

Chapter 4

Internet of Things (IoT)

Chapter 4: Internet of Things

At the end of this chapter, Students will be able to:

- Describe IoT
- Explain the history of IoT
- Describe the pros and cons of IoT
- Explain how IoT works
- Explain the architecture of IoT
- Describe IoT tools and platforms
- Describe some of the application areas of IoT

Definition of IoT

- Have different definitions used by several groups for promoting the particular concept in the whole world

According to the Internet Architecture Board (IAB),

- IoT is the networking of smart objects, meaning a huge number of devices intelligently communicate in the presence of internet

According to the Internet Engineering Task Force (IETF);

- IoT is the networking of smart objects in which these objects have some *constraints like limited bandwidth, power, and processing* for achieving interoperability.

According to the IEEE Communications category magazine's;

- IoT is a framework of all things that have a representation in the presence of the internet in

According to Oxford dictionary;

- IoT is the interaction of everyday object's of computing devices through the Internet that enables the sending and receiving of useful data.

□ The term Internet of Things (IoT) according to the **2020 conceptual framework** is expressed through a simple formula:

$$\text{IoT} = \text{Services} + \text{Data} + \text{Networks} +$$

-
- Generally, IoT is the network of physical objects or "things" embedded with **software's**, **sensors**, and **network connectivity** which enables these objects to **collect** and **exchange data**.
 - **IoT is a system of interrelated computing devices**, **mechanical** and **digital machines**, objects, animals or people that are provided with **unique identifiers** and **the ability to transfer data** over a network without requiring **human-to-human** or **human-to-computer interaction**.
 - **IoT is a network of devices** that can **sense**, **accumulate** and **transfer** data over the internet

❑ Simply it consists of any device with an on/off switch connected to the Internet. **Can be applied in several areas;**

- Connected industry
- Smart-city
- Smart-home
- Smart-energy
- Connected car
- Smart agriculture
- Connected building and campus, health care,

