Chapter 4

Internet of Things (IoT)

Compiled By: Tsegaye B.

Objective

After accomplishing this chapter, Students will be able to:

- ➢ Describe IoT
- ➢ Describe the pros and cons of IoT
- ➢ Explain how IoT works
- ➢ Explain the architecture of IoT
- ➢ Describe application areas of IoT

Outline

- ✓Overview of IoT
  - What is IoT?
  - IoT – Advantages
  - IoT – Disadvantages
  - Challenges of IoT
- ✓How does it work?
  - Architecture of IoT
  - Devices and Networks
- ✓IoT Based Smart Home
- ✓IoT Based Smart City
- ✓IoT Based Smart Farming

THE INTERNET of
THINGS

What is IoT?

- **Internet Architecture Board's (IAB) definition**

  - IoT is the networking of smart objects, meaning a huge number of devices intelligently communicating in the presence of internet protocol that cannot be directly operated by human beings but exist as components in buildings, vehicles or the environment.

What is IoT?

Internet Engineering Task Force (IETF) definition

- IoT is the networking of smart objects in which smart objects have some constraints such as limited bandwidth, power and processing accessibility for achieving interoperability among smart objects.

What is IoT?

IEEE Communications category magazine's

- IoT is a framework of all things that have a representation in the presence of the internet in such a way that new applications and services enable the interaction in the physical and virtual world in the form of Machine-to-Machine (M2M) communication in the cloud.

What is IoT?

- **Oxford dictionary definition**
  - IoT is the interaction of everyday object's computing devices through the Internet that enables the sending and receiving of useful data.
- **2020 conceptual framework**
  - The term Internet of Things (IoT) according to the 2020 conceptual framework is expressed through a simple formula such as:

$$IoT = Services + Data + Networks + Sensors$$

What is IoT?

- The Internet of Things (IoT) is the network of physical objects or "things" embedded with:
  - Electronics
  - Software
  - Sensors, and
  - Network Connectivity, which enables these objects to collect and exchange data.

What is IoT?

- 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 without any human intervention.

