Abstract

IoT is defined as a paradigm in which objects equipped with sensors, actuators and processors communicate with each other to serve a meaningful purpose. In the present scenario, IoT has gained a great consideration from researchers. It has becomes an important technology that promise a smart human being life. It allows communication between objects, machines and peoples together. IoT represents a system which consists a things in the real world, and sensors attached to or combined to these things, connected to the Internet via wired and wireless network structure. Internet, a revolutionary invention, is always transforming into some new kind of hardware and software making it unavoidable for anyone. The form of communication that we see now is either human-human or human-device, but the IoT promises a great future for the Internet where the type of communication is machine-machine (M2M). This paper aims to provide a comprehensive overview of the IoT scenario. By the technology of the IoT, the world will becomes smart in every aspects, since the IoT will provides a means of smart cities, smart healthcare, smart homes and building, in addition to many important applications such as smart energy, grid, transportation, waste management and monitoring . In this paper, we review IOT architecture, growth, some applications and challenges that have the potential to make a striking difference in human life, especially for the differently abled and the elderly.
I. INTRODUCTION

The term Internet of Things (IoT) was first coined by Kevin Ashton in 1999 in the context of Supply Chain Management. Kevin Ashton, co-founder of the Auto-ID Center at MIT, first mentioned the term Internet of Things in a presentation he made to Procter & Gamble (P&G) in 1999. During his presentation, he wanted to bring Radio Frequency ID (RFID) to the attention of P&G's senior management and he called his presentation "Internet of Things" to incorporate the cool new trend of 1999 i.e the Internet.

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. The essential idea of the Internet of Things (IoT) has been around for nearly two decades, and has attracted many researchers and industries because of its great estimated impact in improving our daily lives and society. When things like household appliances are connected to a network, they can work together in cooperation to provide the ideal service as a whole, not as a collection of independently working devices. This is useful for many of the real-world applications and services, and one would for example apply it to build a smart residence; windows can be closed automatically when the air conditioner is turned on, or can be opened for oxygen when the gas oven is turned on. The idea of IoT is especially valuable or persons with disabilities, as IoT technologies can support human activities at larger scale like building or society, as the devices can mutually cooperate to act as a total system. However, in the past decade, it has covered wide range of applications like healthcare, utilities, transport, etc.

IoT is also sometimes referred as Internet of Objects. The Internet has an impact on education, communication, entertainment, business, science, government, health and humanity. Internet is already one of the most powerful creations by human being and now with the advent of concept of IoT, Internet becomes more favorable to have a smart life in every aspect. Figure 1 and Figure 2 shows the basic concept and scope of IoT. It depicts that with IoT, anything will be able to communicate to the Internet at any time from any place to provide any services to anyone through network. This concept will create new types of applications such as smart vehicles, smart homes, smart health and smart environment etc.

![Figure 1: IoT Concept](image-url)
A quick search on the Internet tinted the following cases/applications under consideration:

- Machine-to-machine communication
- Machine-to-infrastructure communication
- Telehealth: remote or real-time pervasive monitoring of patients, diagnosis and drug delivery
- Continuous monitoring of, and firmware upgrades for, vehicles
- Asset tracking of goods on the move
- Automatic traffic management
- Remote security and control
- Environmental monitoring and control
- Home and industrial building automation
- “Smart” applications, including cities, water, agriculture, buildings, grid, meters, broadband, cars, appliances, tags, animal farming and the environment

The IoT technology is very much close to implementing smart environments by 2020 [3]. In the near future, storage and communication services will be highly pervasive and distributed. The people, machines, smart objects, surrounding space and platforms connected with wireless/wired sensors, M2M devices etc. will create a highly decentralized resources interconnected by a dynamic network of networks [4]. The aim of this paper is to present the IoT Architecture, IoT Growth, IoT Applications, IoT related technologies and IoT challenges.

II. IoT Architecture

The researchers have proposed different types of IoT architectures:-

3-Layer Architecture [5]
The most basic architecture is a 3-layer architecture as shown in Figure 3. The 3-layer architecture defines the main idea of the IoT. It has three layers:

- Perception Layer
- Network Layer
- Application Layer

The perception layer is the physical layer, which has sensors for sensing and gathering information about the environment. It senses some physical parameters or identifies other smart objects in the environment.

The network layer is responsible for connecting to other smart things, network devices, and servers. Its features are also used for transmitting and processing sensor data.

The application layer is responsible for delivering application specific services to the user. It defines various applications in which the IoT can be deployed, for example, smart homes, smart cities, and smart health.

![Figure 3: The 3-Layer Architecture of IoT](image)

5-layer architecture [5]

The 3-Layer is not sufficient for research on IoT because research often focuses on finer aspects of the IoT. That is why, we have many more layered architectures proposed in the literature. One of the is the 5-layer architecture as shown in Figure 4, which additionally includes the processing and business layers. The five layers are:

- Perception Layer
- Transport Layer
- Processing Layer
- Application Layer
- Business Layer

The role of the perception and application layers is the same as the architecture with three layers. We outline the function of the remaining three layers.

