

Study of IoT: Understanding IoT Architecture, Applications, Issues and Challenges

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ABSTRACT-The Internet of Things (IoT) is an emerging and challenging field for researchers. IoT is a network of general objects which are embedded with technologies that helps to communicate and interact within themselves and external environment. This in-turn provides intelligence to the objects to make people life comfortable. In this paper we discussed IoT, its architecture, Relationship between wireless sensor networks (WSN) and IoT. Further we explained different applications of IoT, Current IoT tools for users, IoT advantage, disadvantage and challenges. In this paper we also proposed an idea of using IoT in Indian agriculture domain.

Keywords—Internet of things, wireless sensor networks, sensor, architecture, Smart city, IOT Tools, Smart agriculture.

1. INTRODUCTION

Evolution of internet began by connecting computers. Later many computers were connected together which created World Wide Web. Then mobile devices were able to connect to the internet which leads to mobile-Internet technique. People started using the internet via social networks. Finally the idea of connecting daily objects to the internet was proposed, which lead to the Internet of Things technology [1].

First time the term -Internet of Things: word was used by Kevin Ashton in a presentation during 1998. [2]. He has mentioned -The Internet of Things has the potential to change the world, just as the Internet did May be even more sol. Later during 2001, MIT AutoID Lab center presented their view on IoT. Then during 2005, this is formally recognized by the International Telecommunication Union (ITU).

IoT creates a world where all the objects (also called smart objects) around us are connected to the Internet and communicate with each other with minimum human intervention. The ultimate goal is to create 'a better world for human beings', where objects around us know what we like, what we want, and what we need and act accordingly without explicit instructions.

Current research on Internet of Things (IoT) mainly focuses on how to enable general objects to see, hear, and smell the physical world for themselves, and make them connected to share the observations. In that sense, monitoring and decision making can be moved from the human side to the machine side.

Since IoT is considered as the networked connection of physical objects or devices. One of the definition of IoT by a researcher is [3]-An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environmentl.

With the help of the communication technologies such as wireless sensor networks (WSN) and Radio frequency

identification (RFID), sharing of information takes place [4]. So in general we can say IoT allows people and things to be connected Anytime, Anyplace, with anything and anyone using any network and any service as shown in fig 1.

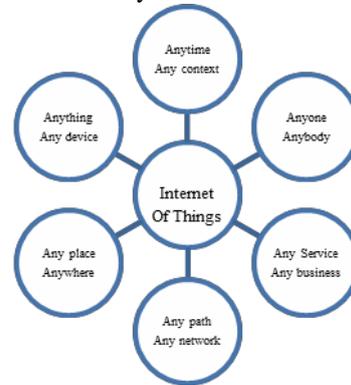


Fig.1 Definition of IoT.

Following table shows the relationship between sensor network and IoT. [5,6]

TABLE I: Relationship between Sensor networks and IoT

Senor Network	IoT
Sensor is a device, which collects data.	Devices or objects are made smart objects, which is connected to the internet.
Sensors are part of IoT.	IoT is combination of sensors, network and people
Data is collected using sensors.	Data is collected , later it is processed and decisions are taken
Especially sensors are used to monitor space, objects and human beings.	Here daily life objects are made intelligent, which alerts when something is wrong.

According to, Cisco Internet Business Solutions Group (IBSG) study, in 2003, there were 500 million devices[7] connected to the Internet and approximately 6.3 billion people were living. Explosive growth of smart phones and tablet PCs brought the number of devices connected to the Internet to 12.5 billion in 2010, while the world's human

population increased to 6.8 billion. It also predicts there will be 25 billion devices connected to the Internet by 2015 and 50 billion by 2020.

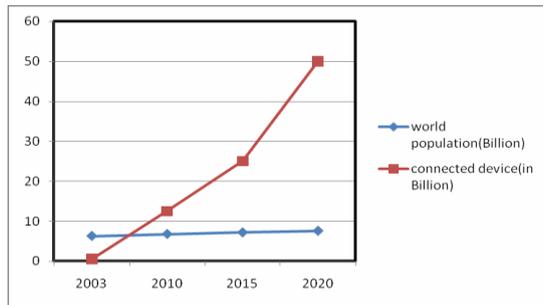


Fig.2: Year Vs world population and connected devices.

