

INTERNET OF THINGS-IOT: OVERVIEW, ARCHITECTURE, FEATURES, APPLICATIONS

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Abstract

Internet of Things refers to the giant network of interconnected devices which can make decisions without any human intervention. It is basically a platform through which everyday things which are embedded with sensing equipment can be connected to the internet enabling them to collect and exchange data. The primary objective of this paper is to provide an overview of IoT, its key characteristics and detailed view of various stages of architecture of Internet of Things. This paper also includes several applications areas of IoT providing examples in those sectors of Internet of Things.

Keywords: *Internet of Things (IoT), Radio Frequency Identification (RFID), architecture, Data Acquisition System (DAS), Internet Protocol (IP)*



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Introduction

In 1999, the IOT concept was introduced by a member of the development sector of Radio Frequency Identification (RFID), and has recently become more applicable to the realistic world primarily due to the growth of smartphones, embedded and ubiquitous communication, cloud services and data analytics. Internet of Things can also be represented as network of networks.

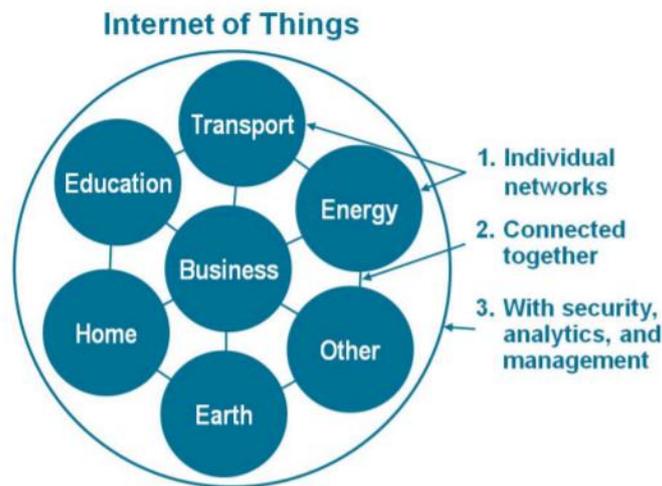


FIGURE 1: INTERNET OF THINGS AS NETWORK OF NETWORKS [2]

The “thing” in Internet of Things (IoT) represents any natural or man-made object to which IP (Internet Protocol) address can be assigned, and data can be exchanged over any network. The word IoT encompasses anything connected to the Internet, but it is mostly used to describe objects that talk with each other. These objects can be used to gather information and perform operations on themselves by interacting with each other when connected to the information sensing devices irrespective of communication means (whether it can be RFID, WLAN, WAN, or other means).

Architecture

The IoT architecture depends upon the functionality and implementation of IoT in various sectors. However, there is basic workflow of IoT process based on which it is built. The basic architecture of IoT is divided into 4 stages which include:

- 1) **Sensing Layer**- The sensing layer which is the lowest layer of architecture includes various sensing devices and actuators which are used to analyze, process, and send out data over the network. The sensors build a connection among physical and digital world and allow the real time information to be used for collecting and processing purposes. There are various types of sensors like body sensors, vehicles sensors and environment sensors which can be used to get information about temperature, air quality, blood pressure, flow and so on.
- 2) **Networking Layer**- The data collected by sensors need transportation medium to send data from one thing to another. This layer consists of network gateways and other networking technologies like Data Acquisition System (DAS) which can be used as

medium of transport. The function of DAS is to aggregate data and convert sensors analog data to digital data. Functionalities of network gateways include data filtering, malware protection, data management services, etc.

- 3) **Data processing Layer**- It is also known as the processing unit of IoT. In this layer, the data is analyzed and pre-processed before sending it to the data center. In this layer, various analytics tools are used to extract relevant information from large amount of raw data and process it. With the use of abstraction, only necessary information is extracted and used among various domains.
- 4) **Application Layer**- In this final layer of IoT, the data is managed by data centers and used by various end-user applications. The IoT applications include domains such as Agriculture, Healthcare, Environment, Energy, Lifestyle and many more.