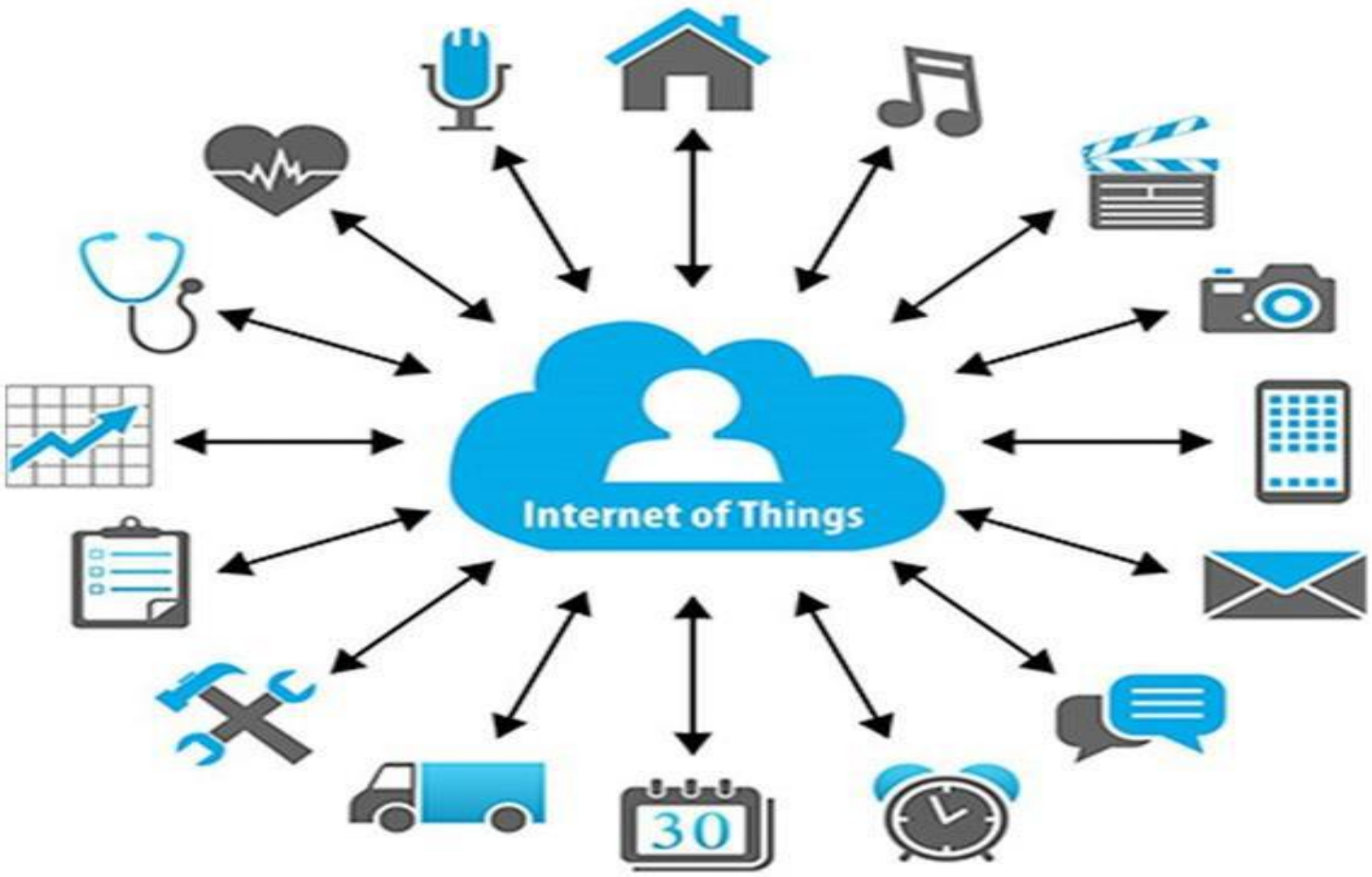
What is IoT?

- IoT consists of any device with an on/off switch connected to the Internet.
- Example of IoT devices
  - Cellphones
  - Building maintenance
  - Jet engine of an airplane.
  - Medical devices (heart monitor implant or biochip transponder in a farm animal).
  - Gigantic network of internet-connected “things” and devices.
  - Ring, a doorbell that links to your smartphone, provides an excellent example of IoT. Ring signals you when the doorbell is pressed and lets you see who it is and to speak with them.

What is IoT?

- Application areas of IoT:
  - Connected industry
  - Smart-city
  - Smart-home
  - Smart-energy
  - Connected car
  - Smart agriculture
  - Connected building and campus
  - Health care
  - Logistics, etc.

What is IoT?



Overview of IoT

The most important features of IoT include:

- Artificial intelligence (AI)
- Connectivity (Network)
- Sensors
- Active engagement, and
- Small device use.

Overview of IoT

Artificial Intelligence

- IoT makes virtually anything "smart"
- Example: enhancing your refrigerator to detect when milk run low, and to then place an order with your preferred grocer.

Connectivity

- To create these small networks between its system devices.

Sensors

- They transform IoT from a standard passive network of devices into an active system capable of real-world integration.

Overview of IoT

Active Engagement

- Much of today's interaction with connected technology happens through passive engagement.
- IoT introduces a new paradigm for active content, product, or service engagement.

Small Devices

- Devices, as predicted, have become smaller, cheaper, and more powerful over time.
- IoT exploits purpose-built small devices to deliver its precision, scalability, and versatility.

IoT – Advantages

The IoT has offer the following advantages

- **Improved Customer Engagement**
  - IoT completely transforms active and effective engagement with audiences.
- **Technology Optimization**
  - IoT can be used to improve device use, and to aid in more effective improvements to technology

IoT – Advantages

- **Reduced Waste**
  - IoT makes areas of improvement clear.
  - IoT provides real-world information leading to the more effective management of resources.
- **Enhanced Data Collection**
  - It allows an accurate picture of everything.

