TRENDS IN INTERNET OF THINGS (IoT) TECHNOLOGY

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Abstract
Internet of Things has become very essential technological tool and gaining wide acceptability globally due to the convenience, economy and effectiveness it adds to various life operations into which it is being applied. This study reviews how IoT has evolved till date and taking a look at the future of this technology. The objectives of the study include examining the technology upon which IoT was developed, various fields into which it has been implemented, its impacts and applications in essential fields, advantages and disadvantages of IoT in several fields of life. IoT has greatly impacted the manufacturing industries, agriculture and sports. IoT market will experience inconceivable increase in the future in that it is expected to be hybridized with artificial intelligence (AI) to facilitate effective security, domestic services and smart cities; with 6G/7G technology for effective telecommunications; with robotic technology for space and marine explorations. Security and interference issues across the complex network of things are some of the anticipated challenges but since no technology stands alone, others such AI will help to mitigate the challenges. Therefore, it is obvious that IoT will make all fields more efficient by ensuring security, enhanced productivity, education and boosting economy, leading to a smart world.

Keywords: Internet of Things, Security, Artificial Intelligence, Smart, Network

Introduction

Since Kelvin Ashton conceived the idea of Internet of Things IoT in 1999, the technology has developed and grown so fast and wide touching all fields and disciplines. Internet of Things IoT has opened the world to new phase of connectivity and real time communication between living and non-living things; it is the internet of everything (Ramasamy and Kadry 2021). It can be defined in three dimensions as internet of three things:

   i.   Internet of People to People
  ii.   Internet of People to devices
 iii.   Internet of devices to devices

Thus, Internet of Things (IoT) is a system of interrelated computing systems, machines, objects, animals or people given unique identities and capable of transferring data over a network without human interaction (Hajjaj *et. al.,* 2024). A thing in IoT may be a car with sensors to alert the owner when the radiator coolant is low or stale, a software monitoring the identity of internet users, human having an implant heart monitor, a farm animal/plant with biochip or any other object that could be assigned an Internet Protocol (IP) address and able to communicate over a network (Gillis, 2022; Adoeye, 2025).

This technology evolved from the Radio-Frequency Identification RFID, an earlier communication technology in which radio waves are used to read and capture information stored on tags attached to objects (living or non-living). RFID readers installed at tracking point can read information from the tags when they come into range which may be some meters away (Yalli *et. al.*, 2023). IoT, illustrated in figure 1 has built a communication platform where billions of objects are interconnected and sharing information over the internet. These objects which may be human, animals or inanimate objects are equipped with some levels of intelligence capabilities thereby autonomously sourcing for data, analyzing them and share with other objects anywhere in the world (Ramasamy and Kadry 2021; Yalli *et. al.*, 2023). The applications of IoT span across all fields of human endeavor; intelligent and smart systems in agriculture, military, medicine, transportation, telecommunication, building design and estate management, manufacturing industries, education, business and accounting just to mention few.

Figure 1: An illustration of Internet of Things and its components (Source: Stoltzfus, 2020)

History of IoT

Technologies never evolve in isolation, every emerging innovation is built on an existing technology, the same applied to IoT. Domotics products like X10 had been produced in 1974 and put to use before the internet as a home automation system that uses power line wiring for signaling and control. Early in 1990s (Himanshu *et al.,* 2020), Digital Desk conceived the idea of augment objects cooperating over the network and interfaces for tangible interactions. Towards the end of 1990s, the Auto-ID center lead the development of RFID tags laying the foundation for a world in which almost all objects could be uniquely identified and addressed on a global network (Bhargavan *et. at.* 2021).

The internet which was introduced in 1989 came to public use in 1990. Taking advantage of the internet, John Romkey designed an internet based device: a toaster that could be activated and deactivated with the internet and Steve Mann developed Wearcam in 1994 which operate in real time with 64bit microprocessor system (Ramasamy and Kadry 2021). In 1999, Kelvin Ashton of Auto-ID center at MIT where RFID-based systems used

in identification of objects were being developed saw the future of interconnectivity of things on the internet and coined out the words "Internet of Things". The IoT which was actually born in 2009 had had around 12.5 billion objects and devices connected to the internet by the middle of 2010. By the middle of 2021, over 46 billion mart devices had been online which is expected to grow to 90 billion in 2026 (Bernard, 2021)