2. ARCHITECTURE OF IOT

Architecture of IoT [8] is broadly classified into 4 layers.

2.1 Sensor Layer

This is lowest layer of IOT Architecture, which consists of sensor networks, embedded systems, RFID tags and readers or other soft sensors which are different forms of sensors deployed in the field. Each of these sensors has identification and information storage (e.g. RFID tags), information collection (e.g. sensor networks), etc [9]

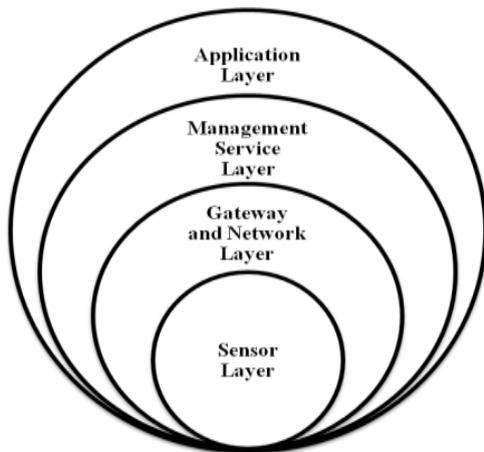


Fig. 3 Layered Architecture of IOT

2.2

ccess Gateway and Network Layer

This layer is responsible for transferring the information collected by sensors to the next layer. It should support scalable, flexible, standards universal protocol for transferring data from heterogeneous devices (Different types of sensor nodes). This Layer should have high performance and robust network. It should also support multiple organizations to communicate independently.

Management Service Layer

This layer acts as an interface between the Gateway - Network layer and the application layer; in bidirectional mode. It is responsible for device management and information management and responsible for capturing large amount of the raw data and extracting relevant information

from the stored data as well from the real time data. Security and privacy of the data should be ensured.

Application Layer

This is the top most layer of IoT which provides a user interface to access various applications to different users. The applications can be used in various sectors like transportation, health care, agriculture, supply chain, government, retail etc.

3 IOT APPLICATION DOMAINS

This technology has a lot of applications in various fields. Following are some possible areas where we can leverage the power of the Internet of Things (IoT) to solve day-to-day problems. However, it can be put to many more uses.

Smart society

Smart home

Now a day homes and offices use IoT technologies. Various electronic gadgets and HVAC systems such as lights, fans microwave ovens, refrigerators, heaters and air conditioners are embedded with sensors and actuators to utilize the energy sufficiently, monitor and control amount of heating, cooling and level of light, room light sense the presence of human beings and turn on when you enter, when fire or smoke detected at home, wireless smoke and carbon monoxide sensors sound alarms and also alert by phone or email and adds more comfort in life, which in turn minimize the cost and increases energy saving. [10]

Smart home automation

The IoT can be used to remotely control and program the appliances in your home [11]. It can be useful in detecting and avoiding thefts.

Smart City

On a broader scale, IoT technologies can be employed to make cities more efficient. The goal of smart cities is to leverage the IoT to improve the lives of citizens by improving traffic control, monitoring the availability of parking spaces, evaluating air quality and even providing notification when trash containers are full.

Smart Traffic

Currently the traffic management is a bigger issue in the metropolitan cities. Managing them manually has become almost impossible. This problem can be overcome by implementing IoT for traffic management. This smart traffic monitoring uses sensors to collect raw traffic data, which provides traffic update to driver, which helps him to make the decision for travelling better route. This also helps user to book a cab without phone call or pick up location and also shows cabs close and also their movement in real time.

Smart parking

Sensors will be placed in parking slots to know whether parking slot is available or not. The drivers park their vehicle looking into the application which provides the details of nearest parking slots available, parking cost based on the data collected and analyzed by the smart sensors which helps them to save time and fuel.

Smart waste Management

A trash bin embedded with sensors which are capable to analyze and alert the authorities when it is full and need to be emptied.