IoT – Disadvantages

Some of the disadvantages of IoT are:

- As the number of connected devices increases and more information is shared between devices, the potential that a hacker could steal confidential information 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 from 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 those devices will be challenging.

Challenges of IoT

- Here is a list of major issues:
  - **Security** – IoT creates an ecosystem of connected devices communicating over networks. The system offers little control despite any security measures. This leaves users exposed to various kinds of attackers.
  - **Privacy** – The sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.

Challenges of IoT

- **Complexity** – IoT systems complicated in terms of design, deployment, and maintenance given their use of multiple technologies and a large set of new enabling technologies.
- **Flexibility** – Many are concerned about the flexibility of an IoT system to integrate easily with another. They worry about finding themselves with several conflicting or locking systems.
- **Compliance** – IoT, like any other technology in the realm of business, must comply with regulations. Its complexity makes the issue of compliance seem incredibly challenging when many consider standard software compliance a battle.

How does IoT work?

- An IoT ecosystem consists of web-enabled smart devices that collect, send and act on data they acquire from their environments using their
  - sensors
  - embedded processors
  - hardware
  - software
  - network connectivity
- The devices do most of the work without human intervention
- People can interact with the devices for example, to set them up, give them instructions or access the data.

Architecture of IoT

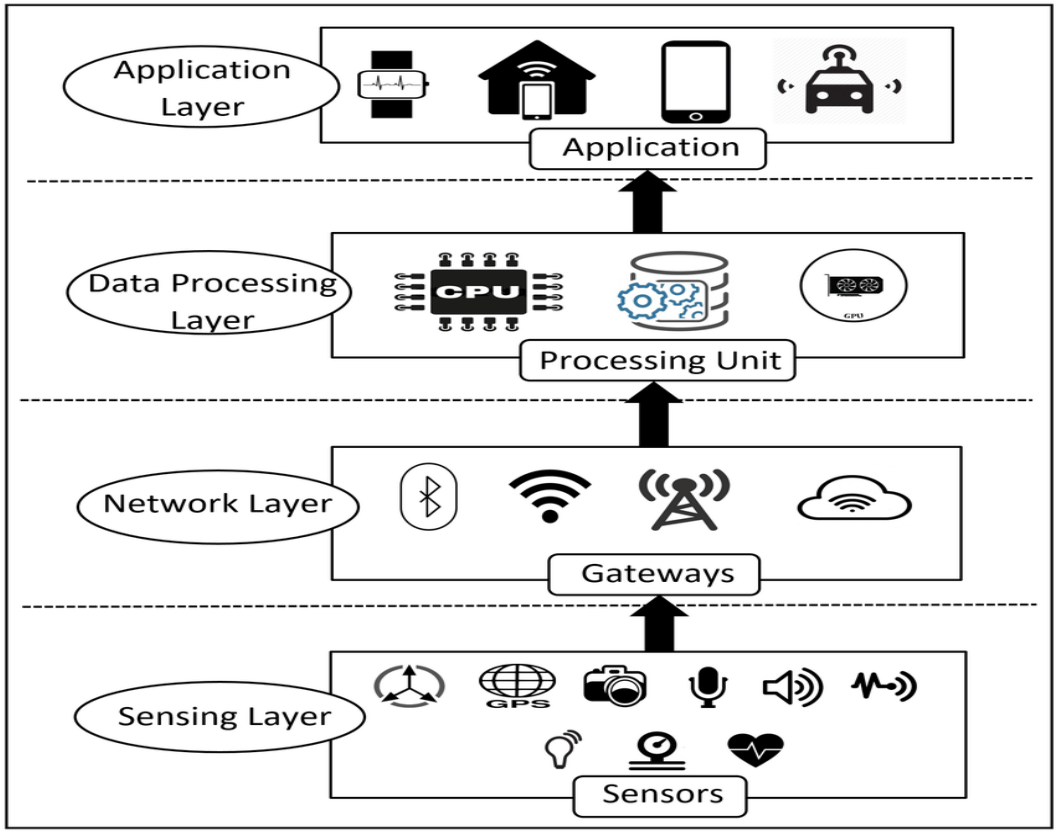
The architecture of IoT devices comprises four major components:

