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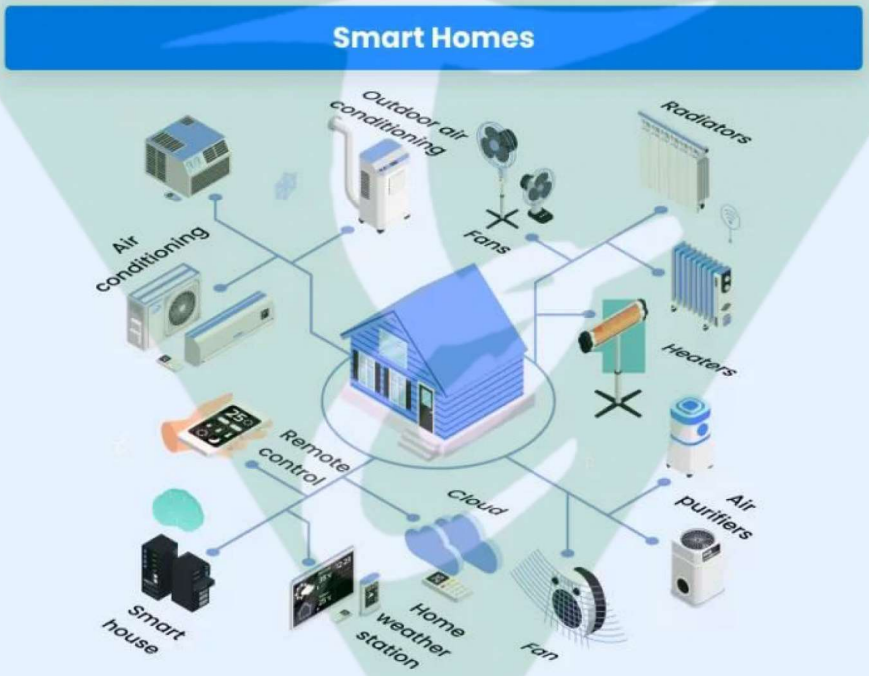
## Internet of Things Definition

The Internet of Things (IoT) refers to the digitally connected universe of smart devices. These devices are embedded with internet connectivity, sensors and other hardware that allow communication and control via the web.

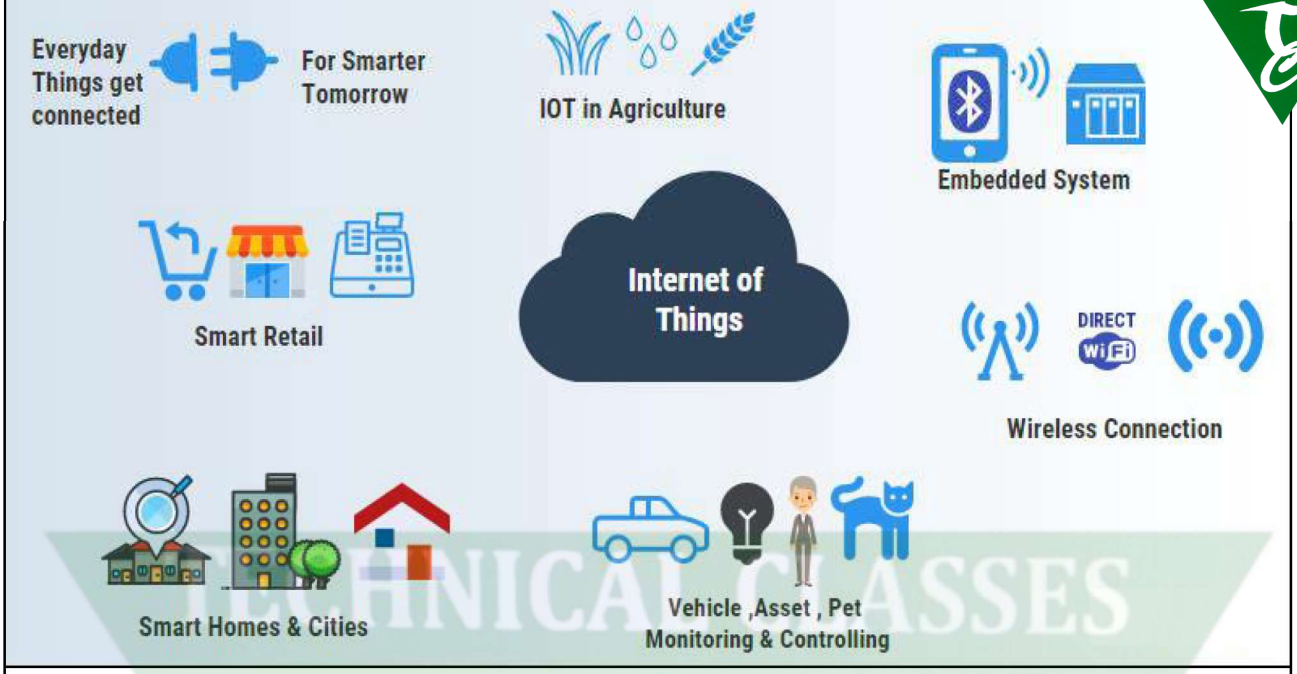
- Let's us look closely at our mobile device which contains GPS Tracking, Mobile Gyroscope, Adaptive brightness, Voice detection, Face detection etc.
- These components have their own individual features, but what about if these all communicate with each other to provide a better environment?
- For example, the phone time-zone is adjusted based on my GPS location.

- Connecting everyday things embedded with electronics, software, and sensors to internet enabling to collect and exchange data without human interaction called as the Internet of Things (IoT).
- The Internet of Things makes everyday devices “smarter” by enabling them to send data over the internet, communicating with people and other IoT-enabled devices.
- IoT is an advanced automation and analytics system which deals with artificial intelligence, sensor, networking, electronic, cloud messaging etc. to deliver complete systems for the product or services. The system created by IoT has greater transparency, control, and performance.




- As we have a platform such as a cloud that contains all the data through which we connect all the things around us. For example, a house, where we can connect our home appliances such as air conditioner, light, etc. through each other and all these things are managed at the same platform.

- If there is a common platform where all these things can connect to each other would be great because based on my preference, I can set the room temperature.
- For example, if I love the room temperature to to be set at 25 or 26-degree Celsius when I reach back home from my office, then according to my car location, my AC would start before 10 minutes I arrive at home. This can be done through the Internet of Things (IoT).




## What is IoT?

- The Internet of Things (IoT) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.
- These devices range from ordinary household objects to sophisticated industrial tools.
- With more than 7 billion connected IoT devices today, experts are expecting this number to grow to 10 billion by 2020 and 22 billion by 2025.

## Why is Internet of Things (IoT) so important?

- Over the past few years, IoT has become one of the most important technologies of the 21st century.
- Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes, and things.

## Why is Internet of Things (IoT) so important?

- By means of low-cost computing, the cloud, big data, analytics, and mobile technologies, physical things can share and collect data with minimal human intervention.
- In this hyperconnected world, digital systems can record, monitor, and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate.



## Why is Internet of Things (IoT) so important?

While the idea of IoT has been in existence for a long time, a collection of recent advances in a number of different technologies has made it practical.

## What technologies have made IoT possible?

Access to low-cost, low-power sensor technology - Affordable and reliable sensors are making IoT technology possible for more manufacturers.

Connectivity - A host of network protocols for the internet has made it easy to connect sensors to the cloud and to other "things" for efficient data transfer.

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## What technologies have made IoT possible?

Cloud computing platforms - The increase in the availability of cloud platforms enables both businesses and consumers to access the infrastructure they need to scale up without actually having to manage it all.



## What technologies have made IoT possible?

Machine learning and analytics - With advances in machine learning and analytics, along with access to varied and vast amounts of data stored in the cloud, businesses can gather insights faster and more easily. The emergence of these allied technologies continues to push the boundaries of IoT and the data produced by IoT also feeds these technologies.

## What technologies have made IoT possible?

Conversational artificial intelligence (AI) - Advances in neural networks have brought natural-language processing (NLP) to IoT devices (such as digital personal assistants Alexa, Cortana, and Siri) and made them appealing, affordable, and viable for home use.

# Internet of Things with Python

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## What is Python?

- Python is a high-level, general-purpose programming language with an elegant syntax that allows programmers to focus more on problem-solving than on syntax errors.

- Python is a popular programming language. It was created by Guido van Rossum, and released in 1991.
- Its syntax is too easy just like English language.

For example,

```
print("Hello, World!")
```

# Internet of Things with Python

- Generally, prototypes or real-life Internet of Things (IoT) systems have to be designed and developed swiftly and competently.
- Whenever this occurs, two activities instantly come to life: One is to program the IoT devices, and another is to organize a backend to interact with these devices.



- In both activities, we can utilize the Python programming language for their development. Or we can utilize a functional and practical edition of *MicroPython* in order to work on devices with small computing resources, and accordingly, at a very low price.

# Why use Python in the Internet of Things?

For many developers, Python is considered as the language of preference in the market. It is simple to learn, has clean syntax, and has a large online community supporting it.

- Python becomes a great choice when it comes to IoT.
- We can either use it for the backend side of development or the software development of devices.
- Moreover, Python is available to work on Linux devices, and we can make use of MicroPython for microcontrollers.
- Python is the coding language that we can use to reduce the volume of data that we need to deal with, accessible in the cloud.



- Some of the many benefits of working with Python for IoT devices are a large number of libraries for all types of platforms and the speed it offers at which we can develop the code.

## What are the best solutions for IoT in Python?

Some of the best solutions for IoT in the Python programming language are as follows:

- Python on Raspberry Pi
- Python on PyBoard
- ESP8266, ESP32 with Micropython

# Advantages and Disadvantages

## Internet of Things



## IoT

- Any technology available today has not reached to its 100 % capability.
- It always has a gap to go. So, we can say that Internet of Things has a significant technology in a world that can help other technologies to reach its accurate and complete 100 % capability as well.

## Advantages of IoT

Internet of things facilitates the several advantages in day-to-day life in the business sector. Some of its benefits are given below:

- **Efficient resource utilization:** If we know the functionality and the way that how each device work we definitely increase the efficient resource utilization as well as monitor natural resources.

- **Minimize human effort:** As the devices of IoT interact and communicate with each other and do lot of task for us, then they minimize the human effort.

- **Save time:** As it reduces the human effort then it definitely saves out time. Time is the primary factor which can save through IoT platform.



- **Enhance Data Collection:**

- **Improve security:** Now, if we have a system that all these things are interconnected then we can make the system more secure and efficient.

## Disdvantages of IoT

As the Internet of things facilitates a set of benefits, it also creates a significant set of challenges. Some of the IoT challenges are given below:

- **Security:** As the IoT systems are interconnected and communicate over networks. The system offers little control despite any security measures, and it can be lead the various kinds of network attacks.

- **Privacy:** Even without the active participation on the user, the IoT system provides substantial personal data in maximum detail.
- **Complexity:** The designing, developing, and maintaining and enabling the large technology to IoT system is quite complicated.



# IoT Platforms

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## IoT Platform

- As in IoT, all the IoT devices are connected to other IoT devices and application to transmit and receive information using protocols.
- There is a gap between the IoT device and IoT application.
- An IoT Platform fills the gap between the devices (sensors) and application (network).

Thus we can say that an IoT platform is an integrated service that **fulfills the gap between the IoT device and application** and offers you to bring physical object online.




There are several IoT Platforms available that provides facility to deploy IoT application actively. Some of them are listed below:

- Amazon Web Services (AWS) IoT platform
- Microsoft Azure IoT platform
- Google Cloud Platform IoT

## Amazon Web Services (AWS) IoT platform:

- Amazon Web Service IoT platform offers a set of services that connect to several devices and maintain the security as well.
- This platform collects data from connected devices and performs real-time actions.

## Microsoft Azure IoT platform:

- Microsoft Azure IoT platform offers strong security mechanism, scalability and easy integration with systems.
- It uses standard protocols that support bi-directional communication between connected devices and platform.
- Azure IoT platform has an Azure Stream Analytics that processes a large amount of information in real-time generated by sensors.



## Google Cloud Platform IoT:

- Google Cloud Platform is a global cloud platform that provides a solution for IoT devices and applications.
- It handles a large amount of data using Cloud IoT Core by connecting various devices.
- It allows to apply BigQuery analysis or to apply Machine learning on this data.

## How IoT platform help?

- IoT Platform connects sensors and devices.
- IoT platform handles different software communication protocol and hardware.
- IoT platform provides security and authentication for sensors and users.
- It collects, visualizes, and analyzes the data gathered by the sensor and device.

# CONCEPTS OF IOT

WORKING MECHANISM, TYPES AND CHALLENGES



## WHAT IS IOT?

- IoT stands for internet of things. Most simply, it refers to physical objects linked through wired and wireless networks. More specifically, it refers to the collection of internet-connected devices that are able to communicate autonomously over the internet, without needing a person to initiate the communication.

- Kevin Ashton, who coined the term internet of things, preferred the term internet for things. While not widely used, this term provides a helpful way to understand the concept behind IoT. Think of the "normal" internet you access from your PC or smartphone as the internet for people and IoT as an internet of interrelated computing devices, mechanical and digital machines, objects, etc.

- The internet of things is everywhere. It is used in a range of industries and has both corporate and consumer uses. Today, for example, automobiles often have dozens of sensors that collect and transfer data for safety, maintenance, entertainment, fleet management and other purposes. These internet-connected cars are considered part of the internet of things, because they communicate with other devices over the internet based on input from the environment, not just from direct human manipulation.



## HOW DOES IOT WORK?

- IoT works through a combination of wireless networking technology, physical devices, advanced data analytics and cloud computing.

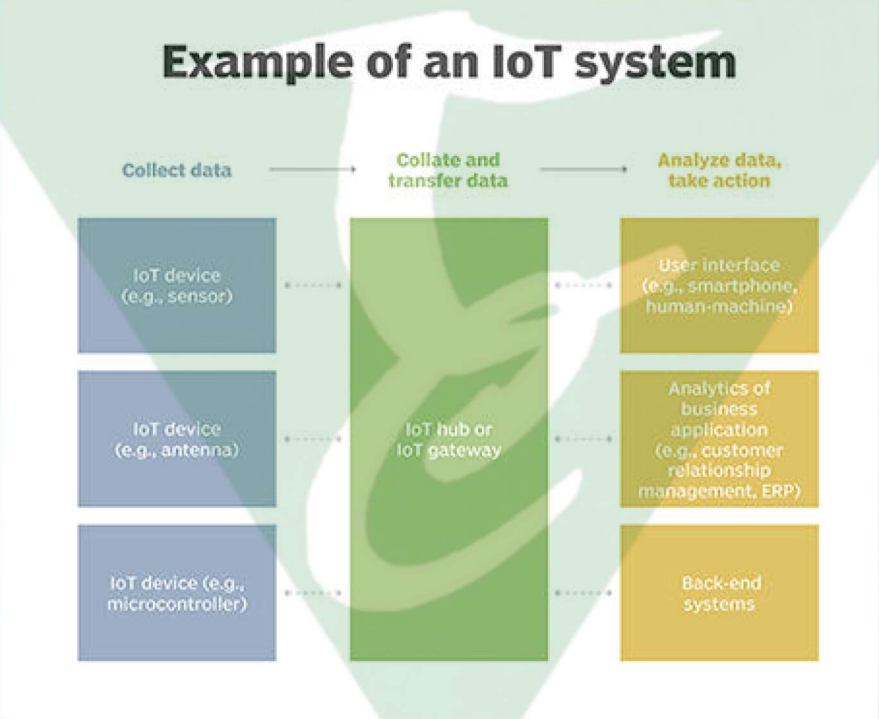
The basic process of how IoT works is as follows:

- A group of physical devices is wired or wirelessly linked to each other and/or a central area.
- The devices collect data from the external world using some kind of sensor.
- That data is then stored somewhere, whether it be in the cloud, an intermediary network location, or on the device itself.
- The data is then processed, often by machine learning and artificial intelligence.
- The processed data is used by the physical device to perform some action.

For example, this process as applied to a smart thermostat would go like this:

- The thermostat has a sensor that reads the temperature in the room.
- The thermostat stores and processes that data.
- If the temperature exceeds a certain value, the thermostat automatically regulates the temperature to some predefined value.
- The thermostat transmits periodic temperature readings to the energy provider's external database over a wireless network.
- A data analytics application derives insights from the data over time to improve energy efficiency by adjusting the thermostat's temperature settings.






## BASIC IOT FUNDAMENTALS, CONCEPTS AND TERMS

The four pillars of IoT and the main concepts to understand are:

i. Data - IoT technologies provide myriad ways to collect data about the physical world. Data is the fuel of IoT and is why it is so important.

ii. Device - The actual, physical components or things in the internet of things that collect this data.

iii. Analytics - The process of making collected data useful by turning raw data into actionable insights.

iv. Connectivity - Makes sharing data and insights possible, increasing the value of that data. This is the internet in internet of things.