The transport layer transfers the sensor data from the perception layer to the processing layer and vice versa through networks such as wireless, 3G, LAN, Bluetooth, RFID, and NFC.

The processing layer is also known as the middleware layer. It stores, analyzes, and processes huge amounts of data that comes from the transport layer. It can manage and
provide a diverse set of services to the lower layers. It employs many technologies such as databases, cloud computing, and big data processing modules.

![IoT Architecture Diagram]

**Figure 4: The 5-Layer Architecture of IoT**

The business layer manages the whole IoT system, including applications, business and profit models, and users’ privacy. The business layer is out of the scope of this paper. Hence, we do not discuss it further.

Another architecture proposed by Ning and Wang [6] is inspired by the layers of processing in the human brain. It is inspired by the intelligence and ability of human beings to think, feel, remember, make decisions, and react to the physical environment. It is constituted of three parts. First is the human brain, which is analogous to the processing and data management unit or the data center. Second is the spinal cord, which is analogous to the distributed network of data processing nodes and smart gateways. Third is the network of nerves, which corresponds to the networking components and sensors.

### III. IoT Growth [7]

It is expected that by the year 2020, around fifty to hundred billion things will be connected electronically through Internet. Figure 5 shows the growth of the things connected to the Internet from 1988 and it further forecasts the connectivity up to 2020. Depending on who you talk to, the Internet of Things (IoT) is defined in different ways, and it encompasses many aspects of life: from connected homes and cities to connected cars and roads (yes, roads) to devices that track an individual’s behavior and use the data collected for “push” services. Some mention one trillion Internet-connected devices by 2025 and define mobile phones as the “eyes and ears” of the applications connecting all of those connected “things.”
IV. IoT Applications

IoT promises many applications in human life, making life easier, safe and smart. There are many applications such as smart homes, smart lighting, smart cars, smart health, smart transportation, smart parking and smart environment etc. as shown in Figure 6.

Brief description of some of the main application areas of IoT are given below:-

**Smart Cities [7]**

Smart cities mean cities of the future and having smart life in all aspects. Such cities require careful planning at every stage, with support both from governments and citizens to implement the IoT technology in every aspect. By connecting all systems in the cities like transportation system, healthcare system, weather monitoring systems etc., the cities will become smarter by means of the IoT as shown in Figure 7 and Figure 8.
In smart home/buildings, electronic and various electrical devices such as TV, air conditioner, CCTV cameras, lights, mobile devices, smart phones, tablets, fans etc. are usually supported by Wi-Fi. Many companies are considering developing platforms that integrate the building automation with entertainment, healthcare monitoring, energy monitoring and wireless sensor monitoring. By the concept of IoT, homes and buildings may operate many devices and objects smartly. The most interesting application of IoT in smart homes and buildings are smart lighting, smart environmental and media, air control and central heating, energy management and security as shown in Figure 9.
Smart Health [7]
The concept of smart health replaces the process of having a health professional come at home by regular intervals to check the patient’s vital signs, instead providing a continuous automated flow of information. Many peoples around the worlds are suffering from the bad health because they don’t have ready access to effective health monitoring and may be a suspected to be as critical situation patients. But with small, powerful wireless solutions connected through the IoT are now making possible for monitoring to come to these patients.

Smart Environment [7]
A close attention that required to hospitalized patients whose physiological status should be monitored continuously can be constantly done by using IoT monitoring technologies. For smart health, sensors are used to collect comprehensive physiological information and use gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review as shown in Figure 10.

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**Figure 9: Smart Home and Buildings**

**Figure 10: Smart Health**

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Environment plays a major effect in human life. Human beings, animals, birds, fishes and plants may be affected in unhealthy environment. Lots of researches have been done to solve the problems of environmental pollution and waste resources. The environment needs a smart ways and new technologies for monitoring and management. Smart environment is an important technology in our everyday life which provides many facilities and solutions for many environmental applications such as water and air pollution, weather and radiation monitoring, waste management, natural disaster, and many other environment indicators as shown in Figure 11.

![Smart Environment Diagram](image)

**Figure 11: Smart Environment**

Integration of Smart environment devices using IoT technology provide potential benefits to achieve a green world and sustainable life. There are many applications of IoT in environment and that can be divided to two main categories:-

- Environmental Resources Management
- Environmental Quality And Protection Management

The resources management relates to all natural resources include animals, planets and forests, birds and fishes, coal, petroleum, land, freshwater, air and heavy metals including gold, copper and iron. All these resources are likely to decrease significantly or affected by several factors, including pollution, waste, and abuse. IoT can provide an effective way to communicate between each of these resources through sensors so as to make appropriate decisions in the consumption of these sources. Renewable resources include sunlight, and wind also can be managed and sensed to Ideal use in several uses, such as the provision of renewable energy sources.

The IoT technology can monitor and manage the air quality by collecting data from remote sensor across the city, and providing full-time geographic coverage to achieve a way of better managing urban traffic in major cities. The IoT also can be used to measure the levels of pollution in water in order to inform decisions on water usage and treatment. Waste management is also one of the most important environment issues. The various
types of waste material chemical or elements can pollute the environment and threaten life in a number of ways in ground effect on animals, peoples and plants and in addition to air and water. IoT provides an environmental protection means by control the industrial pollution by real time monitoring and management systems integrated to supervision and decision-making networks to reduce waste, and improved environment. Other environment aspect is a weather forecast and monitoring. IoT can provide a high resolution, and accuracy for weather monitoring by data exchange and information sharing.