a. Sensing Layer

b. Network Layer

c. Data processing

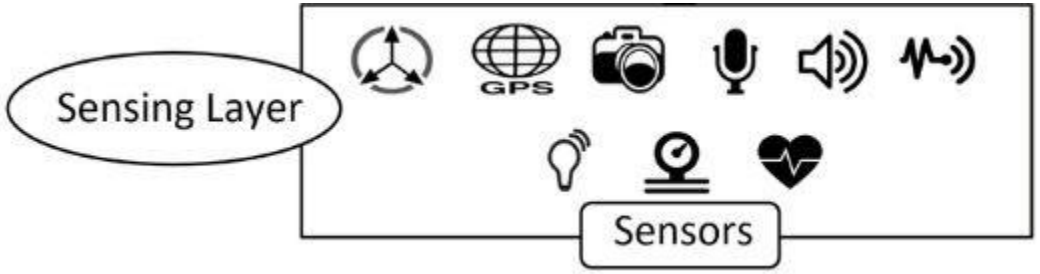
d. Application layer



Sensing Layer

- Sensors in IoT obtain data from the real world.
- Sensors are usually integrated through sensor hubs.
- A sensor hub is a common 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 conditions that generate the data.
- Actuators take electrical input and transforms the input into tangible action such as shut off a power supply, adjust an airflow valve, or temperature control valves used in smart homes.

sensing Layer



Sensors in IoT devices can be classified into three broad categories

1. **Motion Sensors**: measure the change in motion (angular or linear) as well as the orientation of the devices
2. **Environmental Sensors**: sense the change in environmental parameters in the device's peripheral. E.g. Light and Pressure sensors
3. **Position sensors**: deal with the physical position and location of the device. E.g. Global Positioning System (GPS) and Magnetic Sensors

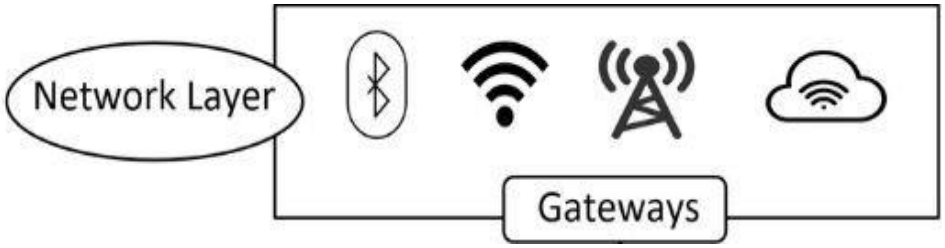
Network Layer

- The network layer acts as a communication channel to transfer data collected in the sensing layer to other connected devices.
- This layer is implemented by using diverse communication technologies to allow data flow between other devices within the same network.

Wi-Fi,

Bluetooth,

Zigbee, Z-Wave, LoRa, cellular network

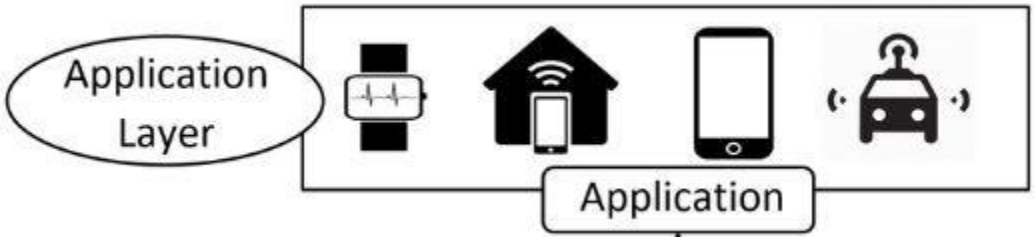


Data Processing Layer

- This layer takes data collected in the sensing layer and analyses the data to make decisions based on the result.
- The data processing layer also saves the result of the previous analysis to improve the user experience.
- This layer may share the result of data processing with other connected devices via the network layer.