Architecture of IoT

The architecture is the framework that IoT is built upon, it is usually in phase which allow the administrator to manage and support the IoT devices (Alabadi *et. al.*, 2022). It refers to the main components; sensors, actuator, cloud services, network protocols and layers that make up the IoT network system. Iot architecture ensures that data is obtained from the right source, processed correctly and transmitted to where they are needed. Although there is no globally accepted standard architecture in that every IoT system is designed based the intended solution it is built to provide. As shown in figure 2 and 3, there are four basic layers that could be recognized in any architecture (Awais and Iqbal 2023).
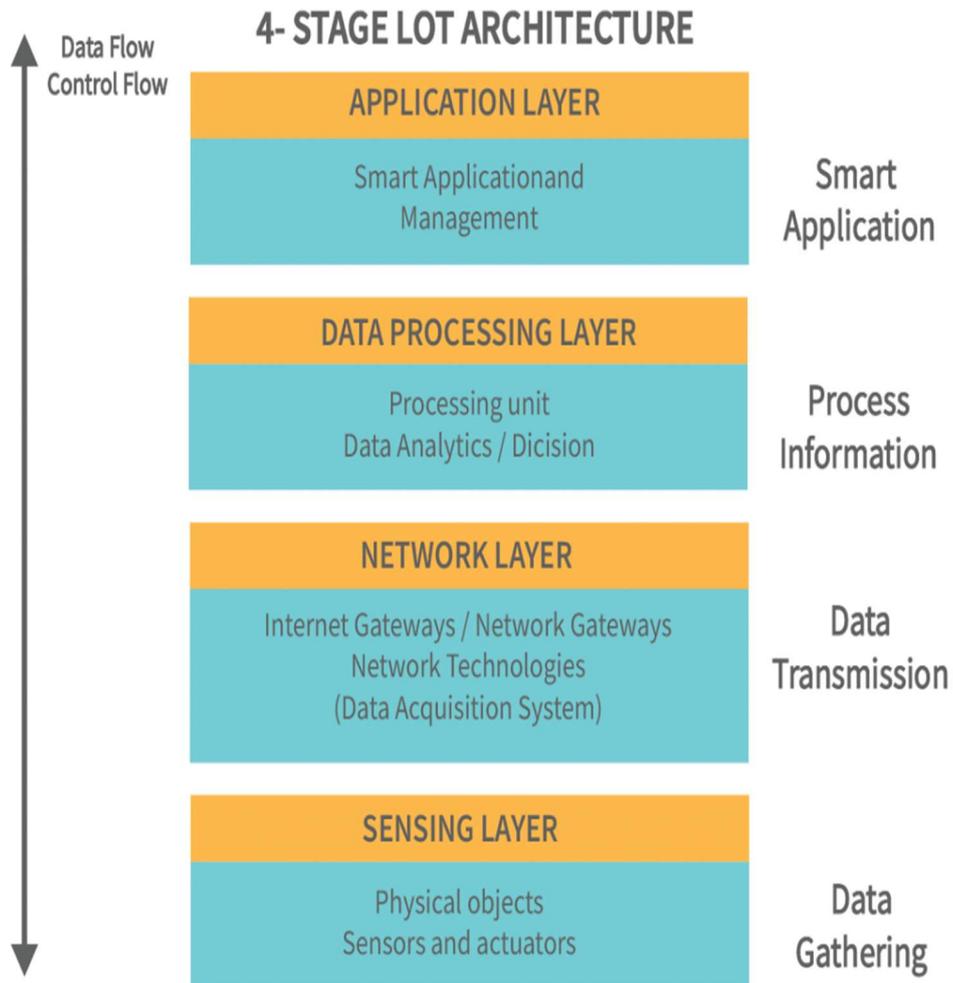
Figure 2: The four layers in IoT architecture (Source: InterviewBit, 2022)

i. *Perception/Sensing layer*: This first layer is the layer of "things" or objects or endpoint devices which are the link between the physical and the virtual worlds. This is the layer where the system interact with the environment, the layer is composed of sensors and actuators (wired or wireless) for collection of data (Awais and Iqbal 2023). While the sensors collect data by measuring the physical properties and parameters which are converted to signals and transferred across a network, actuators allow devices and things to act. There are different types of sensors such as; current/voltage sensor, object sensor, light sensor, humidity sensor, temperature sensor and radiation sensor. Example of actuators are; switches, pneumatic system, electric motor and hydraulic system (Khyayi *et. al.* 2024).

ii. *Network/Transport layer:* This is the gateway by which connectivity is provided between IoT devices and the cloud for exchange of data. It consists of the Data Acquisition System DAS which converts the analogue data from the sensors to digital format and the Network Gateways for malware detection and data management. The transport layer leverages on internet gateways to transmit information from the perception layer into the processing phase (Alabadi *et. al.*, 2022). Some of the technology involved are:
   a. Wi-Fi
   b. Bluetooth
   c. Wide-Area Network
   d. Mobile 4G/5G

iii. *Processing Layer:* This is the brain of IoT. It is the most important stage in that this is

where all raw data is pre-processed and separated then forwarded to data center.