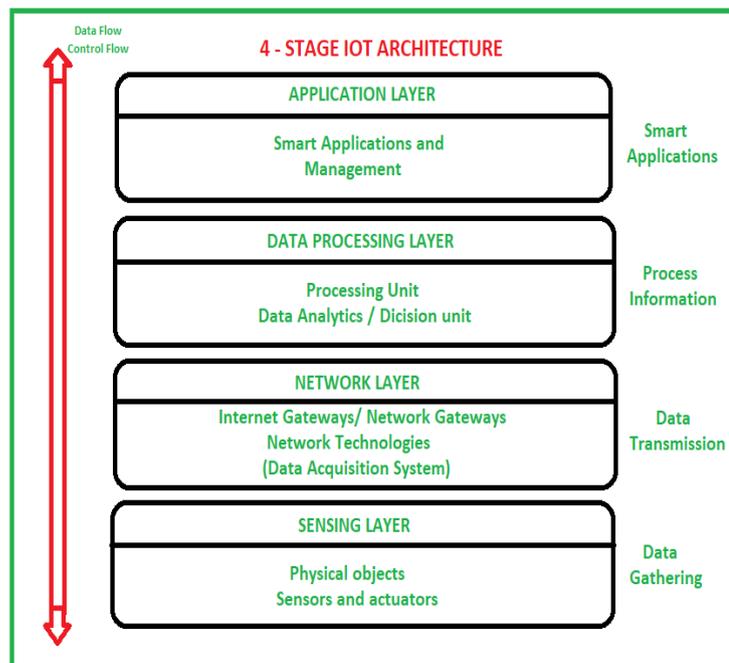


FIGURE 2: ARCHITECTURE OF INTERNET OF THINGS [16]

Features

There are numerous features of the IoT system which vary from one domain to another. Some common key features found during the research are:

- 1) **Connectivity**: The most important feature that one can consider in IoT is connectivity because it brings together everyday objects. Without efficient connectivity among the components of IoT which includes sensors, gateways, data hubs, etc. it is not possible to implement IoT projects. There are various options to connect IoT devices. It can be via

Bluetooth, Wi-fi, Radio waves, etc.

- 2) **Sensing:** It is not possible to implement IoT without the use of sensors. The analog signals generated by sensors are used for better understanding of a physical world. Without sensing devices, the changes in the physical environment cannot be measured or detected.
- 3) **Intelligence:** In today's world, every business use case requires important business decisions to be taken by data. Intelligence in IoT is the capacity to respond smartly in a business situation while performing specific tasks. The combination of algorithms, computations and software are the various aspects of IoT which makes it smart.
- 4) **Heterogeneity:** IoT should support direct connectivity among different networks because the devices can be connected on various hardware platforms through heterogeneous networks.

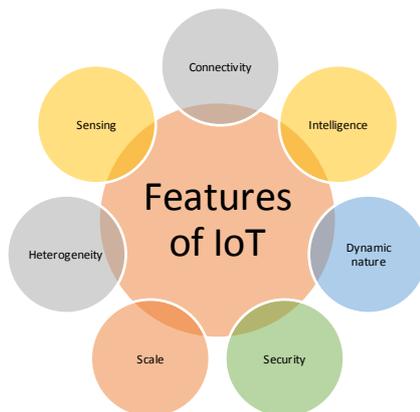


FIGURE 3: FEATURES OF IOT

- 5) **Dynamic nature:** IoT devices should be designed by thinking of the dynamic state of devices because there are several dynamic changes that take place around the devices while collecting and processing data. For example, change in temperature based on weather conditions, speed of car, and location of devices.
- 6) **Scale:** IoT can be used from small scale industries to large factories. So, the IoT devices should be designed depending upon current and future scale. Moreover, the devices should be scaled up and down easily on demand.
- 7) **Security:** One of the main elements of IoT ecosystem is safety and security. As there are many benefits provided by IoT, there is also privacy concerns associated with it. The highly sensitive information is sent through a network that needs to be secured while

transferring. The security can be obtained by adhering to proper security measures and firewalls should be used to protect the data from misuse and manipulations.

Applications

There are numerous applications of IoT. Figure 4 shows the IoT applications in various fields. These applications are explained as follows.