Application Layer

- Application layer implements and presents the results of the data processing layer to accomplish different applications of IoT devices.
- This layer is a user-centric layer that executes various tasks for the users.
- smart transportation, smart home, personal care, healthcare, etc.



Devices and Networks

- IoT devices talk with each other to automate tasks, and to communicate usable sensor data to users, industry or enterprise.
- Connected IoT devices can be categorized into three main groups:
  - Consumer device
  - Enterprise device and
  - Industrial device

Devices and Networks

- Consumer connected devices include:
  - smart TVs, smart speakers, toys, wearables, and smart appliances
- Industrial and enterprise IoT devices include:
  - smart meters, commercial security systems and smart city technologies
  - used to monitor traffic and weather conditions
- Other technologies, include:
  - smart air conditioning, smart thermostats, smart lighting, and smart security, span home, enterprise, and industrial uses.

Devices and Networks

- IoT network includes a number of devices with constrained resources such as power, processing, memory etc.
- Device in IoT is characterized by their heterogeneity and resources constrained networks.
- Therefore, the efficient management of IoT networks requires considering both the constraints of low power IoT devices and the deployment complexity of the underlying communication infrastructure.

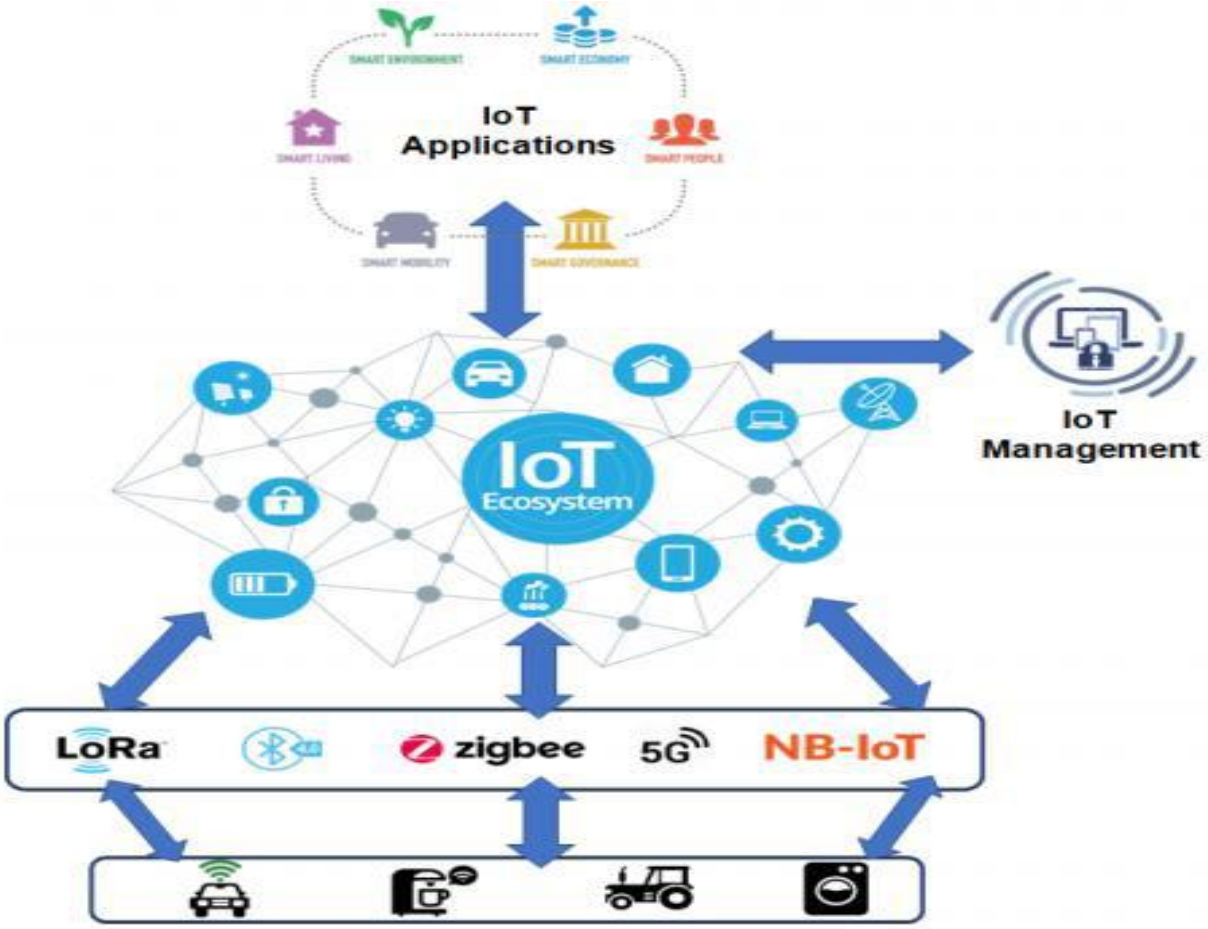
Devices and Networks

- To ensure the correct functioning of those connected devices, they must be remotely accessed to configure, monitoring their status

- Therefore, efficient and autonomic management of IoT networks take in account several elements such as scalability, interoperability, energy efficiency, topology control, Quality of Service (QoS), fault tolerance, and security.

