communication technologies in systems enhances the threat and cyber-attacks to information of users and the systems from production, transmission, and distribution to consumption. These threads define the security challenge in the every sector. Moreover, IoT- based energy systems are widely deployed in large geographical areas within the energy sector to offer services. The large deployment of IoT systems puts them in more risk of being under cyber-attacks. In addition, distributed control systems which enable control at different IoT system level are suggested to reduce the risk of cyber-attack and increasing the security of system.

IoT Standards: IoT uses a variety of technologies with different standards to connect from a single device to a large number of devices. The inconsistency among IoT devices that utilize different standards forms a new challenge. In IoT-enabled systems, there are two types of standards, including network protocols, communication protocols, and data-aggregation standards as well as regulatory standards related to security and privacy of data.

The challenges facing the adoption of standards within IoT include the standards for handling unstructured data, security and privacy issues in addition to regulatory standards for data markets. An approach for overcoming the challenge of standardization of IoT-based energy system is to define a system of systems with a common sense of understanding to allow all actors to equally access and use. Another solution pertains to developing open information models and protocols of the standards by the cooperating parties. This shall result in standards which are freely and publicly available.

Architecture Design: IoT-enabled systems are composed of variety of technologies with increasing number of smart interconnected devices and sensors. IoT is expected to enable communications at anytime, anywhere for any related services, generally, in an autonomic and ad hoc fashion. This means that the IoT systems based on their application purposes are designed by complex, decentralized, and mobile characteristics. Taking into account the characteristics and needs of an IoT application, a reference architecture cannot be a unique solution for all of these applications. Therefore, for IoT systems, heterogeneous reference architectures are needed which are open and follow standards. The architectures also should not limit the users to use fixed and end-to-end IoT communications.

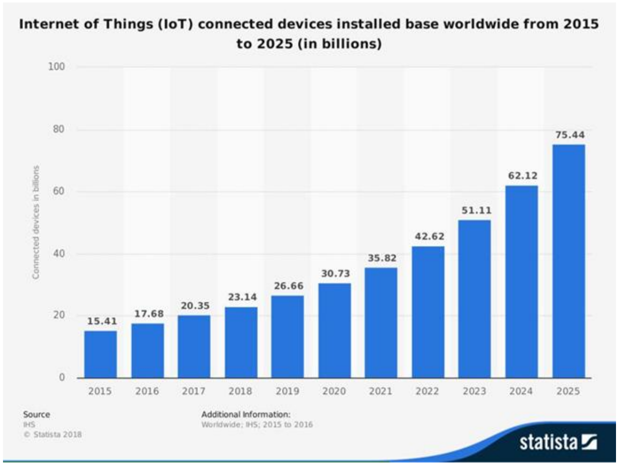
Green IoT: The energy consumption of IoT devices is an important challenge, especially in large-scale deployment of these technologies in near future. To run billions of devices that will be connected to the Internet significant amount of energy is required. The big number of IoT devices will also produce a great deal of electronic waste .To tackle these challenges, a low-carbon and efficient communication networks are needed. Fortunately, these necessities has led to the appearance of the green IoT (G-IoT).

The key component of G-IoT is its energy-efficient characteristics throughout the life cycle, i.e., design, production, deployment, and ultimately disposal .G- IoT cycle can be applied in different IoT technologies. For example, in radio frequency identification (RFID) tags. To decrease the amount of material in each RFID tag, which is difficult to be recycled, the sizes of RFID tags are reduced. Green M2M communications is another example, which enables adjusting power transmission the minimum level, facilitates more efficient communication protocols using algorithmic and distributed computing techniques In wireless sensor networks also the sensors nodes can be in the sleep mode and just work when necessary.