Smart Street light Sensors which can analyze the context such as time, season, weather conditions will be embedded within street lights which automatically turns light on or off and sets the dimming levels of individual or group of lights based on the context.

Smart water supply Smart cities must monitor water supply to ensure that there is adequate access of water for resident and business need. Wireless Sensor helps to monitor their water piping systems more accurately and discovers water leakage and alerts them about the water loss which in turn saves money and natural resource too.

Smart Environment
A very important application of IoT is detecting pollution and natural calamities. We can monitor the emissions from factories and vehicles to minimize air pollution. We can track the release of harmful chemicals and waste in rivers and the sea, thereby arresting water pollution. We can also keep tabs on the quality of water being supplied for drinking. We can send warnings of earthquakes and tsunamis by detecting tremors. We can keep the water level of rivers and dams under surveillance to be alert in case of floods. The detection of forest fire is also possible with this technology.

Air Quality Monitoring
By embedding sensors which collects context information such as amount of carbon monoxide (CO), nitrogen dioxide (NO₂) in the air, sound levels, temperature, humidity levels in the environment. This provides continuous information about the context, which helps to take the precaution if it exceeds the normal level.

Smart Water Quality Monitoring
Sensors which can detect context such as water quality, water flow, speed, temperature, water pollution, contents of water are placed or flowed in the water. This helps in real-time analysis and management of the water resources available for use.

Smart sewage water management
Embedded sensors in sewage tank, helps to control the overflow of the waste water flowing into; by continuously providing the information about the level of waste water stored. By these data, the maintenance people can schedule the water treatment process to avoid the overflow of sewage.

Natural Disaster Monitoring
Natural disasters such as earth quake, landslides, forest fire, volcanoes, flood, etc. can be predicted by using wireless detection sensors. These detections intimate the respective authorities to take the precautions before the disaster occurs.

Agriculture

3.3.1 Smart Farming

Context information such as current temperature, soil moisture conditions, leaf wetness, and solar radiation is collected and analyzed by the sensors, which in turn informs

the owner regarding the requirements of water, pesticides, manure, fertilizer or treatment for the infected plants.

Healthcare

Health tracking

The IoT is used in healthcare domain to improve the quality of human life by assisting basic tasks that humans must perform through application. Sensors can be placed on health monitoring equipment used by patients. The information collected by these sensors is made available on the Internet to doctors, family members and other interested parties in order to improve treatment and responsiveness. Additionally, IoT devices can be used to monitor a patient's current medicines and evaluate the risk of new medications in terms of allergic reactions and adverse interactions. With the use of sensors and the technology stated above we can track the person's body temperature, heart beat rate, blood pressure, etc. In case of emergency, the individual and their personal doctor will be notified with all the data collected by the sensors. This system will be very useful to senior citizens and disabled people who live independently.

Pharmaceutical products

Safety of pharmaceutical product is of utmost importance to prevent the health of patients. Attaching smart labels to drugs, and monitoring their status with sensors has benefits like maintaining the storing conditions, expiry of drugs which will prevent the transporting the expired medicines to the patients [12].

Food sustainability

Packed Food that we eat has to go through various stages of food cycle such as production, harvesting, transportation and distribution. Sensors are used to detect context like temperature, humidity, light, heat etc. which precisely notifies the variation and intimates the concerned persons to prevent the food from spoiling.

Supply-chains

Internet of Things monitors every stage of supply chain from purchasing of raw materials from the suppliers by the manufactures, production, distribution, storage, product sales and after sales services. This will help to maintain the stock required for continuous sale, which in turn results in customer satisfaction and increased sales [12]. According to Cisco's economic analysis, IoT will generate \$1.9 trillion from supply chain and logistics over the next decade[13]. By using this we can also diagnose if the machines require repair and maintenance.

Even the Indian Government has planned to develop 100 smart cities which cover some of the above mentioned IoT applications.

4 IOT TOOLS FOR USERS

IOT can also function as a tool that saves people's money and time. Some of the tools used are:

- HAPIfork[14]—Is an electronic fork to monitor and track the eating habits of user. When the user is eating too fast it alerts with the help of indicator lights and gentle vibrations.