Devices and Networks

Networked IoT Devices



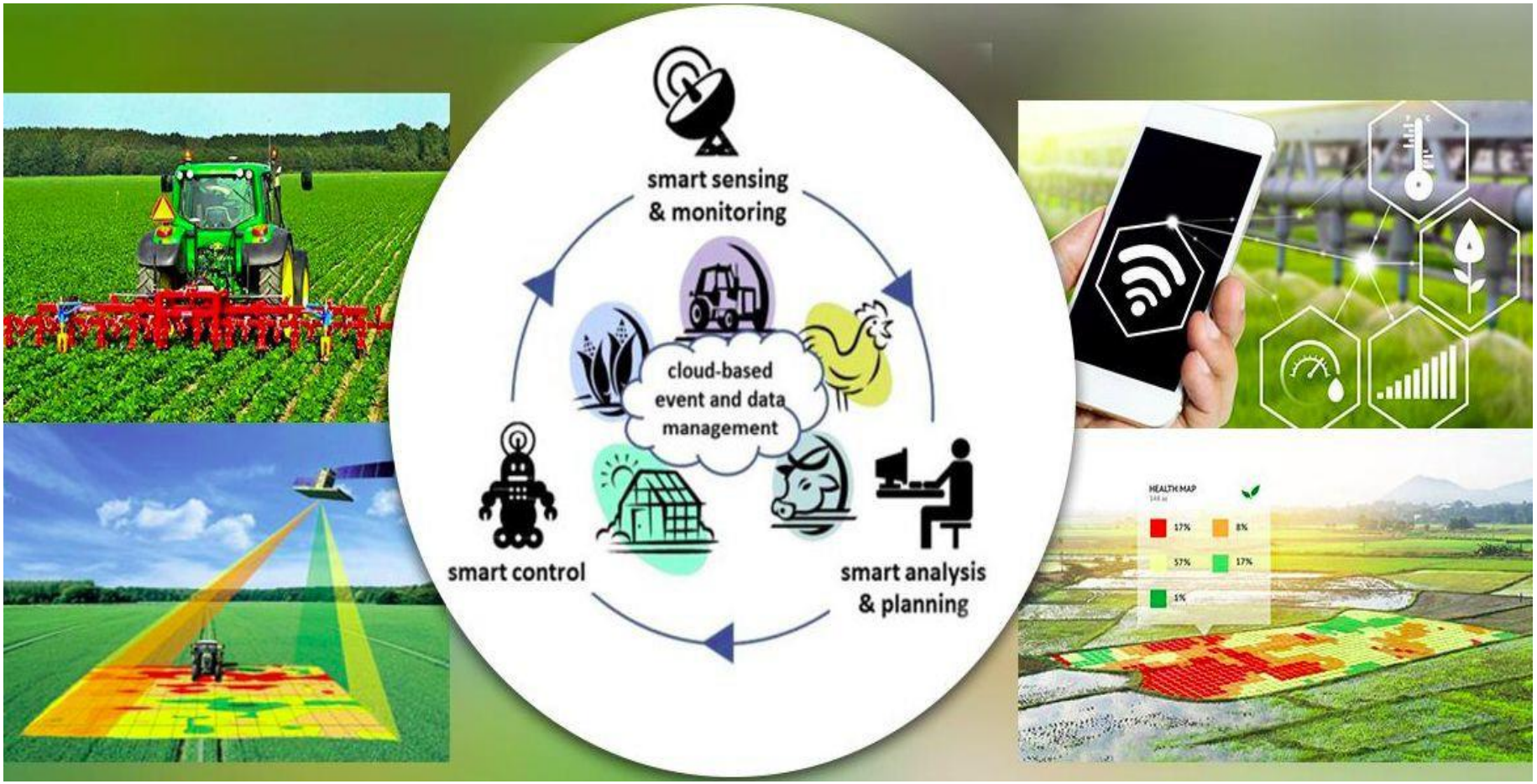
Applications of IoT

- The versatile nature of IoT makes it an attractive option for so many businesses, organizations, and government branches
  - Agriculture
  - Consumer use
  - Health care
  - Manufacturing
  - Retail
  - Transportation
  - Utilities

Applications of IoT- Agriculture

- IoT makes monitoring and management of micro-climate conditions a reality, which in turn increases production.
- IoT technology can sense soil moisture and nutrients, in conjunction with weather data, better control smart irrigation and fertilizer systems.

Applications of IoT: Agriculture



Applications of IoT

Consumer Use

- IoT devices such as Fitbit, Smart Phones, Apple Watches, Health Monitors
- help improve entertainment, health, and fitness

Applications of IoT

Consumer Use

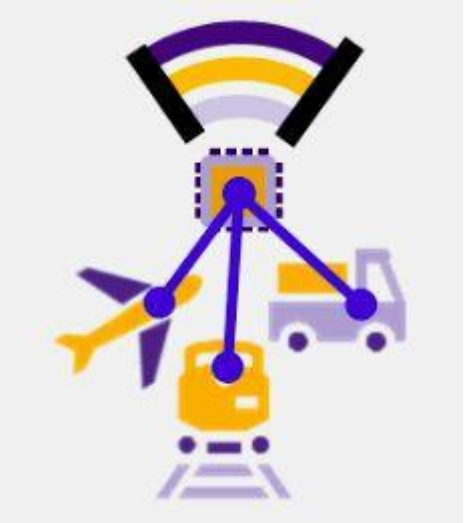
- Smart homes take care of things like activating environmental controls so that your house is at peak comfort when you come home
- Appliances such as Oven, Lights, and security devices such as Smart Locks can be controlled remotely

Applications of IoT: Healthcare

- Help monitor patients' health at home, thereby reducing hospital stays while still providing up to the minute real-time information that could save lives

Applications of IoT: Manufacturing

- RFID and GPS technology can help a manufacturer 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
- Sensors can gather information on travel time, product condition, and environmental conditions that the product was subjected to