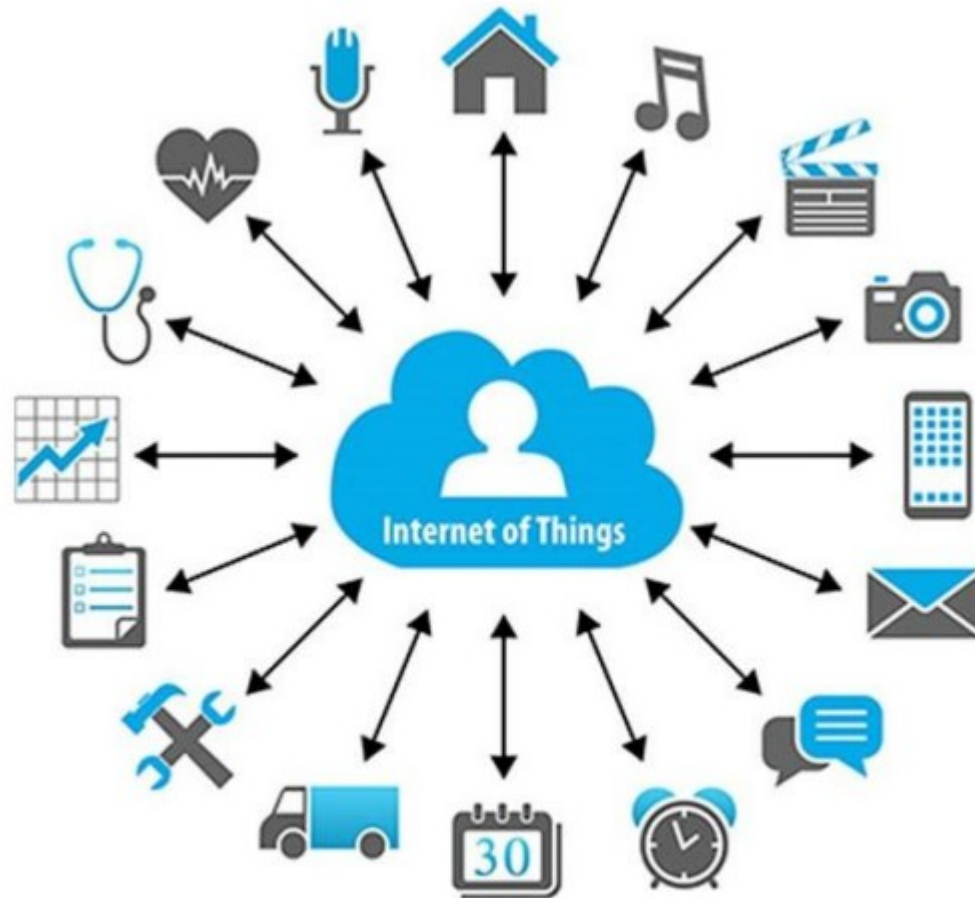


Figure 4.1 IoT in Different Domains

4.1.2. History of IoT

- The Internet of Things has not been around for a long time
- However, there have been visions of **machines communicating with each other since the early 1800s**
- The Internet of Things, as a concept, wasn't officially named until 1999
- One of the first examples of an Internet of Things is from the early 1980s and **was a Coca Cola machine**, located at the **Carnegie Mellon University**
- Local programmers would connect by the Internet **to the refrigerated appliance**, and check to see if there **was a drink available and if it was cold**

-
- By the year 2013, the Internet of Things had evolved into a system using multiple technologies, ranging from the Internet to wireless communication and from micro-electromechanical systems (MEMS) to embedded systems.
 - The traditional fields of automation (including the automation of buildings and homes), **wireless sensor networks, GPS, control systems**, and

-
- **Kevin Ashton**, the Executive Director of Auto-ID Labs at MIT, was the first person to describe the Internet of Things, during his 1999 speech.
 - He stated that **Radio Frequency Identification (RFID)** was a prerequisite for the Internet of Things.
 - He concluded if all devices were “**tagged**,” computers could **manage**, **track**, and **inventory** them
 - Tagging of things has been achieved through technologies such as **digital watermarking**, **barcodes**, and **QR codes**.
 - Inventory control is one of the more obvious

4.1.3. IoT – Advantages

- Improved Customer Engagement
- Technology Optimization
- Reduced Waste
- Enhance data collection

4.1.4. IoT - Disadvantages

- As the number of connected devices increases and more information is shared between devices, ***the security problem also increases***
- ***If there's a bug in the system,*** it's likely that every connected device will become corrupted
- ***Since there's no international standard of compatibility for IoT,*** it's difficult for devices of different manufacturers to communicate with each other.
- Enterprises may eventually have to deal with massive numbers maybe even millions of IoT devices and **collecting and managing** the data from all these

4.1.5 Challenges of IoT

- **Security** – IoT creates an ecosystem of constantly connected devices over network which exposed **users** to various attacks.
- **Privacy** – IoT provides substantial personal data in extreme detail without the user's active participation
- **Complexity** – Some IoT systems are complicated in terms of design, deployment and maintenance on given technologies.
- **Flexibility** – Many are concerned about the flexibility of an IoT system to integrate easily with another.
 - several conflicting or locking systems
- **Compliance** – IoT complexity makes the issue of

How does it work?

❑ IoT ecosystem consists of ***web-enabled smart devices*** that use ***embedded processors, sensors*** and ***hardware to collect, send*** and ***act*** on data they acquire.

❑ IoT devices share the sensor data they collect by connecting to an ***IoT gateway*** or ***another edge device*** where data is either sent to the cloud to be analyzed or ***analyzed locally***.

Architecture of IoT

- ❑ IoT devices can be explained as a network of things that consists of ***hardware, software, network connectivity, and sensors.***

- ❑ **Hence, the architecture of IoT devices comprise four major components:**
 - Sensing
 - Network
 - Data processing and
 - Application layers