## SPECIFIC TYPES OF IOT AND ITS APPLICATIONS:

- Industrial internet of things (IoT) - Refers to the use of IoT in industrial applications.
- Internet of medical things (IoMT). The use of IoT in medicine.
- V2X communications (vehicle to everything communications). A vehicle's ability to sense its environment and communicate with it.
- Internet of battlefield things (IoBT). When IoT is used for military purposes.



## CHALLENGES OF IOT TECHNOLOGY

Despite its potential, IoT faces several challenges, including:

- IoT security - Oftentimes, IoT devices are meant to automate processes, and so humans don't interact with them as frequently as consumer devices like smartphones (itself a type of IoT device). For example, an administrator of an IoT device like a smart camera is more likely to neglect to change the default password set by the manufacturer. The result is an external-facing IoT device with a simple default password to crack.

- Data privacy - There are also concerns about the data rights and privacy of consumer data as IoT becomes more prevalent. With more networked devices sharing data autonomously, being accountable for all that data becomes difficult; for example, billboards with hidden cameras that track demographic information of passersby who stop to read it (without their knowledge or consent), and securing patient data smart medical devices collect in and out of the hospital.

- Safety - IoT devices, especially those used in industrial, medical, transportation and infrastructural applications -- are often tasked with jobs that, if performed incorrectly, could put lives at risk. If a smart car's warning system malfunctions, it could cause the driver to neglect an obstacle or pedestrian. A malfunctioning sensor at an industrial plant can be catastrophic if a key warning sign is missed.



- Interoperability - Many IoT devices have unique or niche protocols or proprietary services that they run on, and can't interact with other devices or services without considerable tweaking. There is also no universal standard set of terminology for talking about IoT, or a common set of regulations for when these devices see widespread adoption in the public sphere.

# Features of IoT

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# Features of IoT

The most important features of IoT on which it works are connectivity, analyzing, integrating, active engagement, and many more. Some of them are listed below:

- **Connectivity:** Connectivity refers to establish a proper connection between all the things of IoT to IoT platform it may be server or cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable, secure and bi-directional communication.



- **Analyzing:** After connecting all the relevant things, it comes to real-time analyzing the data collected and use them to build effective business intelligence. If we have a good insight into data gathered from all these things, then we call our system has a smart system.

- **Integrating:** IoT integrating the various models to improve the user experience as well.

- **Artificial Intelligence:** IoT makes things smart and enhances life through the use of data. For example, if we have a coffee machine whose beans have going to end, then the coffee machine itself order the coffee beans of your choice from the retailer.

- **Sensing:** The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true IoT environment.

- **Active Engagement:** IoT makes the connected technology, product, or services to active engagement between each other.
- **Endpoint Management:** It is important to be the endpoint management of all the IoT system otherwise, it makes the complete failure of the system. For example, if a coffee machine itself order the coffee beans when it goes to end but what happens when it orders the beans from a retailer and we are not present at home for a few days, it leads to the failure of the IoT system. So, there must be a need for endpoint management.



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# IoT Application

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## Application of IoT

- Smart City
- Health Care
- Education
- Agriculture
- Smart Home
- Vehicle Industry

# ZigBee

Internet of Things

# ZigBee

- ZigBee is a wireless technology standard that defines a set of communication protocols for **short range communications**.

ZigBee®



## Why another short-range communication standard??

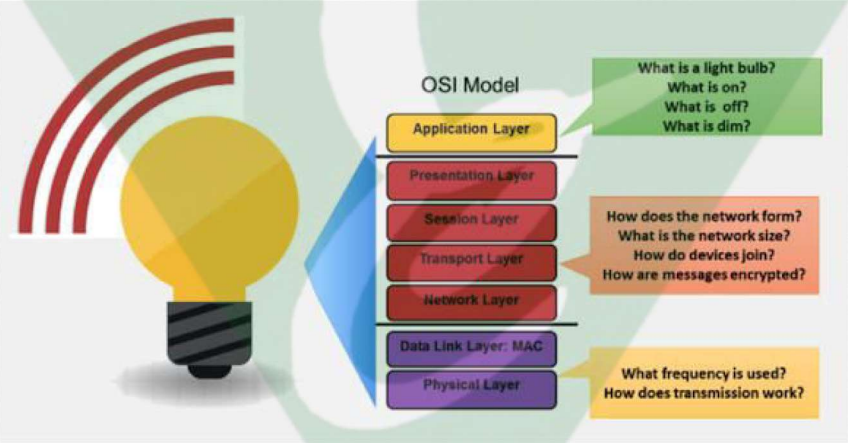

- ZigBee standard is specially build for **control and sensor networks**.


- Zigbee is a standard that addresses the need of **very low-cost implementation** of **Low power devices** with **Low data rate** for **short range wireless communications**.

- It is one of the most commonly used standard for Internet of things (IOT).
- ZigBee is an open source standard that was developed by **ZIGBEE Alliance**.
- ZigBee is a technological standard created for controlling and sensing the network. As we know that ZigBee is the Personal Area Network of task group 4 so it is based on **IEEE 802.15.4**



- IEEE802.15.4 developed the PHY and MAC layer whereas, the ZigBee takes care of upper higher layers.

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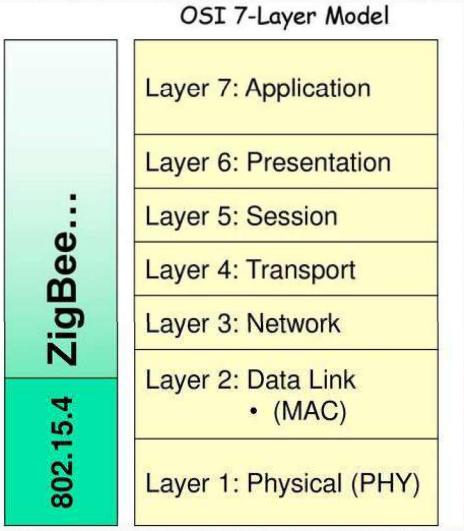
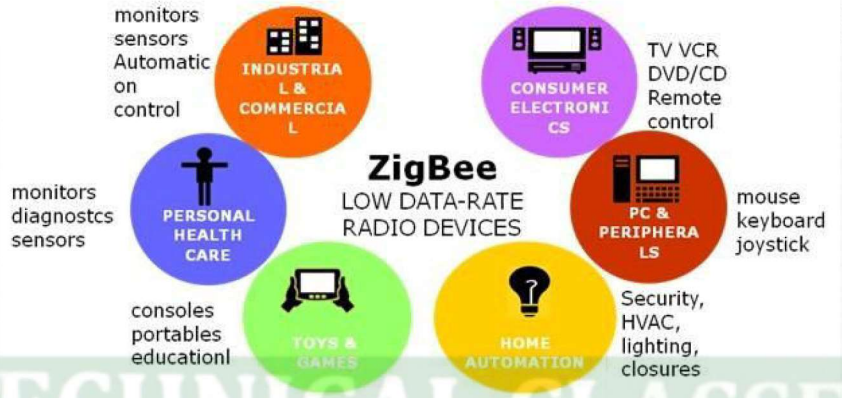


# ZigBee network applications



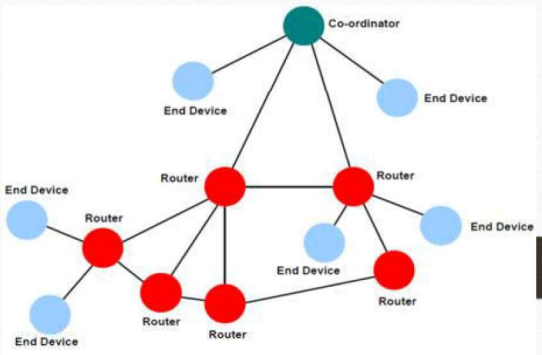



# Types of ZigBee Devices

- Zigbee Coordinator Device
- Zigbee Router
- Zigbee End Device

**ZigBee Coordinator** –

- Most capable device
- Root of the network
- One coordinator in each network

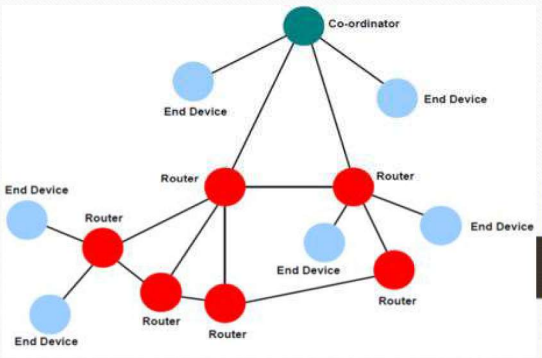



**Tasks:**

- Channel selection
- Assign an ID to the Network
- Allocates unique address to each device
- Initiates and transfers messages in the network

## ZigBee Routers –

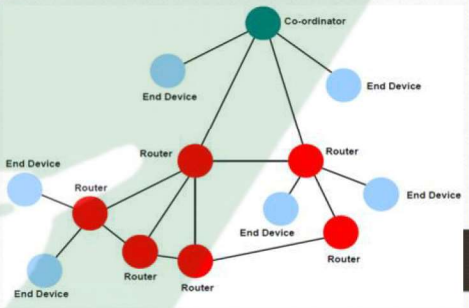
- Act as intermediate nodes between the coordinator and the end devices
- Route traffic between different nodes.
- Receive and store messages intended for their children.
- Can allow other routers and end devices to join the network.



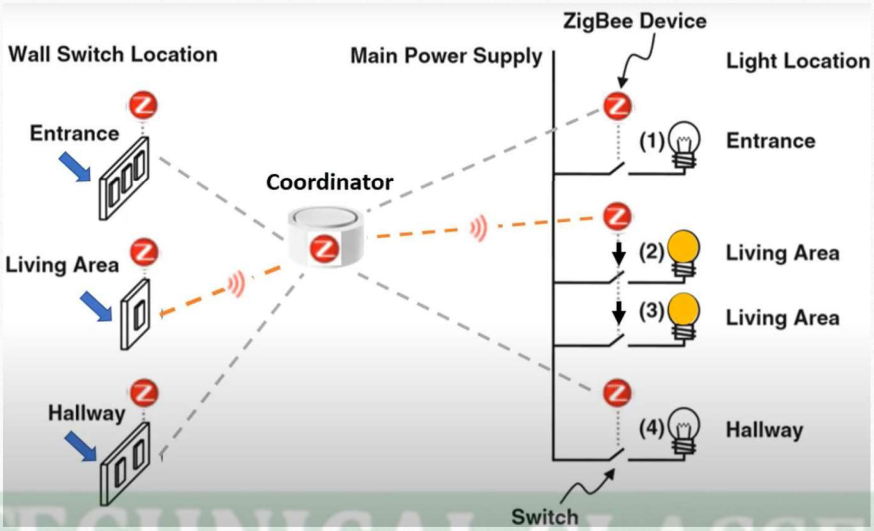



## ZigBee End Device –

- Contains just enough information to talk to the parent node.
- They may sleep (a standby), which makes end devices a suitable choice for battery operated devices.
- All traffic to an end device is first routed to its parent.
- The end device is responsible for requesting any pending messages from its parent.




## Home Automation







# IoT Communication Protocols

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# Need of Communication Protocols in IoT

- IoT devices communicate using IoT protocols.
- Internet protocol (IP) is a set of rules that dictates how data gets sent to the internet.
- IoT protocols ensure that information from one device or sensor gets read and understood by another device, a gateway, a service. Different IoT protocols have been designed and optimized for different scenarios and usage.

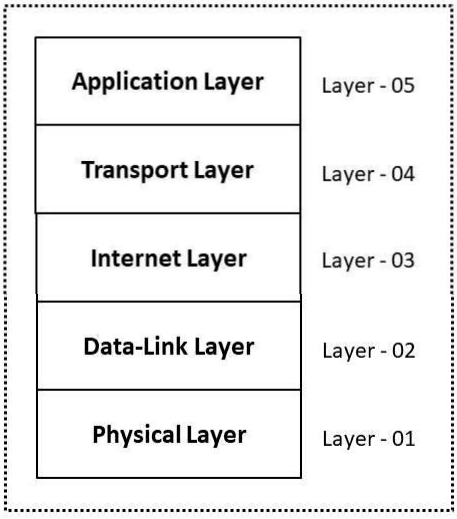
# What IoT protocol is right for me?

- The type of IoT protocol you'll need depends on the system architecture layer that the data will travel in.
- The **Open Systems Interconnection (OSI)** model provides a map of the various layers that send and receive data.
- Each IoT protocol in the IoT system architecture enables device-to-device, device-to-gateway, gateway-to-data center, or gateway-to-cloud communication, as well as communication between data centers.

# TCP/IP Model

- Transmission Control Protocol / Internet Protocol is the implementation of Open System Interconnection Model.

TCP/IP 5-Layers



# Application layer

The application layer serves as the interface between the user and the device within a given IoT protocol.

- Advanced Message Queuing Protocol (AMQP)
- Constrained Application Protocol (CoAP)
- Data Distribution Service (DDS)
- **Message Queue Telemetry Transport (MQTT)**



# Transport layer

In any IoT protocol, the transport layer enables and safeguards the communication of the data as it travels between layers.

- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)

# Network layer

The network layer of an IoT protocol helps individual devices communicate with the router.

- IP (IPv4/IPv6)
- 6LoWPAN

# Data link layer

The data layer is the part of an IoT protocol that transfers data within the system architecture, identifying and correcting errors found in the physical layer.

- IEEE 802.15.4
- LPWAN (Low-power wide-area networks) e.g. **LoRaWAN**



# Physical layer

The physical layer is the communication channel between devices within a specific environment.

- **Bluetooth Low Energy (BLE)**
- Ethernet
- Long-term evolution (LTE)
- Near field communication (NFC)
- Power Line Communication (PLC)
- Radio frequency identification (RFID)
- **Wi-Fi/802.11**
- Z-Wave
- **Zigbee**

# LoRa

Internet of Things




- For the Internet of Things (IoT), many devices are likely to be constrained in terms of cost and power. For many use cases, devices require only a *low data rate but long range*. Cellular technologies, Wi-Fi or Bluetooth don't cater well to these use cases. This is where LoRa (Long Range) becomes relevant.

- LoRa devices are low power, long range devices. They transmit and receive data over unlicensed frequency spectrum. A typical use case is to transmit low-rate sensor data.
- LoRa is one particular technology in the domain of Low-Power Wide-Area Network (LPWAN).
- LoRa technology was developed by a company called **Semtech** and it is a new wireless protocol designed specifically for **long-range, low-power communications**. LoRa stands for **Long Range Radio** and is mainly targeted for M2M and IoT networks. This technology will enable public or multi-tenant networks to connect a number of applications running on the same network.

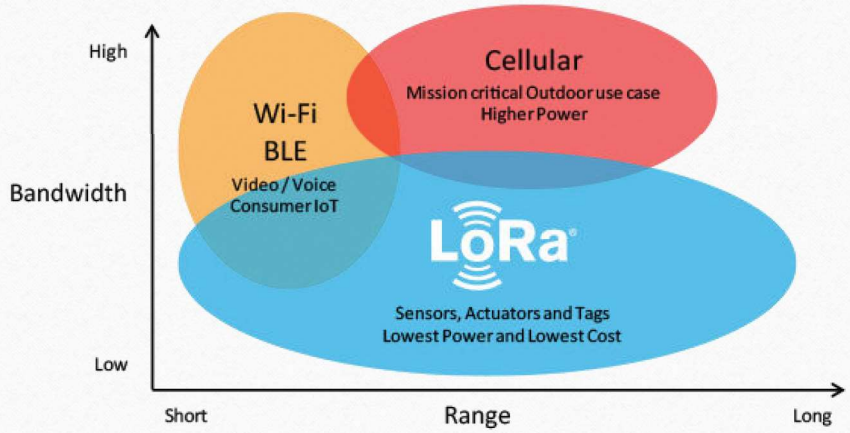
- Each LoRa gateway has the ability to handle up to millions of nodes. The signals can span a significant distance, which means that there is less infrastructure required, making constructing a network much cheaper and faster to implement.



## What led to the wider deployment of LoRa?

- LoRa technology has become a popular name in the field of the Internet of Things (IoT) because of its infinite potential. Two of the reasons why LoRa has become so popular are its broad coverage range and low-energy consumption.

- LoRa technology has long-range transmission distance which can reach more than 10 kms and works at such low currents that battery-powered applications can last for years before it needs a change.
- LoRa technology has license-free frequency band nodes. The cost of its gateways and modules are relatively cheap, the installation and deployment are quick and easy.
- Low power, long-range, and easy to deploy — what more can you ask for? LoRa technology's versatile application makes it a mainstay for IoT and technology for the long run.