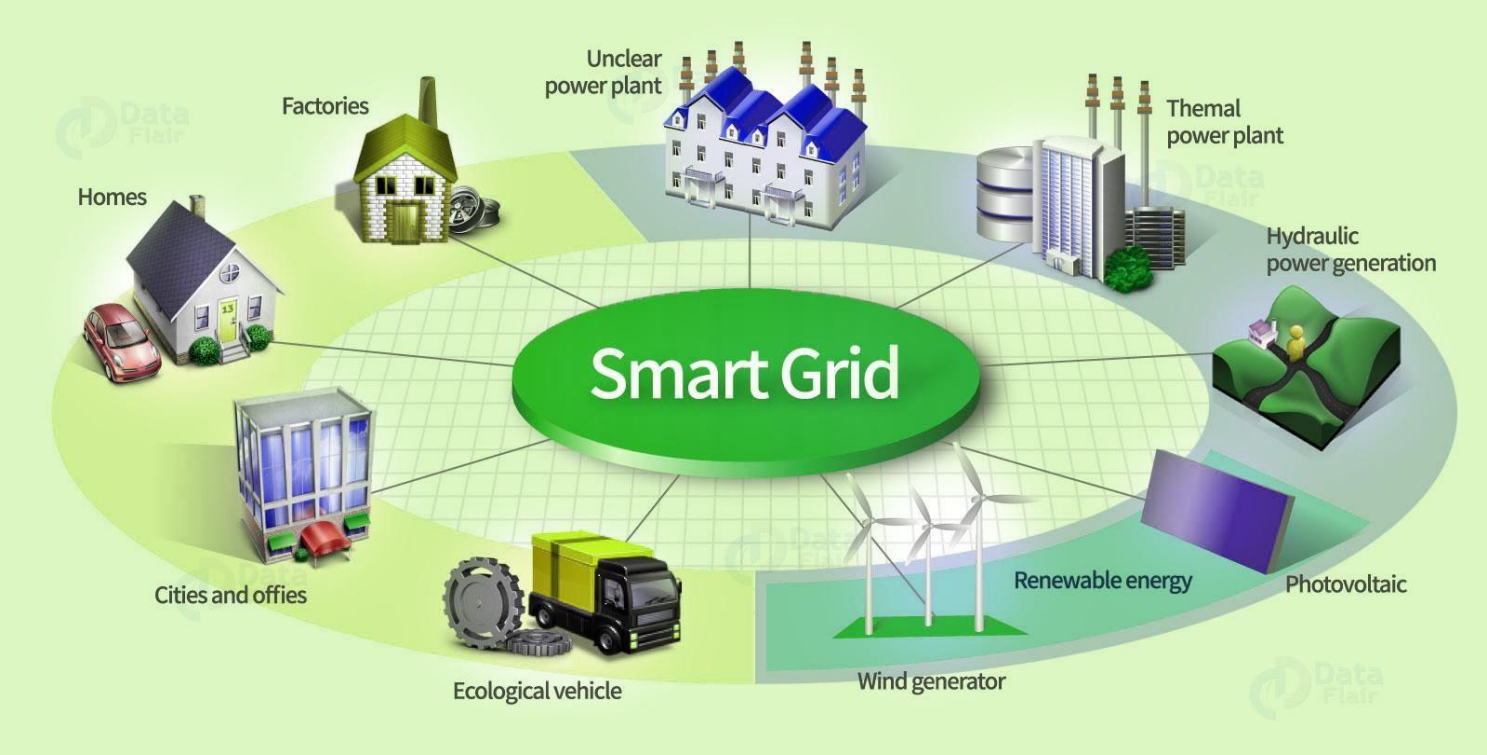
Applications of IoT: Retail

- IoT can help analyze mall traffic to enhance the customer's shopping experience
- IoT helps retailers target customers (for instance for advertisement) based on past purchases

Applications of IoT: Transportation

- IoT for Self-Driving cars
- GPS data can be used to determine traffic patterns, parking space demand, and road construction and maintenance

Applications of IoT: Utilities

- IoT sensors can be employed to monitor environmental conditions such as humidity, temperature, and lighting
- With IoT-driven environmental control, businesses and private residences can experience significant energy savings
- Data gathered by the Internet of Things can be used to help run municipal power grids more efficiently, analyzing factors such as power usage
- Sensors can help pinpoint outages faster

Applications of IoT: Utilities