- HeatWatch[15]- is a cattle monitoring solution that records the activities of animal which in turn helps farmer to breed more cows.
- Smart Traffic ParkSightis[16]: Is a parking management application to guide the driver regarding the availability of parking slots.
- SmartBelly[17] : is a smart waste management solution to alert authorities when the trash bin is full .
- Airqualityegg[18]: is an application which notifies the amount of air pollution.
- Aircasting[19] is a platform for sharing health (heart and breathing rate, pressure, etc.) and environmental data(temperature, humidity, sound level, air contents).
- G.Dontflush[20]- is an application to intimate peoples to reduce the usage of water when the sewage tank is full.
- Insightrobotics[21]- is a forest fire detection system.

Some other tools are bumblebee , Floating Sensor Network and Intelligentriver , MyVessylCup , Smart Tooth brush, Smart propane tank, Glucose monitoring, Smart Washing machines, Hydroponic System, Smart sprinkler Controller, Smart home security, Smart lightening, Smart a/c, Blood pressure monitor, Smart weather station, Smart slow cooker, Smart bike, Smart garbage cans, Smart gardening.

5 THE ADVANTAGES AND DISADVANTAGES OF IOT

Advantage

Communication

Since IoT has communication between devices, in which physical devices are able to stay connected and hence the total transparency is available with lesser inefficiencies and greater quality.

Automation and Control

Without human involvement, machines are automating and controlling vast amount of information, which leads faster and timely output.

Monitoring saves money and time

Since IOT uses smart sensors to monitor various aspects in our daily life for various applications which saves money and time.

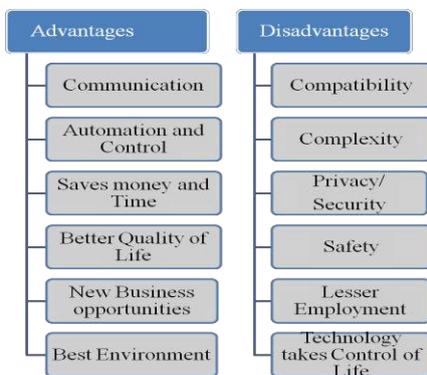


Fig.4 Advantages and Disadvantages of IoT

Better Quality of Life

IoT based applications increases comfort and better management in our daily life; thereby improving the quality of life.

New business opportunities

Creates new business for IoT technology, hence increases economic growth and new jobs .

Better Environment

Saves natural resources and trees and helps in creating a smart greener and sustainable planet.

Disadvantages

5.2.1Compatibility

As devices from different manufacturers will be interconnected in IoT, presently , there is no international standard of compatibility for the tagging and monitoring equipment.

5.2.1 Complexity

The IoT is a diverse and complex network. Any failure or bugs in the software or hardware will have serious consequences. Even power failure can cause a lot of inconvenience.

5.2.2.Privacy/Security

IoT has involvement of multiple devices and technologies and multiple companies will be monitoring it. Since lot of data related to the context will be transmitted by the smart sensors, there is a high risk of losing private data.

5.2.3 Lesser employment of menial staff:

With the advent of technology, daily activities are getting automated by using IoT with less human intervention, which in turn causes fewer requirements of human resources. This causes unemployment issue in the society.

5.2.4 Technology Takes Control of Life

Our lives will be increasingly controlled by technology, and will be dependent on it. The younger generation is already addicted to technology for every little thing. With IoT, this dependency will spread amongst generations and in daily routines of users. We have to decide how much of our daily lives are we willing to mechanize and be controlled by technology.

5.3 Challenges and issues

5.3.1 Scalability

Spontaneously various new smart objects or devices are getting connected to the network. So IoT should be capable to solve the issues such as addressing, information management and service management and also should support both small-scale and large-scale environments.

5.3.2 Self configuration

IoT objects should be programmed for self configuration to suit particular environment without manual configuration by the user.