V. Who’s using it?
The IoT is more than just a convenience for consumers. It offers new sources of data and business operating models that can boost productivity in a variety of industries.

- **Health Care**
  Many people have already adopted wearable devices to help monitor exercise, sleep and other health habits – and these items are only scratching the surface of how IoT impacts health care. Patient monitoring devices, electronic records and other smart accessories can help save lives.

- **Manufacturing**
  This is one of the industries that benefit from IoT the most. Data-collecting sensors embedded in factory machinery or warehouse shelves can communicate problems or track resources in real time, making it easy to work more efficiently and keep costs down.

- **Retail**
  Both consumers and stores can benefit from IoT. Stores, for example, might use IoT for inventory tracking or security purposes. Consumers may end up with personalized shopping experiences through data collected by sensors or cameras.

- **Telecommunications**
  The telecommunications industry will be significantly impacted by the IoT since it will be charged with keeping all the data the IoT uses. Smart phones and other personal devices must be able to maintain a reliable connection to the Internet for the IoT to work effectively.

- **Transportation**
  While cars aren’t at the point of driving themselves, they’re undoubtedly more technologically advanced than ever. The IoT also impacts transportation on a larger scale: delivery companies can track their fleet using GPS solutions. And roadways can be monitored via sensors to keep them as safe as possible.

- **Utilities**
  Smart meters not only collect data automatically, they make it possible to apply analytics that can track and manage energy use. Likewise, sensors in devices such as windmills can track data and use predictive modeling to schedule downtime for more efficient energy use.
VI. IoT Challenges [7]

There are numbers of challenges with respect to the implementation of IoT technology. Following are few challenges which must be considered and addressed for successful IoT implementation:

- **Sensing a complex environment**
  Innovative ways to sense and deliver information from the physical world to the cloud

- **Connectivity**
  Variety of wired and wireless connectivity standards are required to enable different application needs

- **Power is critical**
  Many IoT applications need to run for years over batteries and reduce the overall energy consumption

- **IoT is complex**
  IoT application development needs to be easy for all developers, not just to experts

- **Cloud is important**
  IoT applications require end-to-end solutions including cloud services

- **Fault tolerance**
  Objects in IoT are much more dynamic and mobile than the internet computers, and they are changing rapidly in unexpected ways. Structuring an IoT in a robust and trustworthy manner would require redundancy on several levels and an ability to automatically adapt to changed conditions.

- **Scalability**
  IoT has a big concept than the conventional Internet of computers. Basic functionality such as communication and service discovery therefore need to function equally efficiently in both small scale and large scale environments. The IoT requires a new functions and methods in order to gain an efficient operation for scalability.

- **Self-Organizing**
  Smart things should not be managed as computers that require their users to configure and adapt them to particular situations. Mobile things, which are often only sporadically used, need to establish connections spontaneously, and able to be organize and configure themselves to suit their particular environment.

- **Data volumes**
  Some application scenarios of the IoT will involve to infrequent communication, and gathering information’s form sensor networks, or form logistics and large scale networks, will collect a huge volumes of data on central network nodes or servers. The term represent this phenomena is big data which is requires many operational mechanism in addition to new technologies for storing, processing and management.

- **Data interpretation**
  To support the users of smart things, there is a need to interpret the local context determined by sensors as accurately as possible. For service providers to profit from the disparate data that will be generated, needs to be able to draw some generalizable conclusions from the interpreted sensor data.
Interoperability
Each type of smart objects in IoT have different information, processing and communication capabilities. Different smart objects would also be subjected to different conditions such as the energy availability and the communications bandwidth requirements. To facilitate communication and cooperation of these objects, common standards are required.

Automatic Discovery
In dynamic environments, suitable services for things must be automatically identified, which requires appropriate semantic means of describing their functionality.

Software complexity
A more extensive software infrastructure will be needed on the network and on background servers in order to manage the smart objects and provide services to support them. that because the software systems in smart objects will have to function with minimal resources, as in conventional embedded systems.

Some other key issues involved are as under:
- Delivering Value to the Customer
- Hardware Compatibility Issues
- Data Capture Difficulties
- Analytics Challenges
- Data Security issues
- Data Privacy issues
- Wide range of Regulatory and Legal issues

VII. Conclusion
IoT is a new technology which provides many applications to connect the things to things and human to things through the internet. All networks and technologies of communication are used in building the concept of the IoT. Using this technology, many smart applications become real in our life, such as smart healthcare, smart homes, smart energy, smart cities and smart environments. IoT may face two major challenges in order to guarantee seamless network access; the first issue relates to the fact that today different networks coexist and the other issue is related to the big data size of the IoT. The IoT also promises future new technologies which are related to cloud, fog and distributed.

VIII. References


TO CITE THIS PAPER