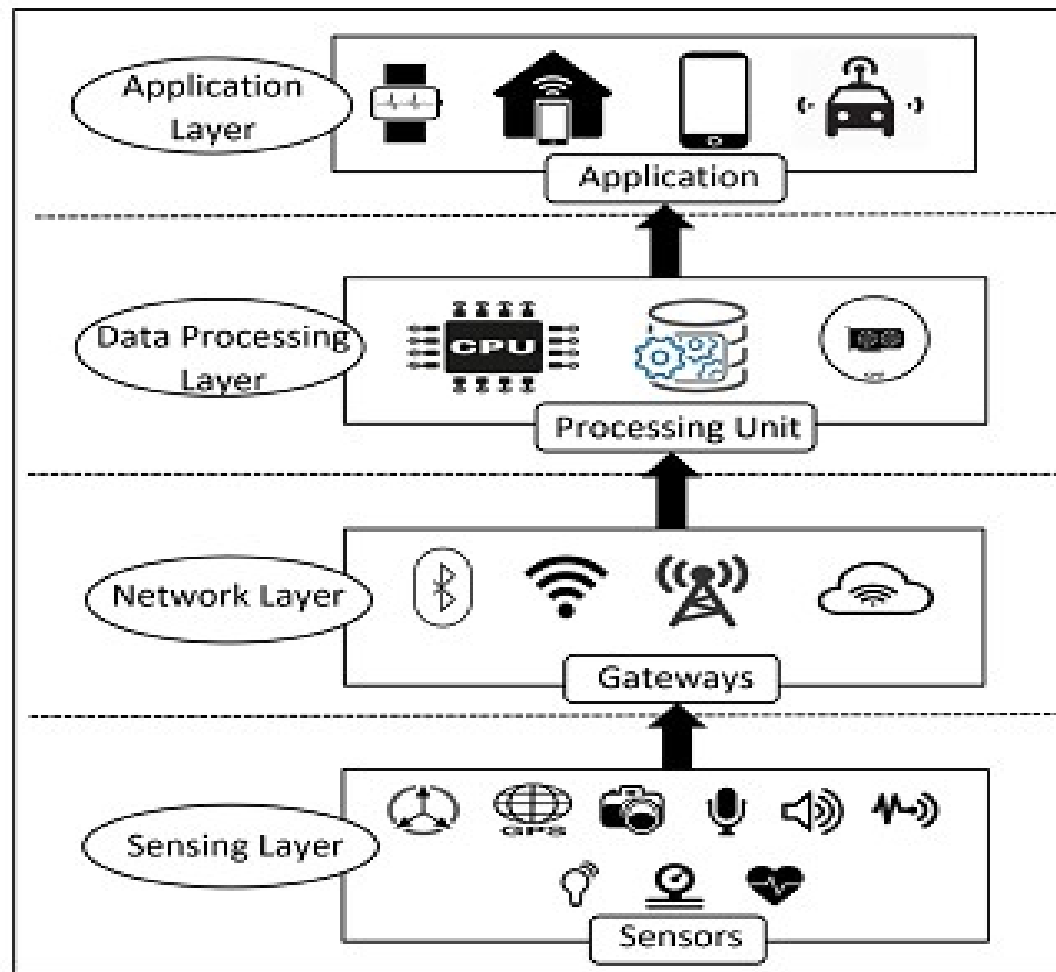


Figure 4.2 Architecture of IoT

1. Sensing Layer

- ❑ The main purpose is to ***identify*** any phenomena in the devices' peripheral and ***obtain data from the real world***.
- ❑ It consists of several sensors; as using multiple sensors for applications is one of the primary features of IoT devices.
- ❑ Sensors in IoT devices are integrated through **sensor hubs**.
 - ***it is a connection point*** for multiple sensors that accumulate and forward sensor data to the ***processing unit of a device***.

- ❑ Actuators can also intervene to change the physical

Three categories of sensor devices in IoT

A. Motion Sensors: to measure the change in motion as well as the orientation of the devices.

- There are two types of motions: **linear** and **angular** motions.
- **Linear motion**; refers to the linear displacement of an IoT device
- **Angular motion** refers to the rotational displacement of the devices

B. Environmental Sensors: embedded in IoT devices **to sense the change in environmental parameters**

- Include sensors such as Light sensors, Pressure sensors, etc.
- Used in many applications to improve user experience (e.g., home automation systems, smart ¹⁹

C. Position sensors: It's about physical positioning and location of the devices

❑ ***The most common position sensors*** used in IoT are ***magnetic sensors*** and ***Global Positioning System (GPS) sensors***.

- **Magnetic sensors**; used as digital compass and help to fix the orientation of the device display.

2. Network Layer

- ❑ *Acts as a communication channel to transfer data collected in the sensing layer*
- ❑ In IoT devices, the network layer is implemented by using diverse communication technologies (e.g., *Wi-Fi, Bluetooth, Zigbee, ZWave, LoRa, cellular network, etc.*) to allow data flow between other devices within the same network.

3. Data Processing Layer

- ❑ Consists of the main data processing unit of IoT devices.
- ❑ It takes data collected in the *sensing layer* and *analyze* it to make a decision based on the result.
- ❑ In some IoT devices (e.g., smartwatch, smart home hub, etc.), the data processing layer also saves the result of the previous analysis to *improve the user experience*.

4. Application Layer

- ❑ It ***implements*** and ***presents*** the results of the data processing layer to accomplish disparate applications of IoT devices.
- ❑ ***It is a user-centric layer*** that executes various tasks for the users
- ❑ There exist diverse IoT applications, which include ***smart transportation, smart home, personal care, healthcare***, etc.