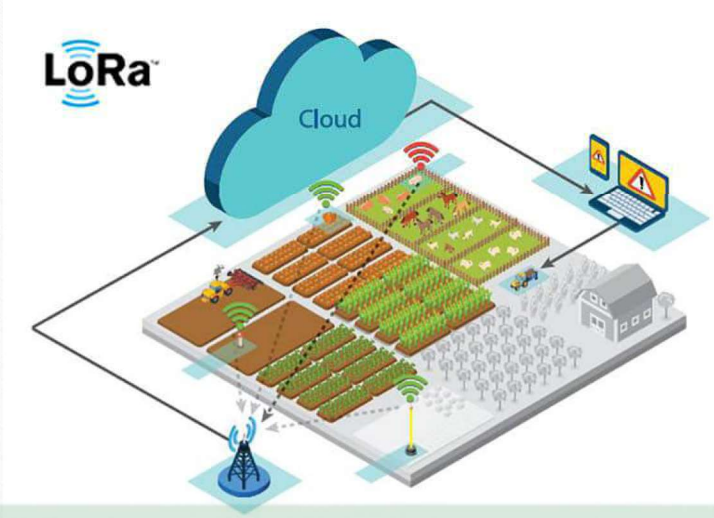



## What are the typical use cases of LoRa?

- Among its application areas are smart cities, smart homes and buildings, smart agriculture, smart metering, and smart supply chain and logistics.

- A typical use case is smart metering. For example, LoRa-enabled meters will increase efficiency and optimize processes. For water management, sensors will monitor water pressure, water level or detect leaks.
- In smart buildings, the typical use of LoRa is for smoke detection, asset and vehicle tracking, room usage and more. Asset tracking is possible because LoRa works well even when devices are in motion.

Smart Agriculture






The following table showcases some of the key features of the LoRa protocol

| Specification | LoRa Feature |
|---|---|
| Range | 2-5Km Urban (1.24-3.1 mi), 15Km suburban (9.3 mi) |
| Frequency | ISM 868/915 MHz |
| Standard | IEEE 802.15.4g |
| Capacity | One LoRa gateway takes thousands of nodes |
| Battery | Long battery life |

# MQTT Protocol

Internet of Things



## MQTT Protocol

- MQTT stands for **Message Queuing Telemetry Transport**.
- MQTT is a machine to machine internet of things connectivity protocol.
- It is an extremely lightweight and **publish-subscribe** messaging transport protocol.
- These characteristics make it useful in various situations, including constant environment such as for communication machine to machine and internet of things contexts.

- It is a **publish and subscribe** system where we can publish and receive the messages as a client. It makes it easy for communication between multiple devices.
- It is a simple messaging protocol designed for the constrained devices and with low bandwidth, so it's a perfect solution for the internet of things applications.

# Characteristics of MQTT

The MQTT has some unique features which are hardly found in other protocols. Some of the features of an MQTT are given below:

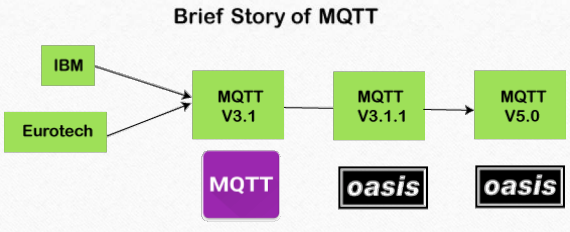
- It is a machine to machine protocol, i.e., it provides communication between the devices.



- It is designed as a simple and lightweight messaging protocol that uses a publish/subscribe system to exchange the information between the client and the server.
- It does not require that both the client and the server establish a connection at the same time.
- It provides faster data transmission, like how WhatsApp/messenger provides a faster delivery. It's a real-time messaging protocol.
- It allows the clients to subscribe to the narrow selection of **topics** so that they can receive the information they are looking for.

# History of MQTT

MQTT was created by Dr. Andy Stanford-Clark of **IBM** and Arlen Nipper of Arcom -- now **Eurotech** -- in **1999**.



# MQTT Architecture

To understand the MQTT architecture, we first look at the components of the MQTT.

- Message
- Client
- Server or Broker
- TOPIC



# Message

The message is the data that is carried out by the protocol across the network for the application.

# Client

- In MQTT, the subscriber and publisher are the two roles of a client.
- The clients subscribe to the topics to publish and receive messages.
- In simple words, we can say that if any program or device uses an MQTT, then that device is referred to as a client.

- A device is a client if it opens the network connection to the server, publishes messages that other clients want to see, subscribes to the messages that it is interested in receiving, unsubscribes to the messages that it is not interested in receiving, and closes the network connection to the server.
- In MQTT, the client performs two operations:

i. **Publish:** When the client sends the data to the server, then we call this operation as a publish.

ii. **Subscribe:** When the client receives the data from the server, then we call this operation a subscription.



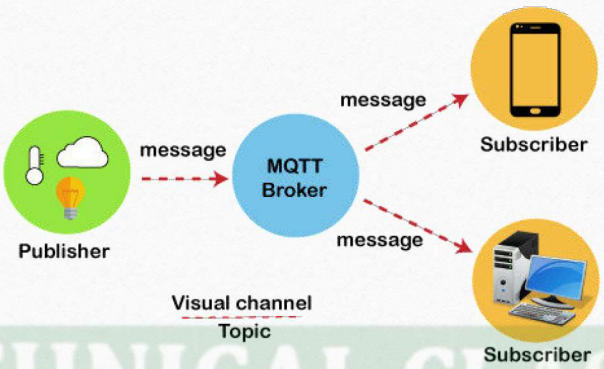
## Server

- The device or a program that allows the client to publish the messages and subscribe to the messages.
- A server accepts the network connection from the client, accepts the messages from the client, processes the subscribe and unsubscribe requests, forwards the application messages to the client, and closes the network connection from the client.

## TOPIC

- The label provided to the message is checked against the subscription known by the server is known as TOPIC.

# Architecture of MQTT

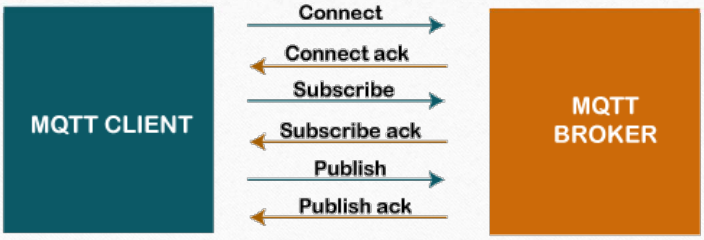





- To understand it more clearly, we will look at the example. Suppose a device has a temperature sensor and wants to send the rating to the server or the broker. If the phone or desktop application wishes to receive this temperature value on the other side, then there will be two things that happened. The publisher first defines the topic; for example, the temperature then publishes the message, i.e., the temperature's value. After publishing the message, the phone or the desktop application on the other side will subscribe to the topic, i.e., temperature and then receive the published message, i.e., the value of the temperature. The server or the broker's role is to deliver the published message to the phone or the desktop application.

# MQTT Message Format

- The MQTT uses the command and the command acknowledgment format, which means that each command has an associated acknowledgment.






## Bluetooth low energy

Internet of Things

## Bluetooth

- Bluetooth is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances and building personal area networks (PANs).

Bluetooth®

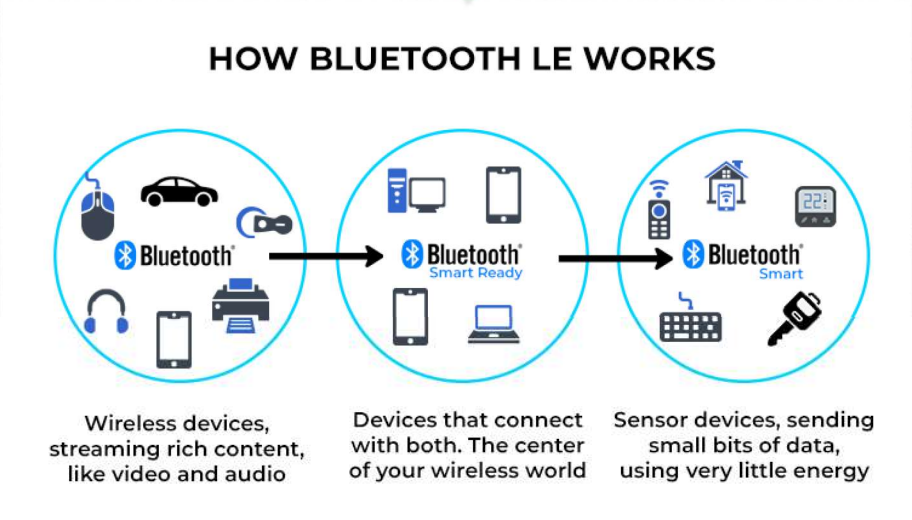
- It employs UHF radio waves in the ISM bands, from 2.402 GHz to 2.48 GHz.
- Before the onset of the smartphone era, Bluetooth used to be the de facto connectivity standard in transferring data from one phone to another; usually, audio, videos and picture files. Now in its latest avatar, **Bluetooth Low Energy (BLE)**, or **Bluetooth Smart**, the technology is making a full-fledged return because of its ease of use in connecting devices for the Internet-of-Things



# What Is Bluetooth LE?

Bluetooth Low Energy or Bluetooth LE is defined as connectivity technology that enables wireless personal area networks using radio waves in the **2.4 GHz band**, which consumes minimal energy and is designed to connect devices across a short-range.

Bluetooth Low Energy is based on Bluetooth. It was released in 2011, and it is also referred to as Bluetooth Smart and **Bluetooth 4.0**.

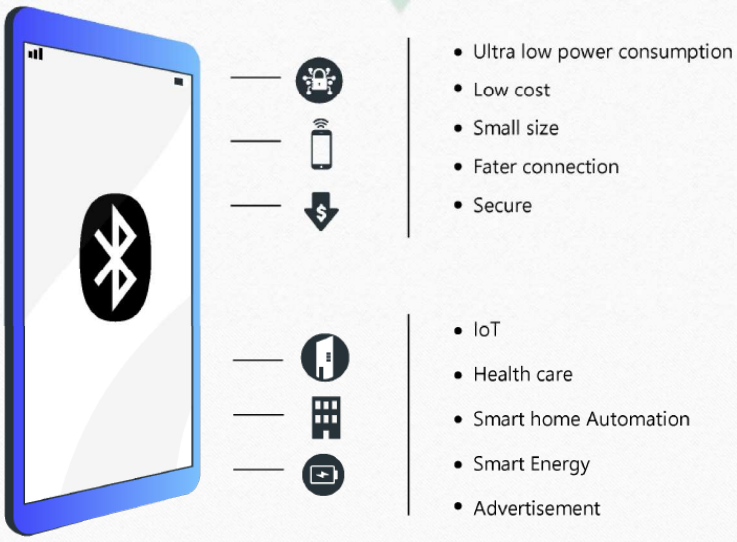


- Bluetooth Low Energy is famous under many names: BLE, Bluetooth LE or Bluetooth Smart, its registered trademark.
- Originally, it has been designed by Nokia under the name of Wibree before being finally implemented by the GIS (Bluetooth Special Interest Group). Its implementation primary objective was to optimize energy consumption.
- The BLE technology provides an easy and a reliable interface, which is highly appreciated by consumer electronics manufacturers, mobile application developers and engineers.
- It has become increasingly suitable for all matters related to the Internet of Things (IoT), which is a fast growing industry nowadays.



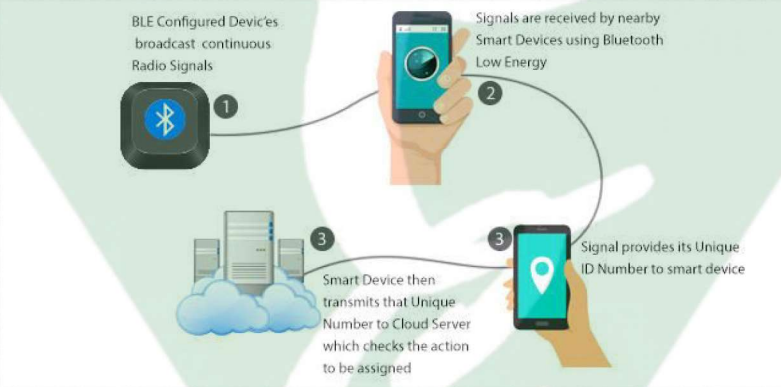
## Features

- The main strength of Bluetooth Low Energy is definitely its very low energy consumption. Designed for periodic transfer of little amounts of short-range data, the BLE technology is easy to deploy.
- It usually consumes only half as much as Bluetooth.
- Finally, it remains cost-effective with a significant battery lifespan.



# How it works?

- BLE devices send out continuous radio signals to nearby smart devices (Android/IOS) within a specified range. Smart devices/Smartphones which are in that range can listen and be triggered. The smart device then sends a UUID (Universally Unique Identifier) number to the cloud server. The server checks what action is assigned to that ID number & responds quickly.




- The signal tells the smart device "Here I am" by giving its ID number. Mobile operating systems like iOS, Android, Windows Phone, Linux, Windows 8 and Windows 10 are compatible with BLE.

# Operating Mode of BLE

There are different types of connections available for the BLE device. A BLE connected item may have up to 4 different functions:

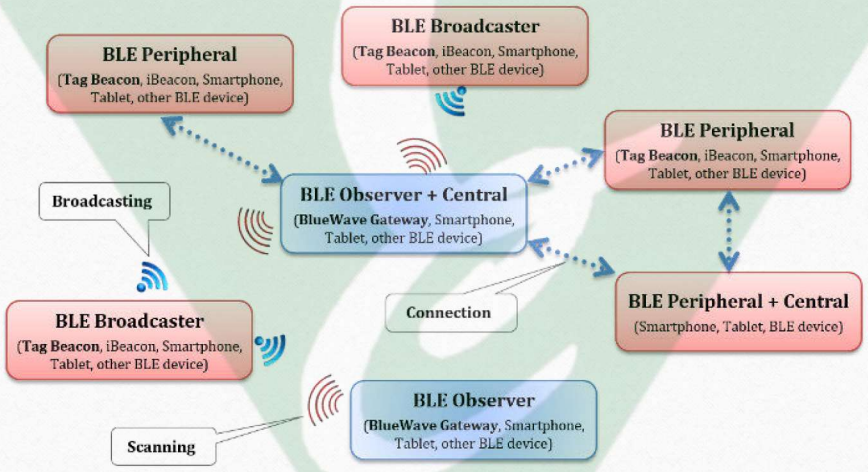
i. **Broadcaster** - The "Broadcaster" shall be used as a server. Thus, its purpose is to transfer data to a device on a regular basis, but it does not support any incoming connection.

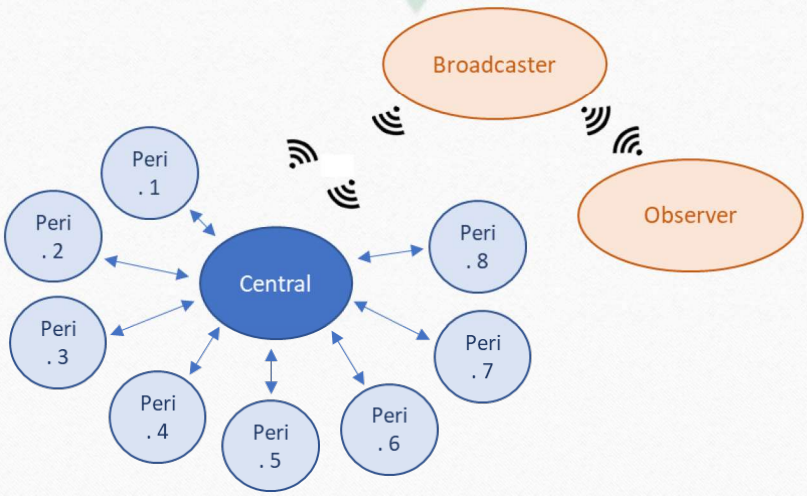
ii. **Observer** - In a second step, the device may only monitor and read the data sent by a "broadcaster". In such a case, the object is not able to send any connection to the server.

iii. **Central** - The "Central" usually consists of a smartphone or tablet. This device provides two different types of connection: either in advertising mode or in connected mode. It is leading the overall process as it triggers data transfer.