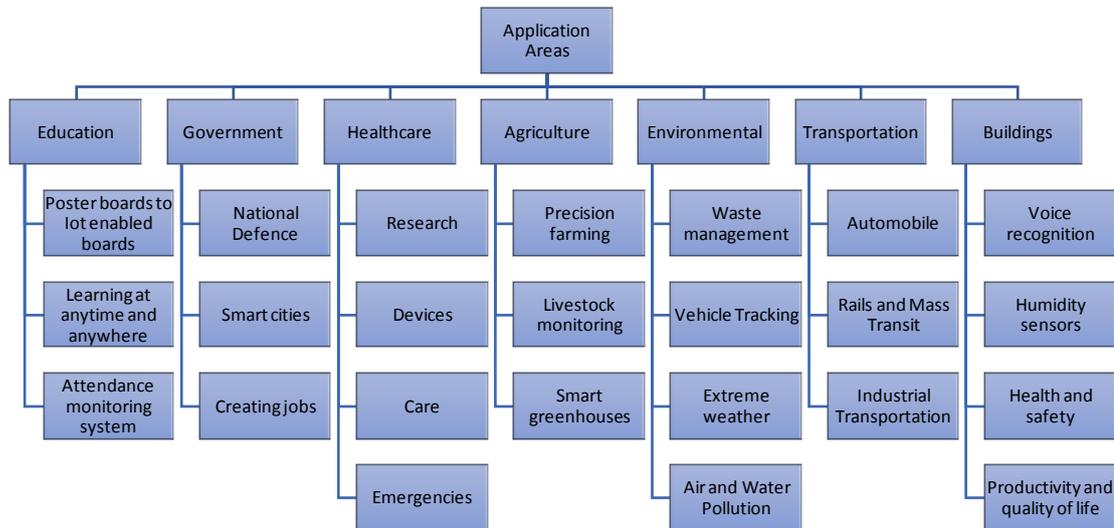


FIGURE 4: IOT APPLICATIONS

A. **Education:** In present-day colleges and schools, IoT has improved schooling a lot. Various IoT gadgets are used within the campus for faculties and to provide facilities to students discussed below:

- 1) **Poster boards into IoT enabled boards:** IoT enabled boards are also called prototyping boards/ development boards. It allows us to create digital posters having the facility of combining audio, videos, and pictures together which remains a problem in poster boards. Sharing of these posters is easier. These can be shared via e-mail and can be displayed using the poster's URL.
- 2) **Learning at anytime and anywhere:** IoT provides applications to students for learning at anytime and anywhere. Students can easily interact with teachers via these apps. One example of these kinds of apps is Edmodo which helps teachers to share lessons and keep parents updated. It also provides complete security and privacy to users.
- 3) **Attendance monitoring System:** It is the most important application used by schools and colleges to monitor the presence of students and faculties. It also saves time of publishing attendance facts and allows school administrators to send the email to parents regarding attendance.

B. **Government:** Several opportunities offered by IoT for the government to improve citizen services are as follows:

- 1) **National Defence:** A country faces various national threats almost everyday. IoT provides inexpensive and better performance gadgets to ensure the border safety.
- 2) **Smart cities:** Smart cities are growing in almost every part of the world. Smart cities are also known as “cities of future” where all the necessary applications which are city specific like traffic control, water management, air quality, waste management etc. are provided by IoT.
- 3) **Creating jobs:** IoT helps in monitoring and analysis of economics. It is also useful to find the possibilities of growth and obstacles in industries.

C. **Healthcare:** The existing healthcare technology can be enhanced by IoT systems in following areas:

- 1) **Research:** A lot of modern scientific work is based on services that lack important real-world information whereas IoT gives information real time analyses of data. Through offering more accurate and realistic data and better leads, IoT will provide meaningful data superior to standard analytics by integrated tools capable of conducting a viable analysis. In this way, research is one of the most significant healthcare IoT applications.
- 2) **Devices:** Even there are many healthcare devices nowadays which are beneficial in many ways but still they offer fewer benefits and qualities than the IoT enabled systems. IoT has power to provide us with better healthcare solutions by creating a logical system instead of carrying set of tools.
- 3) **Care:** Probably the best change IoT provides to healthcare is in the daily practice of medicine as it empowers healthcare practitioners to properly leverage their skills and experience to solve issues. They use much stronger data and resources, which allows them to view blind spots and encourages fast, accurate behavior. IoT helps healthcare practitioners to improve creatively, as they are essentially practicing their creativity rather than wasting hours on logistical activities.
- 4) **Emergencies:** Emergency aid programs have also had the issue of operating from limited resources and disconnecting from the base unit. IoT's digital technology and insights tackle this concern within the healthcare industry. It offers a method of evaluating an incident from miles away. It would also allow the patient exposure to more services until their delivery and provide them with essential care when arrived. In this

way, IoT is helpful in healthcare emergencies.

D. **Agriculture:** The global population is growing large in number and to feed the ever-growing population, the agriculture sector needs IoT. IoT will help farmer to face challenges like climatic change and extreme weather conditions which are due to intensive farming. It will also benefit farmers with increase in productivity and decrease in waste generation. Following are the benefits of IoT in agriculture sector:

- 1) **Precision farming:** Precision farming is a technique that makes the farming process more efficient and managed for livestock rearing and crop cultivation. In recent years, precision agriculture has become one of the most popular implementations of IoT in the agricultural field and many companies have begun to use this technique worldwide. IoT system's products and services include soil moisture probes, VRI optimisation, and so on.
- 2) **Livestock monitoring:** IoT apps help farmers gather data about their cattle 's location, condition and health. This data would allow them to classify their livestock health. Such as identifying infected cows so that they may isolate from the group, keeping the illness from transferring to the whole livestock. Ranchers efficiency of finding their cattle with the use of IoT-based sensors helps to minimize labor costs by a significant amount.
- 3) **Smart greenhouses:** Greenhouse farming is a technique that increases grain, vegetable, fruit yields etc. Greenhouses monitor environment parameters in two ways, either by manual interference or by a method of proportional control. An IoT enabled greenhouse system works intelligently without requirement of human intervention because human interference has demerits like energy loss, labour costs etc. These smart greenhouse systems can also be used to sense the environmental conditions like temperature, pressure, light requirements, humidity and control them according to plant requirement.