4.2.2. Devices and Networks

- ❑ Connected devices are part of a scenario in which every device talks to each other in an environment to **automate home and industrial tasks**.
- ❑ IoT devices are meant to work in concert for people at home, in industry or in the enterprise.

As such, the devices can be categorized into three main groups:

- Consumer
- Enterprise and
- Industrial

-
- ❑ **Consumer** connected devices include *smart TVs*, *smart speakers*, toys, *wearables*, and smart appliances.
 - ❑ *Smart meters, commercial security systems* and *smart city* technologies such as those used to monitor traffic and weather conditions are examples of **industrial and enterprise** IoT devices.
 - ❑ In the enterprise, smart sensors located in a conference room can help an employee locate and schedule an available room for a meeting ensuring

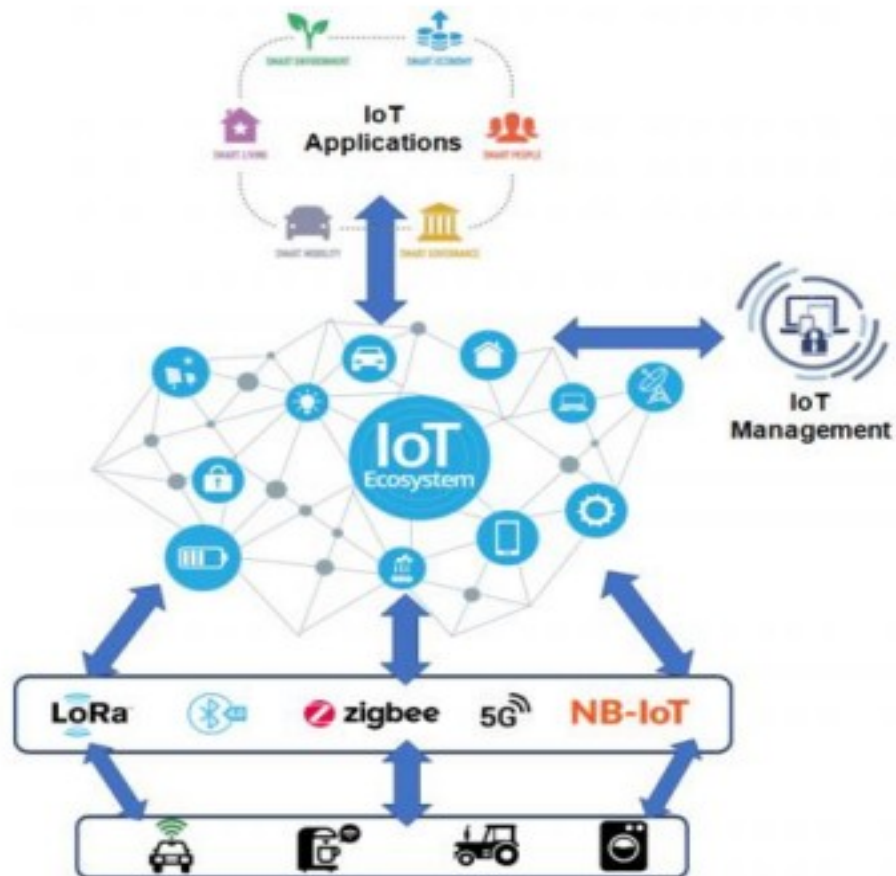


Figure 4.3 Networked IoT Devices

IoT Tools and Platforms

- ❑ There are many vendors in the industrial IoT platform marketplace, offering similar capabilities and methods of deployment
- ❑ These IoT Platform Solutions are based on the *Internet of Things and cloud technology.*
- ❑ They can be used in areas of smart home, city, enterprise, home automation, healthcare or automotive, just to name a few.

IoT Platform	Key features
KAA	<ul style="list-style-type: none"> • Manage an unlimited number of connected devices • Set up cross-device interoperability • Perform real-time device monitoring • Perform remote device provisioning and configuration • Collect and analyze sensor data • Analyze user behavior and deliver targeted notifications • Create cloud services for smart products
SiteWhere	<ul style="list-style-type: none"> • Run any number of IoT applications on a single SiteWhere instance • Spring delivers the core configuration framework • Add devices through self-registration • Integrates with third-party integration frameworks such as Mule any point • Default database storage is MongoDB • Eclipse Californium for CoAP messaging • InfluxDB for event data storage • Grafana to visualize SiteWhere data
ThingSpeak	<ul style="list-style-type: none"> • Collect data in private channels • Share data with public channels • MATLAB analytics and visualizations • Alerts • Event scheduling • App integrations • Worldwide community