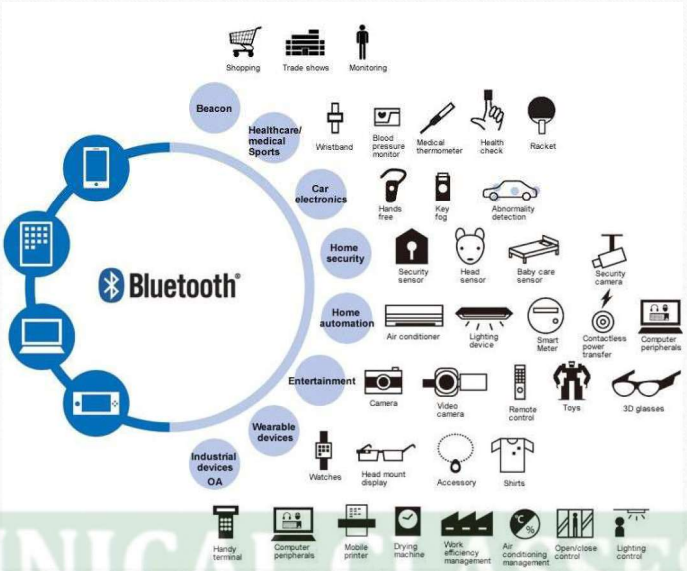
iv. **Peripheral** - The "Peripheral" device allows connections and data transfer with the ¨Central¨ on a periodical basis. This system´s goal is to ensure universal data transmission by using the standard process, so that other devices also may read and understand the data.





## BLE Devices







# Wi-Fi

Internet of Things

# Analogy



# Analogy

# Wi-Fi (IEEE 802.11)

- Wi-Fi stands for **Wireless Fidelity**, and it is developed by an organization called IEEE (Institute of Electrical and Electronics Engineers) they set standards for the Wi-Fi system.
- We all know about Wi-Fi, in our mobile, laptop everywhere Wi-Fi is supported. Wi-Fi is a wireless networking technology, by which we can access networks or connect with other computers or mobile using a wireless medium. In Wi-Fi, data are transferred over radio frequencies in a circular range.

- Each Wi-Fi network standard has two parameters :

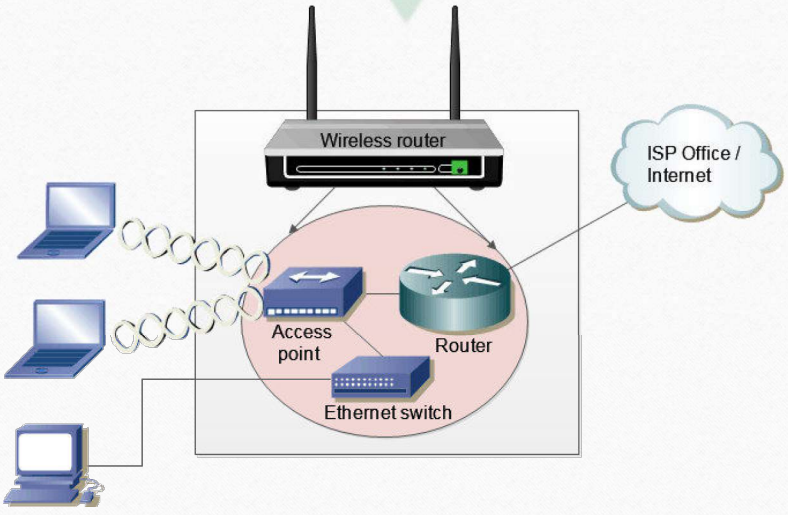
  i. **Speed –** This is the data transfer rate of the network measured in Mbps (1 megabit per second).

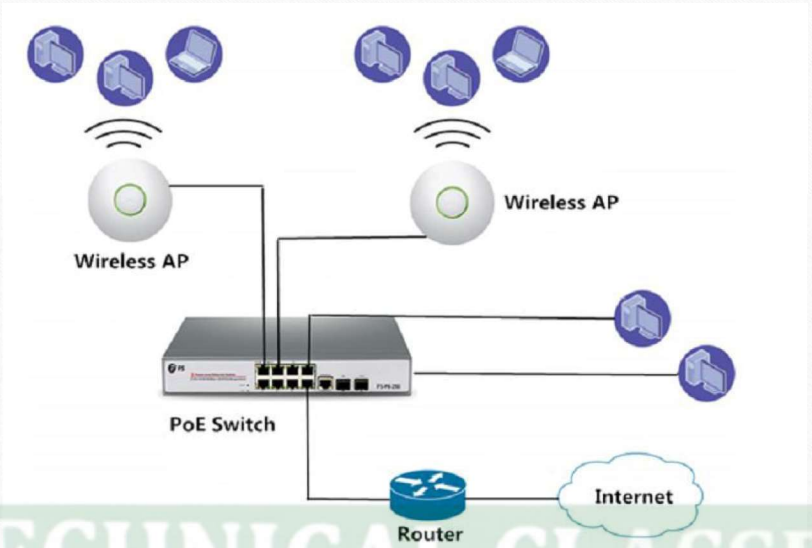
  ii. **Frequency –** On what radio frequency, the network is carried on. Two bands of frequency for the Wi-Fi are 2.4 GHz and 5 GHz. In short, it is the frequency of radio wave that carries data.

- Wi-Fi is known as WLAN. The communication standard is IEEE 802.11.
- Wi-Fi works using Physical and Data Link Layer.



- Like its Ethernet and token ring siblings, 802.11 is designed for use in a limited geographical area (homes, office buildings, campuses).
- It's Primary challenge is to mediate access to a shared communication medium - in this case, signals propagating through space.
- Access Method of IEEE 802.11 Wi-Fi: **CSMA/CA** (Carrier Sense Multiple Access with Collision Avoidance)








# Wi-Fi Adapter


- The Wi-Fi connection is established from the access point or base station to the client connection or any client-to-client connection within a specific range, the range depends on the router which provides the radio frequency through Wi-Fi. These frequencies operate on 2 types of bandwidth at present, 2.4 GHz and 5 GHz.
- All the modern laptops and mobiles are capable of using both bandwidths, it depends on the Wi-Fi adapter which is inside the device to catch the Wi-Fi signal. 2.4 GHz is the default bandwidth supported by all the devices. 2.4 GHz can cover a big range of areas to spread the Wi-Fi signal but the frequency is low, so in simple words, the speed of the internet is less and 5 GHz bandwidth is for a lower range of area but the frequency is high so the speed is very high.

- Let's say, if there is an internet connection of 60 MB/s bandwidth, then for 2.4 GHz bandwidth, it provides approx 30 to 45 MB/s of bandwidth connection and for 5 GHz bandwidth, it provides approx 50 to 57 MB/s bandwidth.



## Applications of Wi-Fi

Wi-Fi has many applications, it is used in all the sectors where a computer or any digital media is used, also for entertaining Wi-Fi is used. Some of the applications are mentioned below –

- **Accessing Internet:** Using Wi-Fi we can access the internet in any Wi-Fi-capable device wirelessly.
- We can **stream or cast audio or video** wirelessly on any device using Wi-Fi for our entertainment.

- We can **share files, data**, etc between two or more computers or mobile phones using Wi-Fi, and the speed of the data transfer rate is also very high. Also, we can print any document using a Wi-Fi printer, this is very much used nowadays.
- We can use Wi-Fi as **HOTSPOTS** also, it points Wireless Internet access for a particular range of area. Using Hotspot the owner of the main network connection can offer temporary network access to Wi-Fi-capable devices so that the users can use the network without knowing anything about the main network connection.

- One more important application is **VoWi-Fi**, which is known as voice-over Wi-Fi. Some years ago telecom companies are introduced VoLTE (Voice over Long-Term Evolution ). Nowadays they are introduced to VoWi-Fi, by which we can call anyone by using our home Wi-Fi network, only one thing is that the mobile needs to connect with the Wi-Fi. Then the voice is transferred using the Wi-Fi network instead of using the mobile SIM network, so the call quality is very good. Many mobile phones are already getting the support of VoWi-Fi.



- **Wi-Fi in offices:** In an office, all the computers are interconnected using Wi-Fi. For Wi-Fi, there are no wiring complexities. Also, the speed of the network is good. For Wi-Fi, a project can be presented to all the members at a time in the form of an excel sheet, ppt, etc. For Wi-Fi, there is no network loss as in cable due to cable break.

## Advantages of Wi-Fi

- It is a flexible network connection, no wiring complexities. Can be accessed from anywhere in the Wi-Fi range.
- It can be set up in an easy and fast way. Just need to configure the SSID and Password.
- Security in a high in Wi-Fi network, its uses WPA encryption to encrypt radio signals.
- It is also lower in cost.
- It also can provide Hotspots.
- it supports roaming also.

## Disadvantages of Wi-Fi

- Power consumption is high while using Wi-Fi in any device which has a battery, such as mobile, laptops, etc.
- Many times there may be some security problems happening even it has encryption. Such as many times has known devices become unknown to the router, Wi-Fi can be hacked also.
- Speed is slower than a direct cable connection.
- It has lower radiation like cell phones, so it can harm humans.



## Disadvantages of Wi-Fi

- Wi-Fi signals may be affected by climatic conditions like thunderstorms.
- Unauthorized access to Wi-Fi can happen because it does not have a firewall.
- To use Wi-Fi we need a router, which needs a power source, so at the time of power cut, we cannot access the internet.

# ZigBee Part-II

Internet of Things



## General Characteristics of Zigbee Standard

- Low Power Consumption
- Low Data Rate (20- 250 kbps)
- Short-Range (75-100 meters)
- Network Join Time (~ 30 msec)
- Support Small and Large Networks (up to 65000 devices (Theory); 240 devices (Practically))

## General Characteristics of Zigbee Standard

- Low Cost of Products and Cheap Implementation (Open Source Protocol)
- Uses AES cryptographic algorithm for data encryption and data authentication

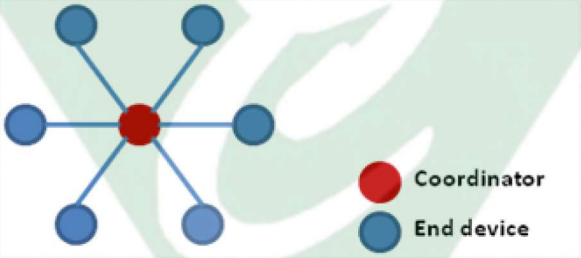
# Zigbee Network Topologies

- Star Topology (ZigBee Smart Energy)
- Mesh Topology (Self Healing Process)
- Tree Topology



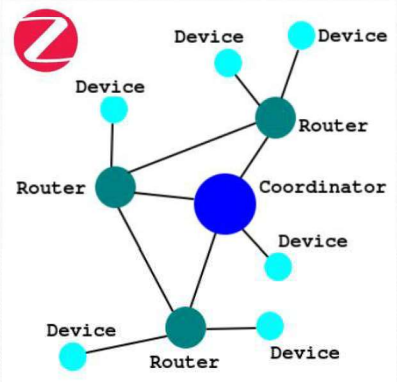
## Star Topology –

- This is the simplest and less expensive implementation
- There are no routers in this architecture.
- End device can not communicate directly with another end device.

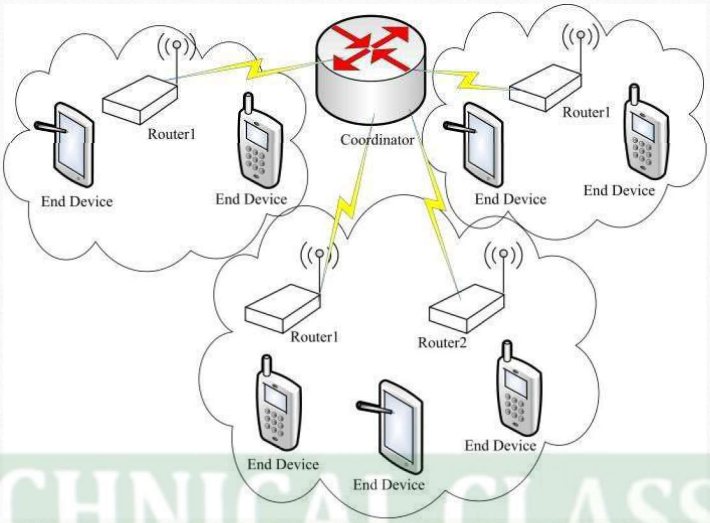



## Mesh Topology –

- Every node is connected with the neighboring node (except for the end devices).
- A message hops from one device to another in order to reach its destination.
- If a node fails, data can be re-routed using another path.
- Self-Healing Process.



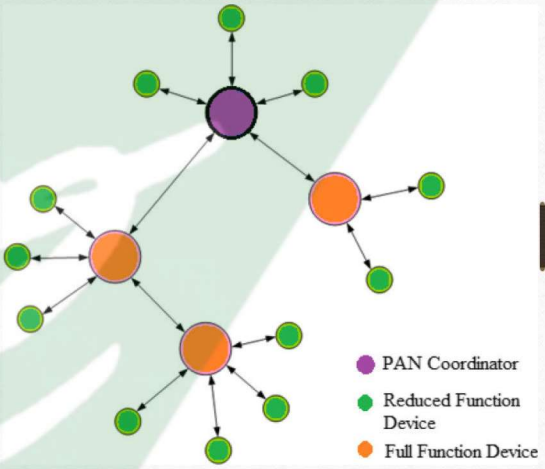
## Mesh Topology –






## Tree Topology –

- In this topology, the network consists of a central node which is a coordinator, several routers, and end devices.
- The function of the router is to extend the network coverage. (Routers are not interconnected)




## Advantages of Zigbee

- Designed for low power consumption.
- Provides network security and application support services operating on the top of IEEE.
- Zigbee makes possible completely networks homes where all devices are able to communicate.
- Use in smart home

- Easy implementation
- Adequate security features.
- **Low cost:** Zigbee chips and modules are relatively inexpensive, which makes it a cost-effective solution for IoT applications.
- **Mesh networking:** Zigbee uses a mesh network topology, which allows for devices to communicate with each other without the need for a central hub or router. This makes it ideal for use in smart home applications where devices need to communicate with each other and with a central control hub.
- **Reliability:** Zigbee protocol is designed to be highly reliable, with robust mechanisms in place to ensure that data is delivered reliably even in adverse conditions.

## Disadvantages of Zigbee

- **Limited range:** Zigbee has a relatively short range compared to other wireless communications protocols, which can make it less suitable for certain types of applications or for use in large buildings.

- **Limited data rate:** Zigbee is designed for low-data-rate applications, which can make it less suitable for applications that require high-speed data transfer.
- **Interoperability:** Zigbee is not as widely adopted as other IoT protocols, which can make it difficult to find devices that are compatible with each other.
- **Security:** Zigbee's security features are not as robust as other IoT protocols, making it more vulnerable to hacking and other security threats.




# NodeMCU

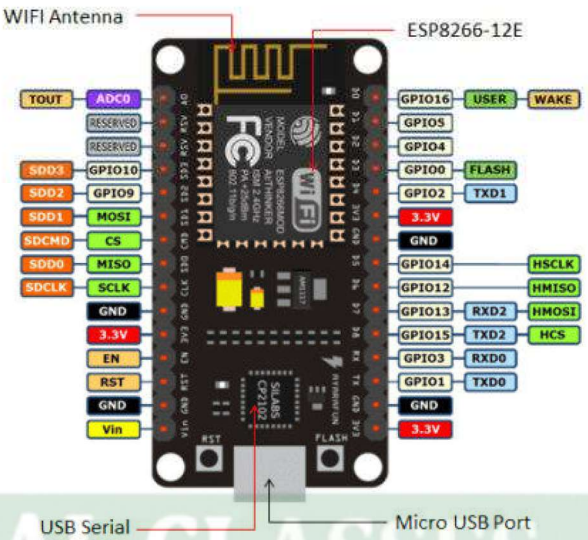
Internet of Things

## Introduction to NodeMCU ESP8266

- The NodeMCU (Node MicroController Unit) is an open source software and hardware development environment that is built around a very inexpensive System-on-a-Chip (SoC) called the ESP8266.
- The ESP8266, designed and manufactured by Espressif Systems, contains all crucial elements of the modern computer: CPU, RAM, networking (wifi), and even a modern operating system and SDK.
- When purchased at bulk, the ESP8266 chip costs only $2 USD a piece. That makes it an excellent choice for IoT projects of all kinds.

## Block Diagram

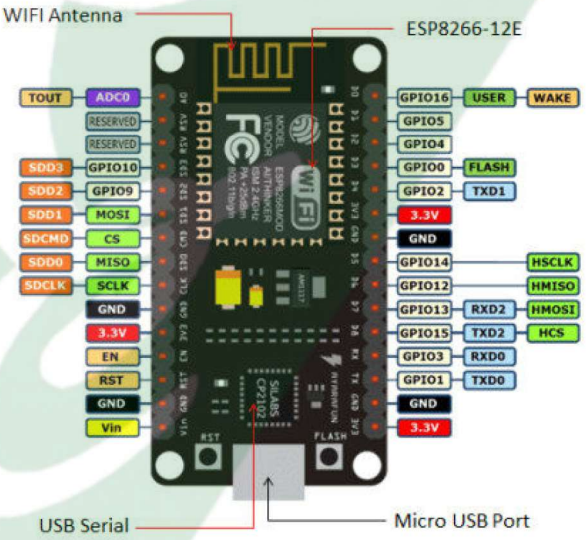
- The NodeMCU_ESP8266 has 30 pins in total out of which there are 17 GPIO pins. GPIO stands for General Purpose Input Output.