iv. *Application Layer:* Application layer is the interface layer by which the IoT system provides services to the end user. It consists of Cloud/Data Centers where data is managed and used by applications like agriculture, defense, health care etc. For instance, analysis of data may require sending automatic commands and alerts to actuators, for example, windows of a smart home can receive an automatic command to open or close depending on forecasts taken from the weather service. When sensors show that the soil is dry, watering systems get an automatic command to water plants (Ebo *et. al*., 2020).
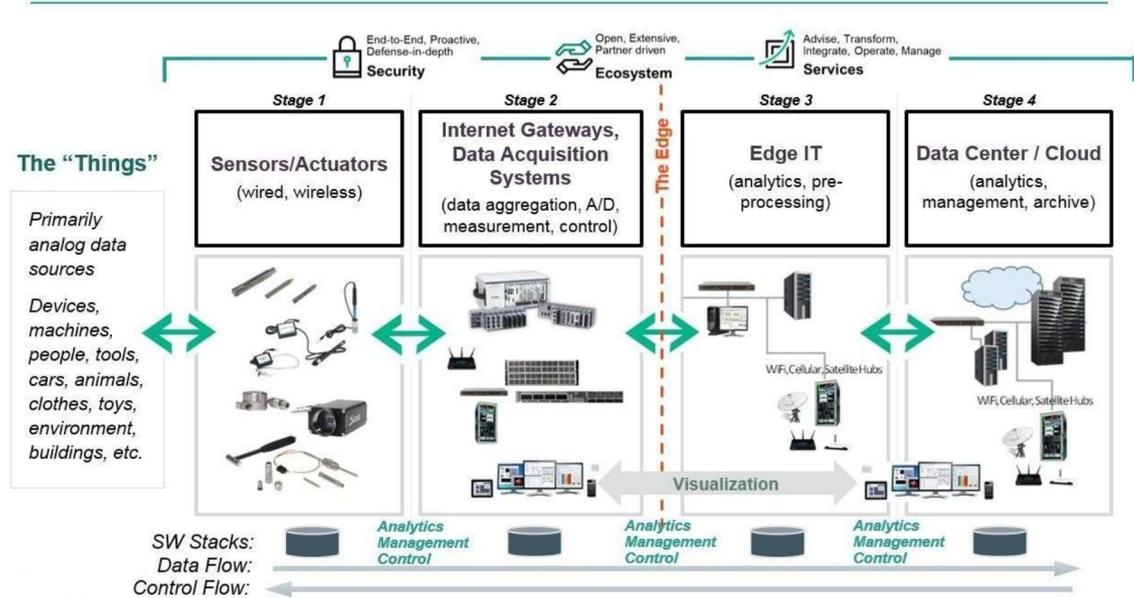

Figure 3: Model of IoT architecture (Stoltzfus, 2020)

Applications of IoT

Since its birth in 2009, internet of things has continuously and progressively being applied to almost all fields of life as shown in figures 4 and 5.
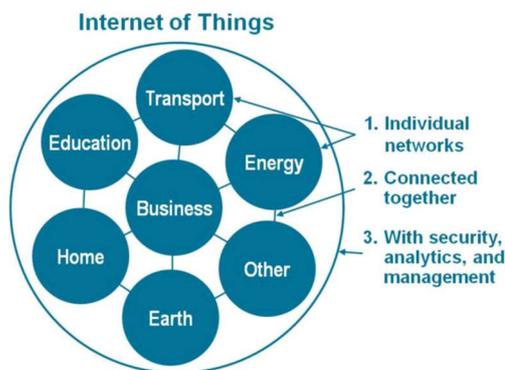

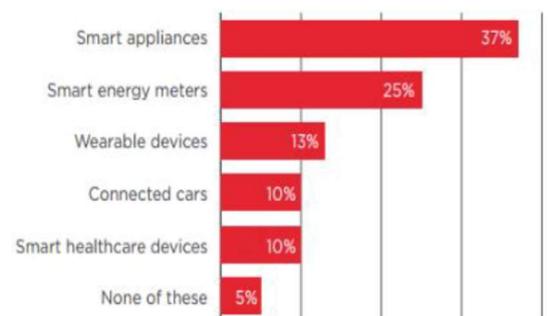Figure 4: Use of IoT based applications as at 2018 (Himanshu, 2020)

Figure 5: Use of IoT based applications as at 2018 (Himanshu, 2020)

IoT has brought about convenience, safety, efficiency, precision and generally increased ease and speed of doing things in all fields. Some of the areas of applications of IoT in the real world are highlighted thus:

i. Medicine and Healthcare: IoT is used in hospitals and clinics for

real-time monitoring of patient health, data acquisition of patient health history and remote surgeries through IoT-enabled robotic equipment.

ii. Agriculture: IoT has helped farmers increase their yield through monitoring and automatically adjusting soil temperature and water to improve crop yield, collection and analysis of data to determine cause and cure of some crop diseases. It has also helped in connecting farmers and farm produce with buyers around the world.