E. **Environmental:** The environmental applications of IoT are broad. In these applications, sensors are used for detection and measurement every change in the environment.

- 1) **Waste management:** The issue of waste management is very critical topic in big cities. To handle waste, a deeper integration in information and communications technology solutions would be required. For example, intelligent waste containers help define the amount of cargo the trucks carry and allow optimizing the collector trucks route, which will minimize the cost of waste collection and increase the efficiency of recycling.
- 2) **Vehicle Tracking:** Vehicle tracking facility is provided by IoT with the help of sensors that are useful to find the best parking place in the city. It is beneficial because it locates

the car at faster rate which is ultimately helpful for reduction in traffic and pollution problems.

- 3) **Extreme weather:** The current advanced systems used for weather forecasting are very powerful however they are suffering from the use of large instruments like satellites and radar systems. The IoT provide solution to this problem with better monitoring and accuracy of data. The early detection and fast response of IoT prevents damage to properties and lives.
- 4) **Air and Water Pollution:** Present air and water health monitoring technology mainly uses manual work along with specialized instruments, and laboratory testing. IoT enhances this technology by reducing the need for human work, allowing regular sampling, and monitoring, and enabling advanced on-site research. As a result, this technology will help us to reduce excessive contamination and the resulting disasters.

F. **Transportation:** IoT allows efficient communication, monitoring and transmission of data in transportation sector. Along with personal vehicles, commercial vehicles, trains, and other equipment, the application of IoT includes all transport elements such as traffic management, parking, fuel usage, and more.

- 1) **Automobile:** In the automotive industry a future for automobiles can be seen where IoT technology makes vehicles "smart," enticing choices equivalent to MRT. Smart automobile technology is not too far away from being a reality. IoT will appear to be a game-changer and close the distance between the automotive and software companies. Some applications of IoT under automobile are google maps for navigation and google assistance as voice assistance system, monitoring engine and break functionalities.
- 2) **Rails and mass transit:** Present systems have advanced integration and performance but use older technologies and MRT approaches. IoT's upgrades provide more comprehensive control and tracking. This leads to improved performance management, compliance problems, and overall improvements. IoT is an affordable and efficient means of improving productivity and taking MRT quality to other transport alternatives, such as buses. It increases managing resources and service quality, optimising travel times, reliability, handling maintenance problems and adapting to client demands.
- 3) **Industrial Transportation:** Transportation services apply to industry and production through the enhancement of organizations' transport branch. With better analytics and regulation, such as tracking fuel usage, traffic conditions, and travel time between

places, it reduces and removes issues related to bad fleet management. As a result, transportation system will be an aligned service instead of contracted offerings.

G. **Buildings/Houses:** IoT in building and house application areas enables us to simplify household and industrial activities. It also enhances quality of life and safety in less cost.



FIGURE 5: IOT APPLICATIONS IN BUILDINGS AND HOMES [18]

- 1) **Voice recognition:** Voice recognition plays a vital role in the whole lot from monitoring babies to regularly turning on and off light to robotically recognizing the speech of your canine at the door to opening it to your pet. Some commonly used sound detection sensors include the SEN-12462 and Easy VR shield.
- 2) **Humidity sensors:** Such sensors hold the capability of measuring levels of humidity in the air inside smart homes. The precision of the accuracy and sensing depends on several different factors, along with the general configuration and position of the sensor.
- 3) **Health and safety:** Certain health and safety issues can be suffered even after constructing buildings with care due to poor foundation, poor construction material and more. IoT offers solution to these minor issues in a fine-grained way before becoming major issues.
- 4) **Productivity and quality of life:** IoT helps people who desire comforts at houses and industrial places by allowing them fast and easy customization of facilities like temperature and lighting. Adjustments can be made to build an optimized environment like smart offices and kitchens.

Conclusion

IoT is the new revolution to the area of internet and is also a key research for the researchers in information technology and computer science due to its various applications and
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architecture. In this paper, the first section includes the introduction to Internet of Things. Architecture of IoT is discussed in another sector which includes four different stages in which data is analysed, monitored, processed, and send to the receiver at other end. Moreover, the various features of IoT are provided in this paper which are found important during research. Finally, the various applications depending on various sectors are provided in the paper.

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