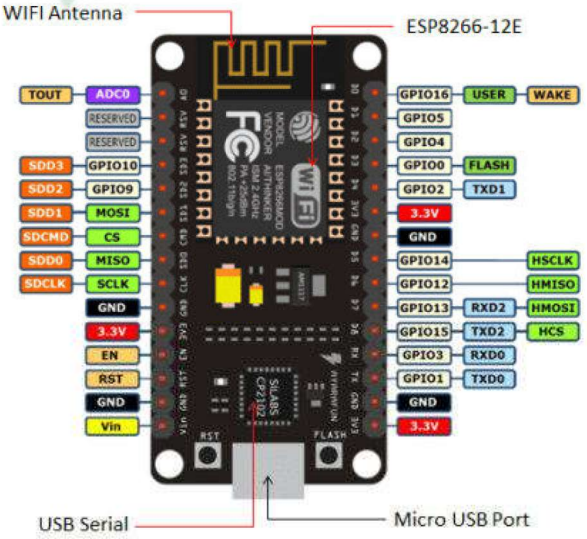

## Block Diagram

- There are the 9 digital pins ranging from D0-D8 and there is only one analog pin A0, which is a 10 bit ADC (Analog to Digital Converter).
- The D0 pin can only be used to read or write data and can't perform other options.



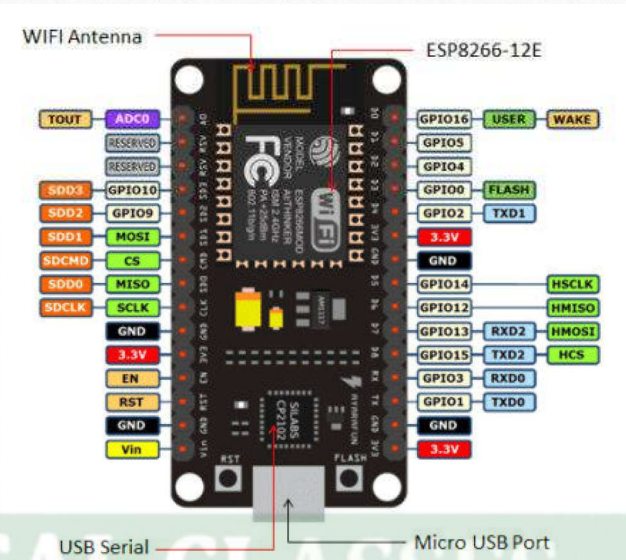

## Block Diagram

- The ESP8266 chip is enabled when the EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.



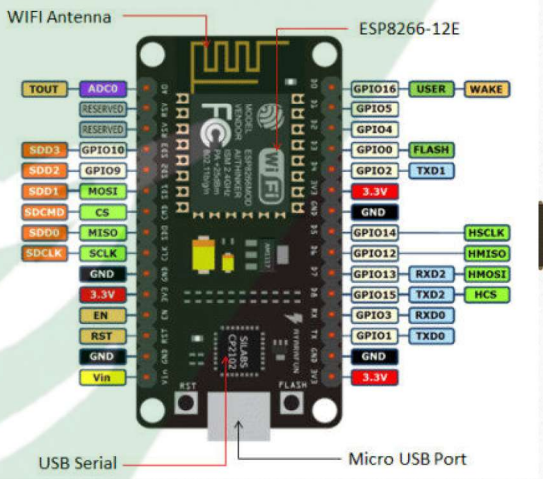
## Block Diagram

- The board has a 2.4 GHz antenna for a long-range of network and the CP2102 is the USB to TTL (Transistor to transistor language) converter.




## Block Diagram

- The development board equips the ESP-12E module containing ESP8266 chip having Tensilica Xtensa® 32-bit LX106 RISC (Reduced Instruction Set Computer) microprocessor which operates at 80 to 160 MHz adjustable clock frequency and supports RTOS (Real Time Operating System).




# Sensors

Unit – 3

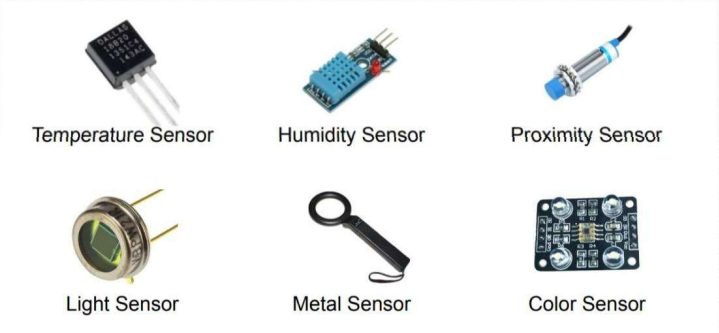
(Internet of Things)



## What is a sensor?

- A sensor is a device that detects and responds to some type of input from the physical environment.
- The input can be light, heat, motion, moisture, pressure or any number of other environmental phenomena.
- The output is generally a signal that is converted to a human-readable display at the sensor location or transmitted electronically over a network for reading or further processing.

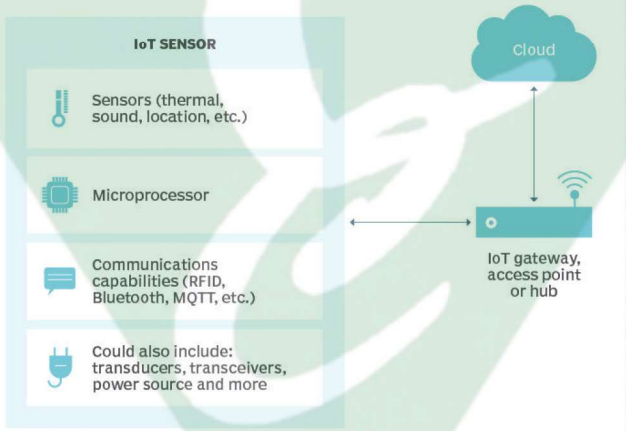
- In the broadest definition, a sensor is a device, module, machine, or subsystem that detects events or changes in its environment and sends the information to other electronics, frequently a computer processor.



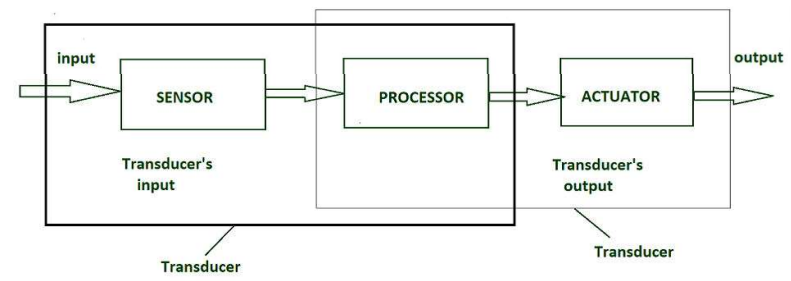
- Sensors play a pivotal role in the internet of things (IoT). They make it possible to create an ecosystem for collecting and processing data about a specific environment so it can be monitored, managed and controlled more easily and efficiently.
- IoT sensors are used in homes, out in the field, in automobiles, on airplanes, in industrial settings and in other environments.
- Sensors bridge the gap between the physical world and logical world, acting as the eyes and ears for a computing infrastructure that analyzes and acts upon the data collected from the sensors.



## An IoT sensor in action




- The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical).
- The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance etc.



- Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, and in innumerable applications of which most people are never aware.



# Transducer

- A transducer can measure similar qualities to a sensor but will convert the signal from one physical form to another meaning their input and output signals are not the same as each other. Transducers are sometimes referred to as **energy converters**.
- There are different types of transducers - **input transducers** and **output transducers**. An input transducer takes a form of energy and converts it into an electrical signal. An output transducer takes electricity and converts it into another form of energy.

## Comparison between a sensor and a transducer

| | Sensor | Transducer |
|---|---|---|
| Definition/ Function | Senses the change and gives readings in the same format that the signals are received. An additional device will be needed to convert the energy should this be required. | Senses a change, and transforms the energy from one form to another. Usually from non-electrical to electrical or vice versa. |
| Examples | Pressure switches, thermistors, mercury thermometers, and motion sensors. | Pressure transducer, cable extension transducer, linear transducer, microphone |
| Applications | Infrared toilet flushes, pressure level in oxygen tanks, patient monitoring. | Engine controls, HVAC monitoring, steering systems on vehicles, ramp or bridge lifting or positioning. |




# Types of Sensors

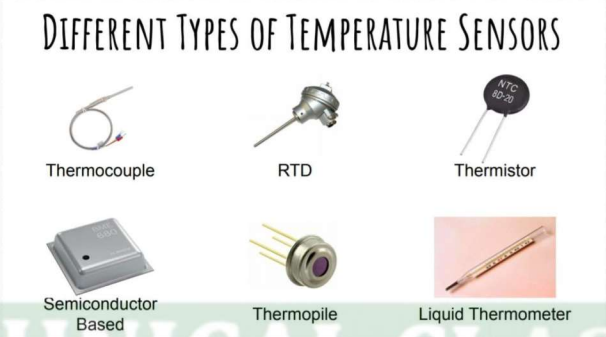
Internet of Things

## Vision and Imaging Sensors

- Vision and Imaging Sensors/Detectors are electronic devices that detect the presence of objects or colors within their fields of view and convert this information into a visual image for display.

## Temperature Sensors

- Temperature Sensors/Detectors/Transducers are electronic devices that detect thermal parameters and provide signals to the inputs of control and display devices.

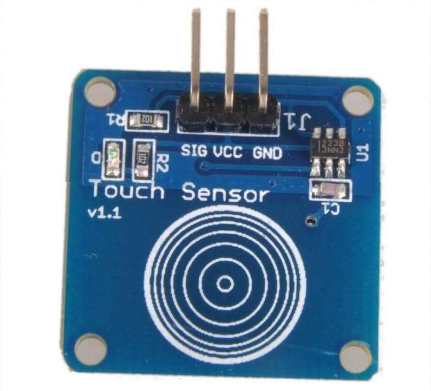



## Radiation Sensors

- Radiation Sensors/Detectors are electronic devices that sense the presence of alpha, beta, or gamma particles and provide signals to counters and display devices.

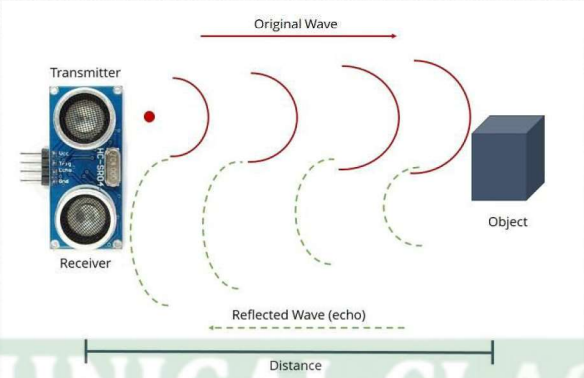
## Touch sensor

- Detection of something like a touch of finger or a stylus is known as touch sensor.



## Range sensor

- Range sensing concerns detecting how near or far a component is from the sensing position.



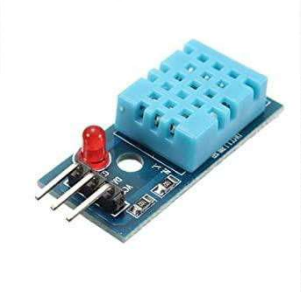



## Pressure Sensors

- Pressure Sensors/Detectors/Transducers are electro-mechanical devices that detect forces per unit area in gases or liquids and provide signals to the inputs of control and display devices.


## Humidity Sensors

- Humidity Sensors/Detectors/Transducers are electronic devices that measure the amount of water in the air and convert these measurements into signals that can be used as inputs to control or display devices.






## Classification of Sensors

Internet of Things

## Classification of Sensors

**Based on input**

- Passive sensor
- Active sensor

**Based on output**

- Analog sensor
- Digital sensor

**Based on data type**

- Scaler sensor
- Vector sensor

## Active Sensor

- An active sensor is one that requires an external power source to be able to respond to environmental input and generate output.
- For example, sensors used in weather satellites often require some source of energy to provide meteorological data about the Earth's atmosphere.



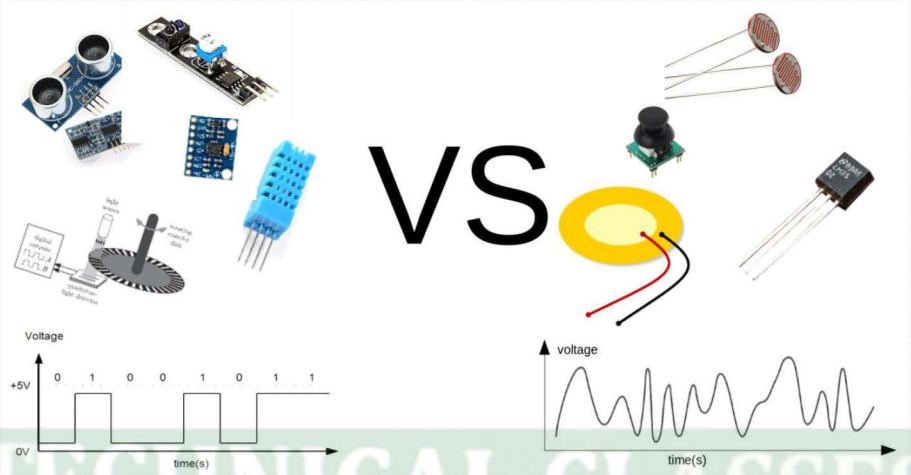
## Passive Sensor

- A passive sensor, on the other hand, doesn't require an external power source to detect environmental input.
- It relies on the environment itself for its power, using sources such as light or thermal energy.
- A good example is the mercury-based glass thermometer. The mercury expands and contracts in response to fluctuating temperatures, causing the level to be higher or lower in the glass tube. External markings provide a human-readable gauge for viewing the temperature.

## Analog Sensor & Digital Sensor

- Analog sensors convert physical data into an analog signal.
- Analog sensors are much more precise than digital sensors, which are limited to a finite set of possible values. Because analog signals are continuous, they can account for the slightest change in the physical variable (such as temperature or pressure).
- **Digital signals**, while following the general trend of variation, are restricted to fixed data (ones and zeros).

**Digital Sensors** **Analog Sensors**




## Scaler Sensor

- Detects the input parameter only based on its magnitude.
- The answer for the sensor is a function of magnitude of some input parameter.
- Not affected by the direction of input parameters.
- Example – temperature, gas, strain, color and smoke sensor.

## Vector Sensor

- The response of the sensor depends on the magnitude of the direction and orientation of input parameter.
- Example – Accelerometer, gyroscope, magnetic field and motion detector sensors.



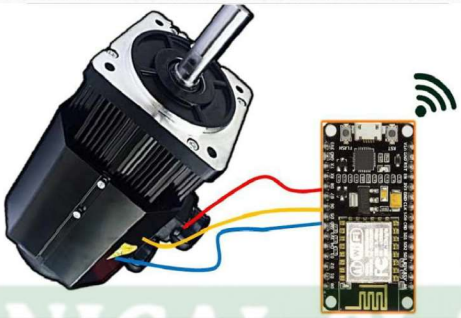

# Actuators

Internet of Things

## What is an Actuator?

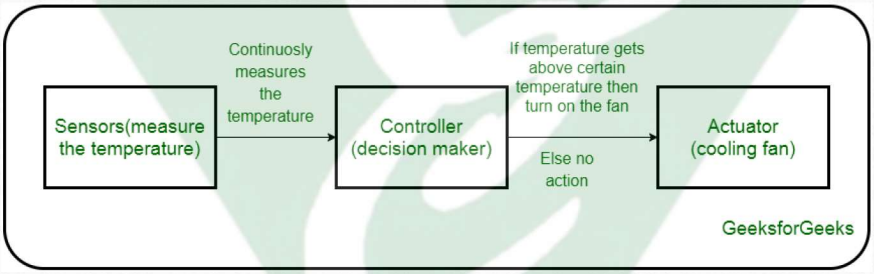
- An IoT device is made up of a Physical object ("thing") + Controller ("brain") + Sensors + Actuators + Networks (Internet).
- An actuator is a machine component or system that moves or controls the mechanism of the system.
- Sensors in the device sense the environment, then control signals are generated for the actuators according to the actions needed to perform.

- A servo motor is an example of an actuator. They are linear or rotatory actuators, can move to a given specified angular or linear position. We can use servo motors for IoT applications and make the motor rotate to 90 degrees, 180 degrees, etc., as per our need.





- The following diagram shows what actuators do, the controller directs the actuator based on the sensor data to do the work.