DeviceHive	<ul style="list-style-type: none"> • Directly integrate with Alexa • Visualization dashboard of your choice • It supports Big data solutions such as ElasticSearch, Apache Spark, Cassandra and Kafka for real-time and batch processing. • Connect any device • It comes with Apache Spark and Spark Streaming support. • Supports libraries written in various programming languages, including Android and iOS libraries • It allows running batch analytics and machine learning on top of your device data
Zetta	<ul style="list-style-type: none"> • Supports a wide range of hacker boards • Zetta allows you to assemble smartphone apps, device apps, and cloud apps
ThingsBoard	<ul style="list-style-type: none"> • Real-time data visualization and remote device control • Customizable rules, plugins, widgets and transport implementations
	<ul style="list-style-type: none"> • Allows monitoring client-side and provision server-side device attributes. • Support multi-tenant installations out-of-the-box. • Supports transport encryption for both MQTT and HTTP(s) protocols.

4.4. Applications of IoT

- ❑ The versatile nature of IoT makes it an attractive option for so many businesses, organizations, and government offices

Various application of IoT are;

- **Agriculture:** For indoor and outdoor planting IoT used to monitor **microclimate**, **sense soil moisture** and **nutrients**, **better control of smart irrigation** and **fertilizer systems**.
- **Consumer Use:** For private IoT devices in the form of wearables and smart homes make life easier. Wearables cover accessories such as **Fitbit**, **smartphones**, **Apple watches**, **health monitors** to name a few
- **Healthcare:** Wearable IoT devices let hospitals to monitor

-
- **Insurance:** Insurance companies can offer their policy holders discounts for IoT wearables such as Fitbit.
 - **Manufacturing-** RFID and GPS technology can help a manufacturer to track a product from its start on the factory floor to its placement in the destination store, the whole supply chain from start to finish.
 - **Retail** - Online and in-store shopping sales figures can control warehouse automation and robotics, information gleaned from IoT sensors.

-
- **Transportation**- The GPS is being utilized to help transportation companies to plot faster and more efficient routes for trucks hauling freight, thereby speeding up delivery times. It can be used to determine traffic patterns, parking space demand, and road construction and maintenance.
 - **Utilities**- IoT sensors can be employed to monitor environmental conditions such as **humidity**, **temperature**, and **lighting**
 - The information provided by IoT sensors can aid in the creation of algorithms that regulate energy usage and make the appropriate adjustments

4.3.1. IoT Based Smart Home

- ❑ Smart Home initiative allows subscribers to remotely manage and monitor different home devices from anywhere via smartphones or over the web with no physical distance limitations.

These “smart” devices have the potential to share information with each other over internet connection

- Remote Control Appliances
- Smart home Appliances
- Weather
- Safety monitoring

4.3.2. IoT Based Smart City

- ❑ In cities, the development of smart grids, data analytics, and autonomous vehicles will provide an intelligent platform to deliver innovations in energy management, traffic management, and security, sharing the benefits of this technology throughout society.
 - Structural hall
 - Lightening
 - Safety
 - Transportation

References

- Brewster, C., Roussaki, I., Kalatzis, N., Doolin, K., & Ellis, K. (2017). IoT in agriculture:
- Designing a Europe-wide large-scale pilot. *IEEE communications magazine*, 55(9), 26-33.
- Ramakrishna, G. Kiran Kumar, A. Mallikarjuna Reddy, Pallam Ravi (2018). A Survey on various IoT Attacks and its Countermeasures. *International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)*, 5(4), 2394-2320.
- Elijah, O., Rahman, T. A., Orikumhi, I., Leow, C. Y., & Hindia, M. N. (2018). An overview of the Internet of Things (IoT) and data analytics in agriculture: Benefits and challenges. *IEEE Internet of Things Journal*, 5(5), 3758-3773.
- Foote, K. D. (2016). A brief history of the internet of things. *Data Education for Business and IT Professionals*. Available online: <http://www.dataversity.net/brief-history-internet-things/> (accessed on 12 November 2018).
- Gupta, B. B., & Quamara, M. (2018). An overview of the Internet of Things (IoT): Architectural aspects, challenges, and protocols. *Concurrency and Computation: Practice and Experience*, e4946.
- John Terra (2019). Everything You Need to Know About IoT

Videos on IOT

- <https://www.youtube.com/watch?v=VRRPy-yEK>

RM

- <https://www.youtube.com/watch?v=GkD0NjUub>

WM