5.3.3 Interoperability (Devices heterogeneity)

In IoT many smart objects are connected and each smart object has its own information collection capability, processing and communication capability. For communication and cooperation between the smart objects of different types; they should have common communication standard.

5.3.4 Software complexity

Since software systems in smart objects work with minimal resources, there is a need for software infrastructure to

support the network and requires a server on the back ground to manage and support smart objects of the network.

5.3.5 Storage Volume

Based on the scenario and context, smart objects collect either small amount of data or huge volume of data. So based on amount of data, storage has to be allocated.

5.3.6 Data interpretation

It's very important to interpret the context, that sensor has to sense. Context has important role for generating useful information and to draw a conclusion from the data sent by the sensors.

5.3.7 Security and personal privacy

In IoT, network formed by smart objects via internet, so providing security and privacy is a big challenge. In IoT, sometimes user prevent other user to access some particular information at certain time or preventing some communication or some transaction to protect secrete information from competitors. So handling all this situation is a big challenge.

5.3.8 Fault tolerance

In IoT, smart objects or devices are dynamic and rapidly context may change. But still network has to function properly automatically, to adapt to the changed conditions. So IoT has to be structured for fault tolerance and robust [22].

5.3.9 Ubiquitous data exchange through wireless technologies:

Issues such as availability, network delays, and congestion etc. of wireless technologies; which is used for communication of smart devices are big challenge.

5.3.10 Energy-optimized solutions

Network consists of many interconnected devices; which requires high energy to keep the network active. So energy optimization is the major aspect in IoT[23].

6 PROPOSED IDEA FOR AGRICULTURE

Traditionally in India farmer usually follows the following major phases for agriculture. They are Crop Selection, Land Preparation, Seed Selection, Seed Sowing, Irrigation, Crop Growth, Fertilizing and Harvesting. They were completely dependent on man power for all the above mentioned work. Now a day's finding the man power has become tedious task and even the profit is reduced. This has lead to the decrease the number of peoples completely involving in agriculture. A solution is necessary so that the owner being least dependent on others; can manage his own field and gain the best returns from what he grows.

6.1 How technology can help?

By using IoT in different phases of agriculture is a solution to the above mentioned problems. In this multiple sensors are embedded in the fields, which collects real-time information regarding weather, temperature, humidity, rain fall, soil moisture, soil composition, wind speed, wind direction, soil temperature, leaf wetness, air quality, predicting pest, crops, water level, which in turn, this predictive statistical data provides information to the owner to make smarter decisions. This information helps the

owner/farmer in crop selection, crop monitoring, crop maturity, crop yield, spreading of seeds, fertilizers, pesticides, soil erosion, crop yield, diagnosis of crop diseases.

Further IoT sensors enabled machineries could further improve yields. These leads to less man power, increased productivity and profit.

6.2 Present Tools for agriculture

CropIn technology[24] has developed a mobile application which takes input related to farm and helps in efficient maintaining and ensuring the crop quality in short duration. Precisionhawk[25] provides an application for the field of agriculture, which asses plant health, allocates water, detects weeds and monitor seasons.

Sensefly[26] provides eBee presision agriculture drone. This can capture high quality images of field, which in turn helps the farmer to take decisions.

Based on the survey, there are only few tools or applications are available for agriculture. So we propose the idea of embedding multiple sensors in the field which collects the information of crop health and detects the pests if any and this sensors collectively send the data through the gateway, which will be analyzed and results will be passed on to the smart phones of the farmers via application. Based on these data, farmer can accurately know the affected area and can take right decisions at right time.

Initially creating awareness regarding this new technology is very important. This can be done by providing free demo's and training to the farmers on how to use and the advantages of using this application and also providing them with free samples sensor kits. The opinion of usage and results of the application can be collected and analyzed for further improvement of application.

7 CONCLUSION

In this survey paper, we analyzed IoT domain by considering its architecture and applications and advantage and disadvantage. We observed that still IoT is not much used in the field of agriculture. So we find its very much necessary to improve the applications of IoT in this field and educate the same to the agriculturist, this will in turn reduces the dependency on man power and also will improve the yield which leads increase in the economy.

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