- The control system acts upon an environment through the actuator. It requires a source of energy and a control signal. When it receives a control signal, it converts the source of energy to a mechanical operation. On this basis, on which form of energy it uses, it has different types given below.

  i. Hydraulic Actuators
  ii. Pneumatic Actuators
  iii. Electrical Actuators

- **Hydraulic Actuators** - A hydraulic actuator uses hydraulic power to perform a mechanical operation. They are actuated by a cylinder or fluid motor. The mechanical motion is converted to rotary, linear, or oscillatory motion, according to the need of the IoT device.

- **Pneumatic Actuators** - A pneumatic actuator uses energy formed by vacuum or compressed air at high pressure to convert into either linear or rotary motion.



- **Electrical Actuators** - An electric actuator uses electrical energy, is usually actuated by a motor that converts electrical energy into mechanical torque.

# Wireless Sensor Networks

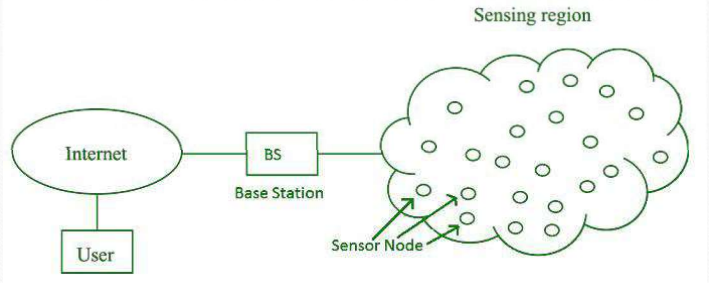
Internet of Things



## Wireless Sensor Networks (WSN)

- Wireless sensor networks (WSNs) are interconnected sensor nodes that communicate wirelessly to collect data about the surrounding environment. Nodes are generally low power and distributed in an ad hoc, decentralized fashion.

- WSN is an infrastructure-less wireless network that is deployed in a large number of wireless sensors in an ad-hoc manner that is used to monitor the system, physical or environmental conditions.

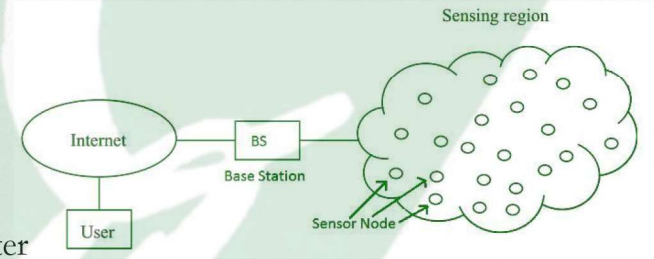


- Sensor nodes are used in WSN with the onboard processor that manages and monitors the environment in a particular area. They are connected to the Base Station which acts as a processing unit in the WSN System.
- Base Station in a WSN System is connected through the Internet to share data.
- WSN can be used for processing, analysis, storage, and mining of the data.



**A sensor node contains:**

- Sensing unit
- Communication unit
- Processing unit
- Storage unit
- Analog to Digital converter
- Options
- Power




# API

Unit-4

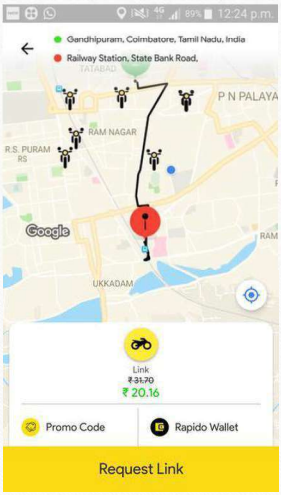
(Internet of Things)



## Application Program Interface (API)

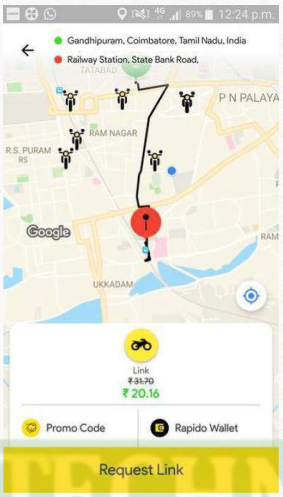
- API is an abbreviation for Application Programming Interface which is a collection of communication protocols and subroutines used by various programs to communicate between them.
- An Application programming interface is a software interface that helps in connecting between the computer or between computer programs.

## Understanding API




Google Maps

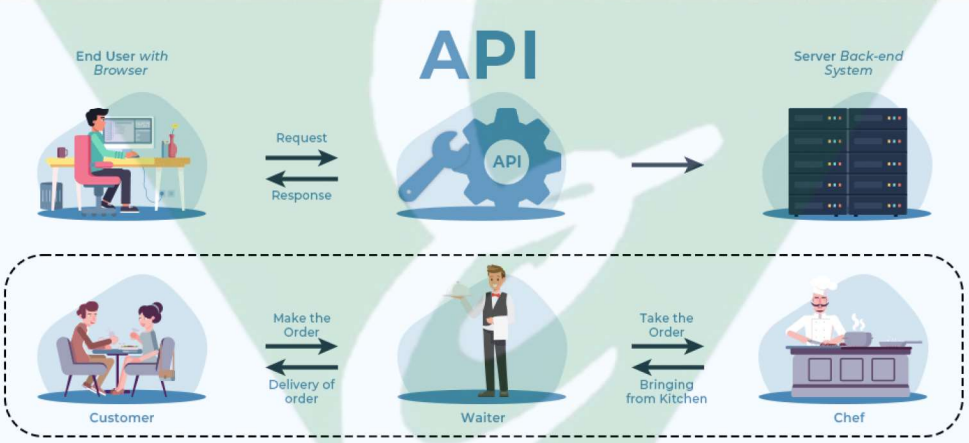
## Understanding API




API

Google Maps






## Understanding API

paytm

goibibo.com

make my trip
Dil toh roaming hai

cleartrip.com
makingtravelsimple

ixigo

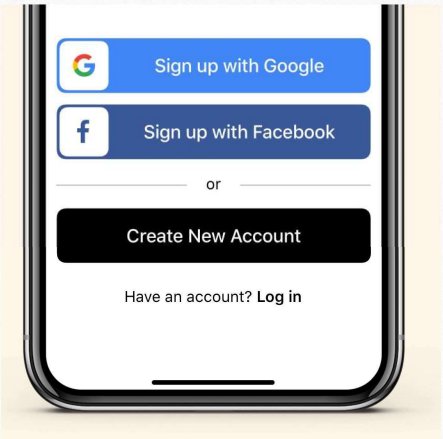
IRCTC

## Understanding API




## Understanding API


## Usage of APIs



- So we can say that, an API helps two programs or applications to communicate with each other by providing them with the necessary tools and functions. It takes the request from the user and sends it to the service provider and then again sends the result generated from the service provider to the desired user.



## Features

- An application programming interface is a software that allows two applications to talk to each other.
- Application programming interface helps in enabling applications to exchange data and functionality easily.

## Features

- The application programming interface is also called a middle man between two systems.
- Application programming interface helps in data monetization.
- Application programming interface helps in improving collaboration.

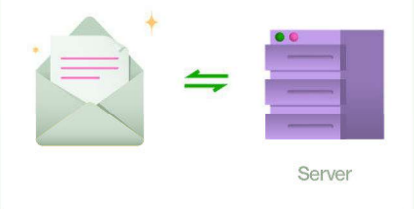
# Thank you

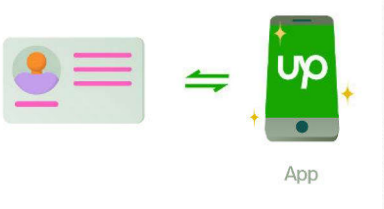


## SOAP Vs REST

Internet of Things

## SOAP Vs REST




**SOAP is like using an envelope**

Extra overhead, more bandwidth required, more work on both ends (sealing and opening).

**REST is like a postcard**

Lighterweight, can be cached, easier to update.

There is no direct comparison between SOAP and REST APIs. But there are some points to be listed below which makes you choose better between these two web services.

- SOAP stands for Simple Object Access Protocol and REST stands for Representational State Transfer.
- Since SOAP is a protocol, it follows a strict standard to allow communication between the client and the server whereas REST is an architectural style that doesn't follow any strict standard but follows six constraints defined by Roy Fielding in 2000. Those constraints are – Uniform Interface, Client-Server, Stateless, Cacheable, Layered System, Code on Demand.



- SOAP uses only XML for exchanging information in its message format whereas REST is not restricted to XML and its the choice of implementer which Media-Type to use like XML, JSON, Plain-text. Moreover, REST can use SOAP protocol but SOAP cannot use REST.
- On behalf of services interfaces to business logic, SOAP uses @WebService whereas REST instead of using interfaces uses URI like @Path.
- SOAP is difficult to implement and it requires more bandwidth whereas REST is easy to implement and requires less bandwidth such as smartphones.

- On the basis of Security, SOAP has SSL( Secure Socket Layer) and WS-security whereas REST has SSL and HTTPS. In the case of Bank Account Password, Card Number, etc. SOAP is preferred over REST.
- SOAP cannot make use of REST since SOAP is a protocol without any architectural pattern. REST can make use of SOAP because it is an architectural pattern having protocol.

| SOAP API | REST API |
|---|---|
| Relies on SOAP (Simple Object Access Protocol) | Relies on REST (Representational State Transfer) architecture using HTTP. |
| Transports data in standard XML format. | Generally transports data in JSON. It is based on URI. Because REST follows stateless model, REST does not enforces message format as XML or JSON etc. |
| Because it is XML based and relies on SOAP, it works with WSDL (Web Service Description Language) | It works with GET, POST, PUT, DELETE |
| Works over HTTP, HTTPS, SMTP, XMPP | Works over HTTP and HTTPS |
| Highly structured/typed | Less structured -> less bulky data |
| Designed with large enterprise applications in mind | Designed with mobile devices in mind |


# REST API

Internet of Things

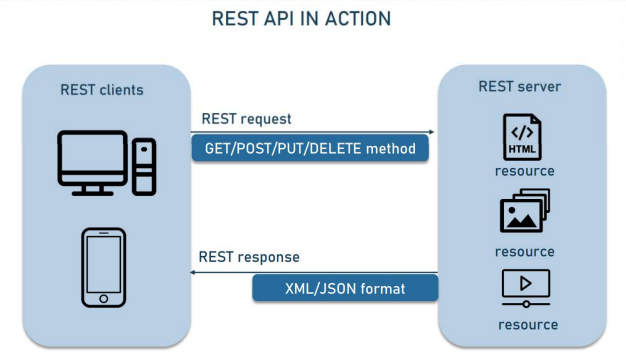
# REST API

- Representational State Transfer (REST) is an architectural style that defines a set of constraints to be used for creating web services.
- REST API is a way of accessing web services in a simple and flexible way without having any processing.
- It provides a flexible, lightweight way to integrate applications, and have emerged as the most common method for connecting components in microservices architectures.



- A RESTful API is an architectural style for an application program interface (API) that uses HTTP requests to access and use data.
- ASP.NET Web API is a framework that makes it easy to build HTTP services that reach a broad range of clients, including browsers and mobile devices.
- ASP.NET Web API is an ideal platform for building RESTful applications on the .NET Framework.
- An API for a website is code that allows two software programs to communicate with each other. The API spells out the proper way for a developer to write a program requesting services from other application.

- Its principles were formulated in 2000 by computer scientist Roy Fielding and gained popularity as a scalable and flexible alternative to older methods of machine-to-machine communication. It still remains the gold standard for public APIs.



## REST API concepts

The key elements of the REST API paradigm are

- **a client** or software that runs on a user's computer or smartphone and initiates communication;
- **a server** that offers an API as a means of access to its data or features; and
- **a resource**, which is any piece of content that the server can provide to the client (for example, a video or a text file).

To get access to a resource, the client sends an HTTP request. In return, the server generates an HTTP response with encoded data on the resource. Both types of REST messages are self-descriptive, meaning they contain information on how to interpret and process them.

# REST API methods and request structure

Any REST request includes four essential parts:

- HTTP method
- an endpoint
- headers
- body

## HTTP Method:

An HTTP method describes what is to be done with a resource. There are four basic methods also named CRUD operations:

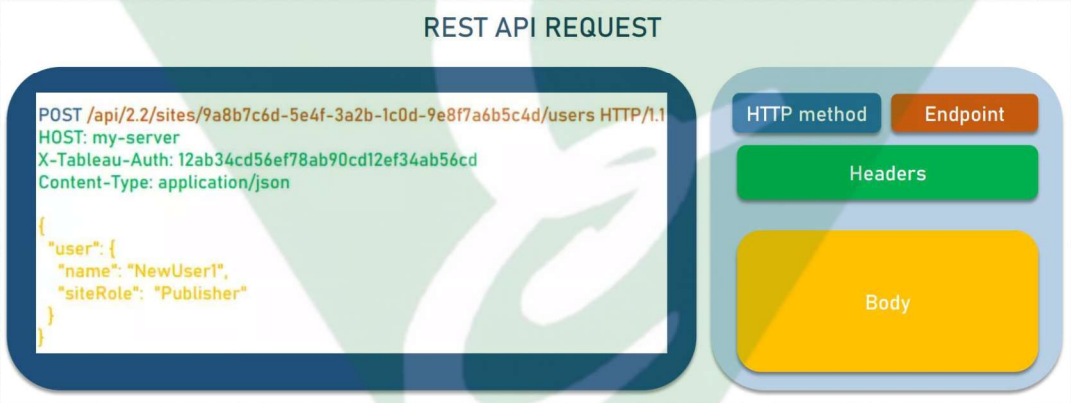
- POST to Create a resource,
- GET to Retrieve a resource,
- PUT to Update a resource, and
- DELETE to Delete a resource.

**Endpoint :** An endpoint contains a Uniform Resource Identifier (URI) indicating where and how to find the resource on the Internet. The most common type of URI is a Unique Resource Location (URL), serving as a complete web address.

**Headers :** Headers store information relevant to both the client and server. Mainly, headers provide authentication data — such as an API key, the name or IP address of the computer where the server is installed, and the information about the response format.

**Body :** A body is used to convey additional information to the server. For instance, it may be a piece of data you want to add or replace.






# Methods of REST API

- In HTTP there are five methods that are commonly used in a REST-based Architecture i.e., POST, GET, PUT, PATCH, and DELETE.
- These correspond to create, read, update, and delete (or CRUD) operations respectively.
- There are other methods which are less frequently used like OPTIONS and HEAD.

## GET:

- The HTTP GET method is used to read (or retrieve) a representation of a resource.
- In the safe path, GET returns a representation in XML or JSON and an HTTP response code of 200 (OK).
- In an error case, it most often returns a 404 (NOT FOUND) or 400 (BAD REQUEST).



## POST:

- The POST verb is most often utilized to create new resources. In particular, it's used to create subordinate resources. That is, subordinate to some other (e.g. parent) resource.
- On successful creation, return HTTP status 201, returning a Location header with a link to the newly-created resource with the 201 HTTP status.

## PUT:

- It is used for updating the capabilities. However, PUT can also be used to create a resource in the case where the resource ID is chosen by the client instead of by the server.
- In other words, if the PUT is to a URI that contains the value of a non-existent resource ID.
- On successful update, return 200 (or 204 if not returning any content in the body) from a PUT. If using PUT for create, return HTTP status 201 on successful creation.

**PATCH:**

- It is used to modify capabilities. The PATCH request only needs to contain the changes to the resource, not the complete resource.

**DELETE:**

- It is used to delete a resource identified by a URI. On successful deletion, return HTTP status 200 (OK) along with a response body.



# Example of REST API

### Twitter

- The Twitter API lets third-party applications read and write data. Use it to write and post tweets, share tweets, and read profiles. This API is especially effective for downloading and analyzing large amounts of tweets about specific topics.

# Example of REST API

### Instagram

- The Instagram Basic Display API offers access to profile information, photos, and videos. You can utilize this API and others to build apps that pull this user information and integrate it into your own product. Instagram also has a Graph API available for professional Instagram accounts to manage their online activities.

# Example of REST API

### Spotify

- Spotify's web API allows clients to request information about artists, songs, albums, and playlists on its platform. You can also use it to add songs to playlists, pause and play music, shuffle songs, and a lot more.




## REST Design Principles

Internet of Things

# REST Design Principles

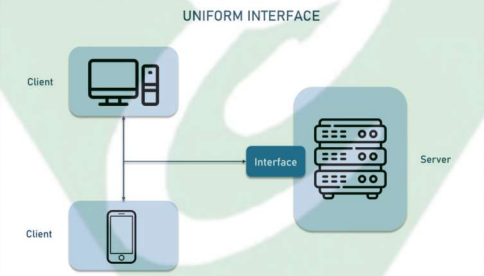
There are six REST design principles.

- Uniform interface
- Client-server decoupling
- Statelessness
- Cacheability
- Layered system architecture
- Code on demand (optional)



## Uniform interface:

- All API requests for the same resource should look the same, no matter where the request comes from.
- The REST API should ensure that the same piece of data, such as the name or email address of a user, belongs to only one uniform resource identifier (URI).