IV. FUTURE PROSPECT

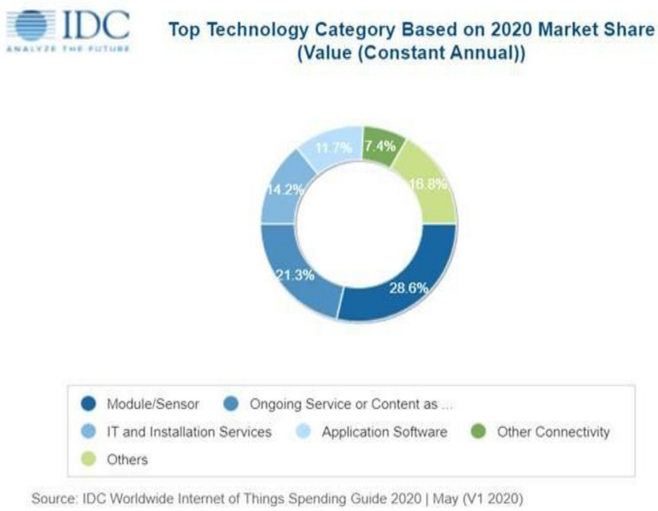
The mobile apps market is poised to grow by $ 653.91 billion during 2021-2025 worldwide, progressing at a CAGR of almost 21% during the forecast period. The mobile apps market is poised to grow by $ 653.91 billion during 2021-2025, progressing at a CAGR of almost 21% during the forecast period. The global smart retail devices market was valued at $17.43 billion in 2019, and is projected to reach $74.68 billion by 2027, registering a CAGR of 17.2% from 2020 to 2027. The future of IoT or where and what advancements that one can see in the IoT future or after 25 years is the scenarios where People will get addicted to Tech connections, Say no to Unplugging the Internet, Increase in Internet participants & they will be very common.

One thing is for sure the number of IoT or the Internet of Things devices will outnumber the total population of the earth. While we can even say that the Internet of Things or future of IoT is something which is increasing tremendously in an unexpected way. In the below graphical representation of the Statista, we can see the increased use of the Internet of Things or IoT connected devices from 2015 to 2025.



Source: https://www.softscripts.net/blog/2019/01/future-of-iot/

All the companies whose original works are related to IoT, cloud computing. Companies like Microsoft Azure, Amazon AWS. All these companies saw a tremendous increase in their sales and the revenue generation and exceeded all the targets set by them. So, we can see significant progress in the IoT security devices. As the purchase and sales of the Internet of things connected devices will increase and touch the peak instead of getting down. On the same side, the revenue of the companies is going to feel the skies.



The total installed base of Internet of Things (IoT) connected devices worldwide is projected to amount to 30.9 billion units by 2025, a sharp jump from the 13.8 billion units that are expected in 2021.For example, Retail stores are focusing on using the emerging technologies such as cloud, mobile, RFID, beacons, and others, to provide connected retail services and better shopping experience to customers. For instance, store owners are integrating sensors in the key zones of retail stores and connecting them to cloud through a gateway that enables real-time data analysis related to products, sales, and customers from the sensors. Factors such as increase in use of robotics and automation in the retail industry, rise in adoption of big data analytics & IoT in retail industry and surge in purchasing power of consumers and economic growth are the major drivers significantly affecting the market growth.

V. CONCLUSION

Technology has made life simpler in terms of comfort. Examples of IoT connections include connected cars, smart home devices, and connected industrial equipment. The introduction and subsequent adoption of a new generation of ecosystem-enabled smart home devices such as the Amazon Echo led to faster adoption of connected home devices than previously assumed. In comparison, non-IoT connections include smartphones, laptops, and computers, with connections of these types of devices set to amount to just over 10 billion units by 2025 – three times fewer than IoT device connections. As a result, revenue from the global IoT market is set to grow considerably in the coming years. Despite the ongoing Covid-19 pandemic, the market share for the IoT devices continues to grow. There are more IoT connections than non-IoT connections. By 2025, it is expected that there will be more than 30 billion IoT connections, almost 4 IoT devices per person on average.

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