iii. Manufacturing and production: This is one of the first area to use IoT. Deployment of IoT in industries and manufacturing companies can help in obtaining data for predictive maintenance, energy management and efficiency as well as reduction in time and cost of production.

iv. Transportation: IoT has changed the transport system of the world in no little way. From auto-piloting to drones which can control the traffic at different signalized intersections across major cities. Also self-driving cars that can locate alternative route to avoid traffic congestion.

v. Homes and Offices: Home and office automations systems are already implementing IoT to control appliances and activities in the offices and homes remotely. Lighting, heating, cooling and other devices are already being controlled and managed on the network. All these will lead to the development of smart cities.
(Alabadi *et. al.* 2022; Awais and Iqbal, 2023; Adeoye, 2025; Himanshu, 2025)

Challenges of IoT

As IoT connects everyday objects to a network for communication, a number of challenges and issues are identified as compared to the conventional internet.

i. *Challenge of Security of Data*
One of the main focus of IoT is for information/data sharing among objects and devices in the network. Data security include how to ensure privacy, authenticity and prevent abuse or unauthorized disclosure of data. Eavesdropping, man-in-the-middle, phishing and denial of service among others are some of the security issues (Scammells, 2020) (Hajjaj *et. al.,* 2024; Tageldin, 2025).

ii. *Challenge of Choice of Communication Network*
There are many technology available to choose from when adding connectivity to objects in IoT. These technologies include Bluetooth, IR, ZigBee, Cellular, Wi-Fi, the choice is depends on several parameters like the coverage, power consumption, security and cost (Bhargavan *et. al.,* 2021).

iii. *Challenge of Power Consumption*
Power issue is very important to IoT. Most systems designs depend on battery for operation and the battery life varies depending on the application and operating environment. A detail power analysis of the objects or devices involved, battery strength and charging facility will help in the optional power management (Hajjaj *et. al.,* 2024) (Khyayi *et. al.,* 2024).

iv. *Challenge of Interference of Things*
Over the years, there have been increase in the population of wireless transmitters in the world occupying the 2.4 GHz spectrum being the most popular operating area for low-cost and license free applications. There is no protection in this channel from all users (Chin *et. al.,* 2020; Tageldin, 2025).
Also in the local networks, few gadgets may use wire-line communications but most of the devices from smart farm devices to home/office appliances and automated medical equipment connect wirelessly using Bluetooth, wi-fi or cellular. Most of these gadgets have no protection against external electromagnetic interference EMI. Thus, transmitters will emit excess out-of-band energy with nearby receivers having no filtering system to reject the unwanted signal, serious interference are bound to occur (Himanshu *et. al.,* 2020).

v. *Challenge of Standard*
Connecting objects and appliances into a network is not as important as ensuring compliance with standard. There are standards for wireless technology, ensuring that devices can interoperate within the network. IEEE P2413 standard for an architectural framework for IoT describes various IoT domains,

abstractions, and identification of commonalities between different IoT domains. It also defines methods for sharing, interoperability of gadgets and security of information over a network (IEEE, 2021)

Future of IoT

Haven considered the past, present, applications and challenges of IoT, it is very important to project into the future of this all important technology based on the current trend. Although these, predictions or projections may not be exactly accurate, yet they may not digress very far from the facts.

Internet of Things IoT has witnessed some extraordinary growth in recent years, a trend that is very likely to continue, with some estimates for the future number of connected devices in 2027 to be about 90-100 billion according to Indian Times, and the market value rising as high as 60 trillion dollars (Times of India, 2022; Chin *et. al.*, 2020; Himanshu, 2025). Before 2040, IoT would have been deployed in all sectors including, waste management, domestic service, constructions, exploration, nutrition, psychiatry, biological cell growths, character/behavioural modification, foetal sex, genes and blood group control, birth rate/population control and crime control among others. Its application to embedded and robotics systems, especially when favoured by 6G/7G communication technology will enhance efficiency and convenience in space and deep water exploration. In few years from now, IoT will reduce the need for physical facilities, school buildings will not be very necessary anymore (Misbahuddin *et al.*, 2023; Mohamed and Abdellatif, 2025). However, the development of IoT married with blockchain, edge computing and artificial intelligence AI will grossly cut down cost in many sectors but will also reduce human interactions and increase unemployment of unskilled and non-tech labours (Alabadi *et. al.,* 2022; Tageldin, 2025).

Conclusion

IoT is the network of computer with everything and everyone where every component has its own IP address. Thus IoT is a technology that attempts to make all things understand and communicate with the language of computer. It is growing daily in scope, network devices and applications as it hybridizes with other technology for the purpose of communication and control though not without some challenges. The future coverage and the economic impact of IoT are so vast; it may involve everything in every field and everyone in all walks of life.

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