## Client-server decoupling

- In REST API design, client and server applications must be completely independent of each other.
- The only information the client application should know is the URI of the requested resource; it can't interact with the server application in any other ways.
- Similarly, a server application shouldn't modify the client application other than passing it to the requested data via HTTP.

**Statelessness:**

- REST APIs are stateless, meaning that each request needs to include all the information necessary for processing it.
- In other words, REST APIs do not require any server-side sessions. Server applications aren't allowed to store any data related to a client request.



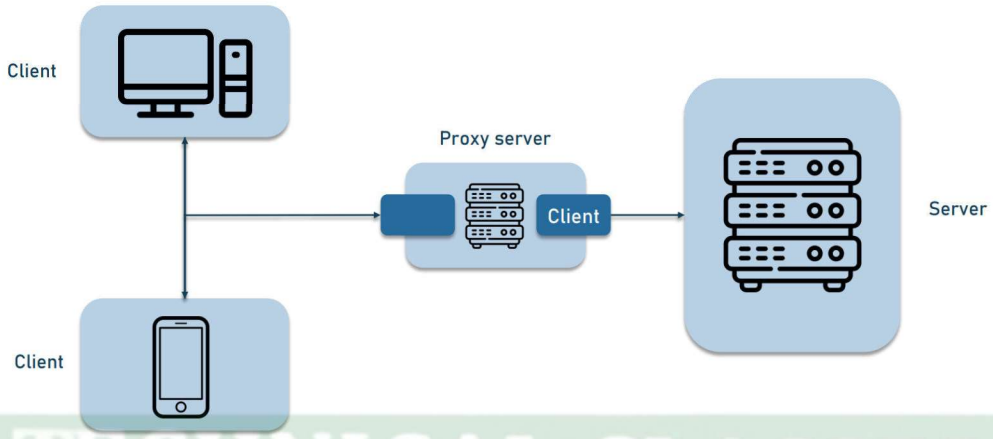
**Cacheability:**

- REST APIs allow clients to store frequently accessed data on their side instead of requesting them again and again.
- As a result, the app makes fewer calls, which reduces the load on the server and its latency. In turn, the application becomes more responsive and reliable.

**Layered architecture:**

- The RESTful system has a layered structure in which each layer works independently and interacts only with the layers directly connected to it. When calling a server, a client doesn't know whether there are any intermediaries along the way.
- Due to the layered architecture, you can place a proxy or load balancer between the client and server and thus improve scalability. Adding security as a separate layer enhances system safety. Although these services are involved in producing the response, the client doesn't have to worry about what's behind the interface.

## LAYERED ARCHITECTURE






### Code on demand (optional):

- REST APIs usually send static resources, but in certain cases, responses can also contain executable code (such as Java applets).
- The CoD practice gives the client more control over the features and allows for extended functionality.

# Types of API

Internet of Things



## Types of API

These are four common types of APIs:

i. Open APIs
ii. Internal APIs
iii. Composite APIs
iv. Partner APIs

## Open APIs

- It is also called public APIs which are available to any other users.
- Open APIs help external users to access the data and services.
- It is an open-source application programming interface in which we access with HTTP protocols.

- For example, Facebook provides an open API that allows third-party tools to create photo albums or post to a user's news feed.
- Facebook has a built-in function that allows the items a user to add publicly to their news feed to also be posted to their Twitter feed. In that case, the Facebook application is using the open API from Twitter to make that interaction happen.



## Internal APIs

- It is also known as private APIs, only an internal system exposes this type of APIs.
- These are designed for the internal use of the company rather than the external users.

- An example of a internal API is if a call center team created a customer information API used in a call center application to access their name, contact information, account info, etc. This data is only accessible company only.

# Composite APIs

- It is a type of APIs that combines different data and services.
- The main reason to use Composites APIs is to improve the performance and to speed the execution process and improve the performance of the listeners in the web interfaces.



- One example might be if a user creates a new account in an eCommerce application.
- The composite API might:
  - ✓ Create a new User ID
  - ✓ Create a new Order Number
  - ✓ Add an item to the order
  - ✓ Remove that item from inventory
  - ✓ Change order status

# Partner APIs

- It is a type of APIs in which a developer needs specific rights or licenses in order to access.
- Partner APIs are not available to the public.

- One of the best examples of Partner API is the Amazon API. Their API allows various online businesses to connect directly with Amazon.com, check the inventory, and find shipping options.




SOAP

Internet of Things

## What is an API?

- Every time you log in to a website with your Facebook account or drag a drop-off pin across a Google map in the ride-hailing app, the application you use communicates with Google or Facebook via a web API.
- An API or an application programming interface is a form of agreement between web services on how they are going to exchange data, e.g. retrieve a map or your account credentials. The data itself is structured in messages that systems send to each other.
- Once you open, say, the Uber app, your phone sends a message request to Google Maps, and Google returns the map itself.



- There's more than one way to build a web API. The modern web is ruled by APIs that use the REST pattern. It's a lightweight and efficient data exchange. But sometimes, you'd come across another approach – the **SOAP protocol**. It doesn't brag about its simplicity and it's not as fast as REST.

## SOAP

- SOAP is the Simple Object Access Protocol, a messaging standard defined by the World Wide Web Consortium and its member editors.
- It is a web communication protocol designed for Microsoft back in 1998.
- SOAP uses an XML data format to declare its request and response messages.

- Both public and private Application Programming Interfaces (APIs) use SOAP as an interface. While more popular in large enterprises, organizations of all sizes produce and consume SOAP APIs.
- Today, it's mostly used to expose web services and transmit data over HTTP/HTTPS. But it's not limited to them. SOAP, unlike the REST pattern, supports the XML data format only and strongly follows preset standards such as messaging structure, a set of encoding rules, and a convention for providing procedure requests and responses.



## SOAP works with XML only

- Web-transmitted data is usually structured in some way. The two most popular data formats are XML and JSON.

- XML (or Extensible Markup Language) is a text format that establishes a set of rules to structure messages as both human- and machine-readable records. But XML is verbose as it aims at creating a web document with all its formality.
- JSON, on the other hand, has a loose structure that focuses on the data itself.
- You see that numerous ending tags in XML make it much longer.

**JSON**

```
{
"siblings": [
{"firstName":"Anna","lastName":"Clayton"},
{"firstName":"Alex","lastName":"Clayton"}
]
}
```

**XML**

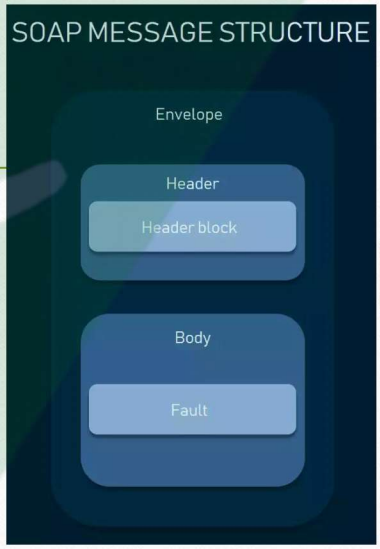
```
<siblings>
<sibling>
<firstName>Anna</firstName>
<lastName>Clayton</lastName>
</sibling>
<sibling>
<firstName>Alex</firstName>
<lastName>Clayton</lastName>
</sibling>
</siblings>
```

- As we've mentioned, when sending requests and response messages within web applications, SOAP requires XML exchange between systems. And when the request is received, SOAP APIs send messages back XML-coded only.
- Besides the data format, SOAP has another level of standardization – its message structure.



## SOAP message structure

- XML isn't the only reason SOAP is considered verbose and heavy compared to REST. It's also the way SOAP messages are composed.
- Standard SOAP API requests and responses appear as an enveloped message that consists of four elements with specific functions for each one.




- **Envelope** is the core and essential element of every message, which begins and concludes messages with its tags, enveloping it, hence the name.
- **Header** (optional) determines the specifics, extra requirements for the message, e.g. authentication.
- **Body** includes the request or response.
- **Fault** (optional) shows all data about any errors that could emerge throughout the API request and response.




# Application of APIs

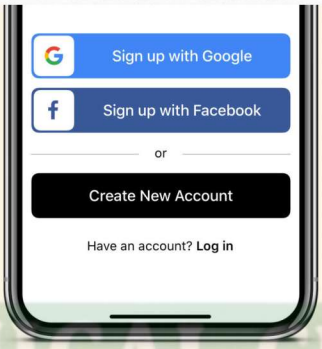
Internet of Things

## Weather snippets –

- In weather snippets, APIs are generally used to access a large set of datasets to access the information of weather forecast which is very helpful information in day-to-day life.

## Login –

- In this functionality, APIs are widely used to log in via Google, Linked In, Git Hub, Twitter and allow users to access the log-in portal by using the API interface.

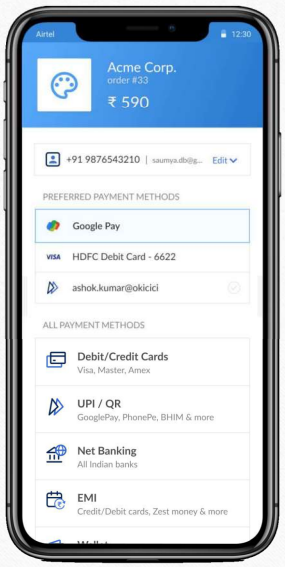



## Entertainment –

- In this field, APIs are used to access and provide a huge set of databases to access movies, web series, comedy, etc.

## E-commerce website –

- In this, APIs provide the functionality like if you have purchase something, and now you want to pay so, API provides interface like you can pay using different bank debit cards, UPI(Unified Payments Interface), credit card, wallet, etc.



## Gaming –

- In gaming, it provides an interface like you can access the information of the game, and you can connect to different users and play with different-different users at the same time.




## Some IMP Questions

## What API means?

Application Programming Interface (API), often referred to as web API, is an interface that allows two systems to communicate with each other (share data and access resources). One of its purposes includes making visible the internal details of how a system works to only those that a programmer finds required.

## What are the 4 types of API?

The four major APIs commonly used in web-based applications are:

- Public
- Partner
- Private
- Composite



## What is an example of an API?

We can take Zomato as an example to explain the concept of an API. Zomato receives a request for an order, the customer can track the driver's location. Here, the API functions in this way- the Zomato app integrates with Google Map where after integration, google maps help you to track the location.

## Which API is most used?

The most used APIs are the social media APIs where developers can access data from social media platforms like Facebook, Instagram, etc. Each social media has its own API that can be used by developers to interact with the platform's data.




API Integration

Internet of Things

## API Integration

- The process of connecting two or more software applications or processes using APIs is referred to as API integration. This allows the systems to exchange data and functionality, allowing them to work in unison.
- APIs are a collection of protocols, routines, and tools used to create software and applications. APIs allow for communication between different applications specifying how the software components should interact with each other.

- API integration is required for businesses to connect their systems and services to other external applications, allowing them to exchange data and functionality in real time.
- This improves efficiency, scalability, and user experience while potentially saving money.
- Businesses can use API integration to automate tasks and integrate new systems and services, creating new opportunities for innovation and growth.
- Without API integration, businesses would have to rely on manual processes and custom development, which can be costly, time-consuming, and less efficient.



# How to Achieve API integration?

Depending on one's need, API integration can be achieved in quite different ways, but it majorly revolves around the following:

- Custom Integration
- Connector Applications

## Custom Integration

- It is the process of connecting one application or service to another via a custom-built API.
- Custom integration can be created when an existing API is not available or does not meet the specific needs of the integration.
- This entails developing a new API that allows data and functionality to be exchanged between systems or services.

## Connector Applications

- It is the process of utilizing third-party software to connect various systems and services via APIs.
- These connector applications, also known as middleware, frequently come with preconfigured tools for popular systems and services and act as a bridge between the systems and services, allowing data and functionality to be exchanged.
- A connector application, for example, can be used to integrate social media platforms such as Instagram with an analytics tool, allowing for the automatic collection of social media data such as follower counts and the analysis of this data in the analytics tool.



# Benefits of API integration

Integrating APIs into one's applications can bring a number of benefits to an individual or an organization, which can include:

- Efficiency
- Scalability
- Cost Savings
- Reduced Errors

- **Efficiency:** API integration automates the transfer of information and data from one application to the next, which was previously done manually by a payroll employee. It has the potential to automate repetitive tasks by allowing systems and applications to communicate and share data with one another, thereby increasing overall efficiency.

- **Scalability:** By utilizing API integration, businesses can avoid having to start from scratch when developing certain services or applications. This can help businesses grow and expand by making it easier for different systems to communicate with one another, share data and functionality, and create new capabilities and services. As a result, the business's scalability improves.

- **Cost Savings:** API integration can reduce the need for manual data entry, which not only improves data accuracy but also saves money on labor and reduces the risk of errors.

- **Reduced Errors:** API integration can reduce the need for manual data entry and thus increase data accuracy by allowing different systems and applications to communicate with each other and share data. For example, accounting software can use an API to automatically import transaction data from a bank account, eliminating the need for manual data entry and lowering the risk of errors.



# Examples of API integration

- API integration comes with the goal of making different applications and services communicate seamlessly irrespective of the technologies they are developed in. Below are a few examples of use cases of API integration.
- Social Media
- Healthcare
- Chatbot
- IoT
- E-commerce
- Accounting

**Social Media:**

- A social media platform can use API integration to connect to a sentiment analysis tool, allowing for the automatic analysis of social media posts to determine customer sentiment.
- It can also be used to enable social login, which allows users to sign into a website or application using their existing social media account.

**Healthcare:**

- API integration could be used by hospital management systems to connect to an EHR or electronic health record system, allowing for the sharing of patient health information.
- APIs can also assist healthcare providers in securely and efficiently sharing patient information with other providers.

**Chatbot:**

- A chatbot application can use API integration to connect to a customer service platform, allowing for the automatic routing of customer inquiries to the appropriate service agent.
- The chatbot can also use APIs to access customer information and provide personalized product recommendations.

**IoT:**

- IoT devices can connect to a data analytics platform via API integration, allowing for the automatic collection and analysis of sensor data.
- API could be used to remotely control a thermostat or to activate a security camera.

**E-commerce:**

- APIs can be used by e-commerce websites to integrate with payment gateway providers such as Google Pay or PayPal to securely process transactions and handle payments.

**Accounting:**

- An accounting system can connect to a payroll system via API integration, allowing for the automatic processing of employee payroll.
- It can also be used with invoicing systems like Zoho Invoice to create and send invoices automatically, as well as track payment status.




# JSON API

Internet of Things

# JSON API

- JSON is an acronym for JavaScript Object Notation, so JSON API means JavaScript Object Notation Application Program Interface.
- It is an open standard format, which is lightweight and text-based, designed explicitly for human-readable data interchange.
- It is a language-independent data format.
- It supports almost every kind of language, framework, and library.



- JSON is an open standard for exchanging data on the web. It supports data structures like objects and arrays. So, it is easy to write and read data from JSON.
- In JSON, data is represented in key-value pairs, and curly braces hold objects, where a colon is followed after each name. The comma is used to separate key-value pairs. Square brackets are used to hold arrays, where each value is comma-separated.

```
{
  "city": "Lisbon",
  "country": "Portugal",
  "population": "Portugal",
  "attractions": [
        "Torre de Belém",
        "Mosteiro dos Jerónimos",
        "Baixa Pombalina"
      ]
}
```

# What is JSON?

- JSON stands for JavaScript Object Notation.
- JSON is an open standard data-interchange format.
- JSON is lightweight and self-describing.
- JSON originated from JavaScript.
- JSON is easy to read and write.
- JSON is language independent.
- JSON supports data structures such as arrays and objects.

# JSON Syntax Rules

- Data is in name/value pairs
- Data is separated by commas
- Curly braces hold objects
- Square brackets hold arrays



# JSON Data - A Name and a Value

- JSON data is written as name/value pairs, just like JavaScript object properties.
- A name/value pair consists of a field name (in double quotes), followed by a colon, followed by a value:

```
"firstName":"John"
```

# JSON Objects

- JSON objects are written inside curly braces.
- Just like in JavaScript, objects can contain multiple name/value pairs:

```
{"firstName":"John", "lastName":"Doe"}
```

# JSON Arrays

- JSON arrays are written inside square brackets.
- Just like in JavaScript, an array can contain objects:

```
"employees":[
    {"firstName":"John", "lastName":"Doe"},
    {"firstName":"Anna", "lastName":"Smith"},
    {"firstName":"Peter", "lastName":"Jones"}
]
```



```
{
  "city": "Lisbon",
  "country": "Portugal",
  "population": "Portugal",
  "attractions": [
        "Torre de Belém",
        "Mosteiro dos Jerónimos",
        "Baixa Pombalina"
      ]
}
```

# Why do we use JSON?

Since JSON is an easy-to-use, lightweight language data interchange format in comparison to other available options, it can be used for API integration. Following are the advantages of JSON:

- Less Verbose
- Faster
- Readable
- Structured Data

- **Less Verbose:** In contrast to XML, JSON follows a compact style to improve its users' readability. While working with a complex system, JSON tends to make substantial enhancements.
- **Faster:** The JSON parsing process is faster than that of the XML because the DOM manipulation library in XML requires extra memory for handling large XML files.
- **Readable:** The JSON structure is easily readable and straightforward. Regardless of the programming language that you are using, you can easily map the domain objects.
- **Structured Data:** In JSON, a map data structure is used, whereas XML follows a tree structure.



## Application of JSON API:

The most desired and popular applications of JSON are listed below:

- It can be used with various modern programming languages such as Python, Ruby, Java, etc.
- It is used for data transmission between a server and web applications
- JSON is used in JS-based applications, for example- web browser extensions and websites.
- APIs and web services use the JSON format for providing public data.
- JSON data format simplifies complex data by converting the data extraction process into a meaningful and predictable JSON file format.

# IoT in Law Enforcement

(Unit-5)

IoT Applications



## IoT in Law Enforcement

- The laws, rules or regulations, different terms having similar meaning. It is important for the immersible growth of the citizens, cities and the country. Enforcing laws not only limit the criminal activities, but also bring harmony in the society. A disciplined society is more vulnerable to growth and development.

- The next thing that comes to mind is how to enforce these laws. Obviously laws are helpful and essential for society, but what are the ways by which we can implement these laws to their fullest worth. We can say that strengthening the police and law forces is a way. But can you ever imagine IoT devices assisting law enforcement?
- The contribution of the Internet of Things (IoT) is undoubtedly strong and uncountable in human lives. Be it pharmaceutical management or cybercrime. IoT is controlling each sphere of life. Law enforcement is also a working field of IoT. Regulation of law and enforcement of legal rights and laws is essential to improve human existence.

# Advantages of IoT in the Law Enforcement

- Crime detection
- Proof gathering
- Wearable tiny devices
- Health trackers for officers
- loT enabled firearms
- Unmanned vehicles
- Smart cars
- Drones
- Crime predictions



## Crime detection

- Security alarms and systems help in early detection of the crimes and records, thus reducing the chances of risks and frauds. The early detections prepare the public and others to take necessary precautions.
- People living in cities have already employed their houses with safety cameras and CCTV validation. These IoT applications make the detections and identification of criminals easier.

## Proof gathering

- IoT is a crucial reason in gathering proofs and validation. The IoT devices and technology make it easier and faster to collect evidence from a wide range of sources.
- In modern days, virtual home assistants like Alexa and others collect several pieces of evidence and proofs on a daily basis. This evidence helps in solving crimes related stories and cases.

## Wearable Tiny Devices

- IoT and its technologies also help in creating wearables and equipment for different law related operations. We all have seen a camera pen or camera button in movies. This is nothing but an evolution in the IoT field.



## Health tracking devices for Law Officers

- For enforcing laws well in the locality, the law officers should be healthy and strong in all three aspects, emotionally, physically and mentally. IoT serves that need of the field too. And, this has been an important application for both human force and police dogs.

## Unmanned Vehicles

- Vehicles without manpower and drivers, the latest technology in automobiles is a boon for the law officers and their safety. Though, this technology has not been applied to underdeveloped countries like India.
- But the developed countries like the USA and UK have employed fully automated cars and vehicles. The unmanned vehicles are used to chase the criminals and others while tracking them. Thus, it adds to the safety of officers and other human forces.

## Drones

- Drones are flying robots. They can be remotely controlled or can fly autonomously using a software-controlled flight system. They offer a new level of surveillance and are assisted with cameras. They can be of any form and any shape thus, pranking the criminals and culprits.
- Drone technology and its sensors help law enforcement devices with a better quality of surveillance. The agencies can also use drones to suspect chases, search and rescue the victims, event management, to evaluate and detect the risky areas around and other situations.




# Medical Applications of IoT

(Unit-5)

IoT Applications

# Medical Applications of IoT

- According to reports submitted by P&S Market Research, there will be a compound annual growth rate (CAGR) of 37.6 percent in the healthcare Internet of Things (IoT) industry between 2015 and 2020. If one thing is certain, IoT has transformed healthcare in a variety of ways over the past several years and will continue to do so for years to come.
- Here are the IoT applications in healthcare everyone needs to know about.



- Consumer Internet of Things or CIoT is an interconnected system of physical and digital objects, personally used by a consumer.

# Implantable Glucose Monitoring Systems

- Patients who suffer from diabetes can have devices with sensors implanted in them, just below their skin.
- The sensors in the devices will send information to a patient's mobile phone when his or her glucose levels get too low and will record historical data for them too.
- This way, patients will also be able to tell when they are most likely to be at risk for low glucose levels in the future, as well as in the present.

## Activity Trackers During Cancer Treatment

- Usually the right treatment for a cancer patient relies on more than just his or her weight and age.
- Their lifestyles and fitness levels also play a huge role in what the proper treatment plan for them will entail. Activity trackers track a patient's movements, fatigue levels, appetite, etc. Plus, the data collected from the tracker prior to treatment and after treatment has started will tell healthcare professionals what adjustments need to be made to the recommended treatment plan.

## Heart Monitors with Reporting

- Patients can wear devices that monitor their heart rates, and that can determine whether they have high blood pressure.
- Healthcare providers will have access to reporting of patient's heart monitor data when they need to pull it during checkups and exams. The wearable devices can even alert healthcare professionals when patients are experiencing arrhythmias, palpitations, strokes, or full-blown heart attacks. Ambulances can then be dispatched in a timely fashion, which can be the difference between life and death.

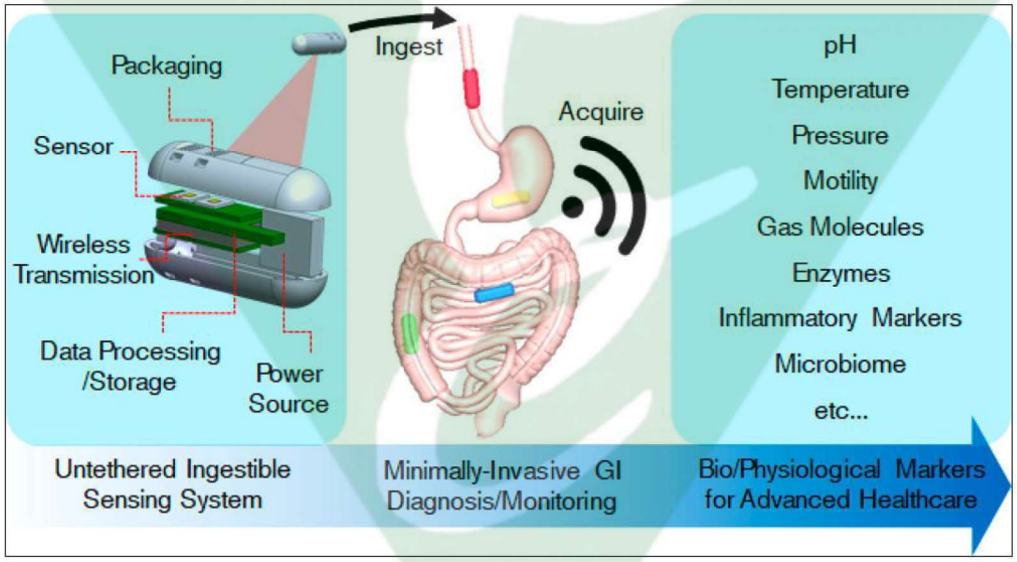
## Medical Alert Systems

- Individuals can wear something that looks like jewelry but is designed to alert family members or friends in case of an emergency. For instance, if an individual is wearing a medical alert bracelet and fell out of bed in the middle of the night, the people they designate to help in the case of an emergency would be immediately notified on their smartphones that their help was needed.

# Ingestible Sensors

- Patients can now swallow devices with sensors that look like pills. Once the sensors are ingested, they relay information to a patient's mobile app that will help them follow the proper dosages for their medications. Most medications aren't taken as prescribed due to forgetfulness or other human error. This ingestible sensor works to ensure patients are taking the right medications, at the right time, in the right dosages.






# Wireless Sensors

- Wireless sensors are being used in labs and hospital refrigerators to ensure blood samples, chilled medications, and other biomedical materials are always kept at the proper temperatures.

## Location Services

- Items like wheelchairs, scales, defibrillators, nebulizers, pumps, or monitoring equipment, can be tagged with IoT sensors and located easily by healthcare staff. A lot of times physical equipment can be misplaced or is hard to track down, but with IoT, staff will know where everything is.



## Remote Monitoring

- With IoT devices, healthcare professionals can monitor their patients who just underwent surgery or who go home for outpatient care. They'll be alerted if a patient reaches a critical state or needs immediate attention.

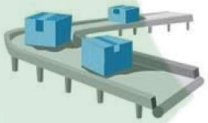
# IIoT

(Unit-5)

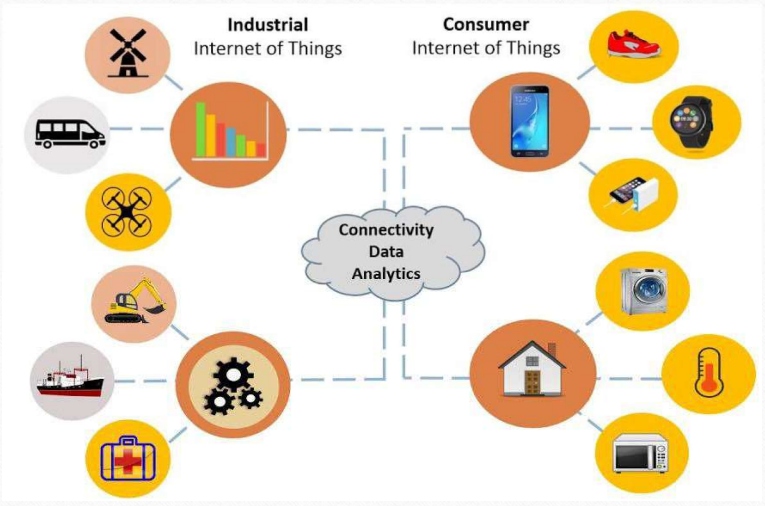
IoT Applications



## Industrial Revolution

| END OF THE 18TH CENTURY | START OF THE 20TH CENTURY | START OF THE 1970S | PRESENT |
|---|---|---|---|
|  |  |  |  |
| **INDUSTRY 1.0**<br>**Mechanization**<br>Introduced mechanization of production by using water and steam to increase production capacity and productivity, versus manual craft work<br>**1784** First mechanical loom | **INDUSTRY 2.0**<br>**Electrification**<br>Introduced labor-based mass production (assembly lines) powered by electrical energy<br>**1870** First production line, Cincinnati slaughterhouses | **INDUSTRY 3.0**<br>**Automatization**<br>Introduced electronics and computers to replace manual work by stand-alone robotic systems<br>**1969** First programmable logic controller (PLC), Modicon 084 | **INDUSTRY 4.0**<br>**Cyber-Physical Systems**<br>The convergence of physical, digital, and virtual environments through **Cyber-Physical Systems (CPS)** and the **Internet of Things (IoT)** |

## IIoT Vs IoT



# IIoT

- The industrial internet of things (IIoT) is the use of smart sensors and actuators to enhance manufacturing and industrial processes.
- It is also known as the industrial internet or Industry 4.0, IIoT uses the power of smart machines and real-time analytics to take advantage of the data that "dumb machines" have produced in industrial settings for years.



- The driving philosophy behind IIoT is that smart machines are not only better than humans at capturing and analyzing data in real time, but they're also better at communicating important information that can be used to drive business decisions faster and more accurately.
- The industrial internet of things (IIoT) refers to the extension and use of the internet of things (IoT) in industrial sectors and applications. With a strong focus on machine-to-machine (M2M) communication, big data, and machine learning, the IIoT enables industries and enterprises to have better efficiency and reliability in their operations.

- Connected sensors and actuators enable companies to pick up on inefficiencies and problems sooner and save time and money, while supporting business intelligence efforts. In manufacturing, specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability, and overall supply chain efficiency.

# How does IIoT work?

IIoT is a network of intelligent devices connected to form systems that monitor, collect, exchange and analyze data. Each industrial IoT ecosystem consists of:

- connected devices that can sense, communicate and store information about themselves;
- public and/or private data communications infrastructure;
- analytics and applications that generate business information from raw data;
- storage for the data that is generated by the IIoT devices; and
- people.



- These edge devices and intelligent assets transmit information directly to the data communications infrastructure, where it's converted into actionable information on how a certain piece of machinery is operating. This information can be used for predictive maintenance, as well as to optimize business processes.

# What are the benefits of IIoT?

- One of the top touted benefits of IIoT devices used in the manufacturing industry is that they enable predictive maintenance. Organizations can use real-time data generated from IIoT systems to predict when a machine will need to be serviced. That way, the necessary maintenance can be performed before a failure occurs. This can be especially beneficial on a production line, where the failure of a machine might result in a work stoppage and huge costs. By proactively addressing maintenance issues, an organization can achieve better operational efficiency.

- Another benefit is more efficient field service. IIoT technologies help field service technicians identify potential issues in customer equipment before they become major issues, enabling techs to fix the problems before they inconvenience customers. These technologies might also provide field service technicians with information about which parts they need to make a repair. That way, the technician has the necessary parts with them when making a service call.



- Asset tracking is another IIoT perk. Suppliers, manufacturers and customers can use asset management systems to track the location, status and condition of products throughout the supply chain. The system sends instant alerts to stakeholders if the goods are damaged or at risk of being damaged, giving them the chance to take immediate or preventive action to remedy the situation.

- IIoT also allows for enhanced customer satisfaction. When products are connected to the internet of things, the manufacturer can capture and analyze data about how customers use their products, enabling manufacturers and product designers to build more customer-centric product roadmaps.

- IIoT also improves facility management. Manufacturing equipment is susceptible to wear and tear, which can be exacerbated by certain conditions in a factory. Sensors can monitor vibrations, temperature and other factors that might lead to suboptimal operating conditions.




Applications of IoT in Agriculture

(Unit-5)

IoT Applications

## Applications of IoT in Agriculture

- The Internet of Things has made smart farming possible. Now, you may wonder what exactly is smart farming? Smart farming is a capital-intensive and hi-tech method of growing food cleanly and sustainably. We can also call it the application of ICT (Information and Communication Technology) in Agriculture.

- When we talk about IoT-based smart farming, we are looking at a system built to monitor the crop field with the help of sensors. These sensors track every essential for crop production like soil moisture, humidity, light, temperature, etc., and automates the irrigation system. This system allows farmers to monitor the field conditions from anywhere. IoT-based farming is way too efficient when compared to conventional farming.
- IoT-based smart farming is also beneficial in terms of environmental issues. It can help the farmers to efficiently use water, optimize the inputs and treatments.



## Major applications of IoT-based smart farming

### Precision Farming

Precision farming, also known as precision agriculture, is anything that makes the whole process of farming accurate and controlled when it comes to raising livestock and growing crops.

### Agricultural Drones

- Technology has progressed significantly and at a higher rate in the past few years. Agricultural drones are a prime example of this development. Drones are being used in the agricultural sector to enhance many farming practices.
- Drones are being used in agriculture for crop health assessment, crop monitoring, spraying pesticides, irrigation, planting, and analyzing the field. These drones capture multispectral, thermal, and visual imagery during their flight.

## Livestock Monitoring

- Owners of large farms utilize wireless IoT applications to track the location, health, and well-being of their cattle.
- This information helps them to identify sick animals and henceforth separate them from the herd, take care of them, and also curb the spread of the disease among other animals. It is also useful for cutting labor costs as owners can locate their cattle with the help of IoT-based sensors.



## Monitor Climate Conditions

- Climate plays an important role in crop production. Different crops require different climate conditions to grow and any little knowledge about climate heavily deteriorates the quantity and quality of crop production. IoT solutions enable the farmers to know real-time weather conditions.
- The sensors placed in the agricultural fields collect data from the environment that is used by farmers to choose a crop that can grow in particular climatic conditions.




# Consumer IoT

(Unit-5)

IoT Applications

## Consumer IoT

- Consumer IoT is a term used to refer to connected devices designed for the consumer market, like smartphones, smart wearables, and the increasing number of smart home devices that collect and share data through an Internet connection.
- With fast-growing computing capabilities, Consumer IoT applications are increasingly becoming more efficient and easier to use.

- Consumer Internet of Things or CIoT is an interconnected system of physical and digital objects, personally used by a consumer.



## Consumer IoT – Use Cases

From streaming devices, wearables, voice command systems, home control devices, healthcare & asset monitoring systems to smart in-store devices and connected cars CIoT is now everywhere.

- Home Automation & Security
- Asset Tracking
- Smart Wearables
- Personal Healthcare

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