

UNIT - I Fundamentals of IoT

Q . Definitions & Characteristics of IoT

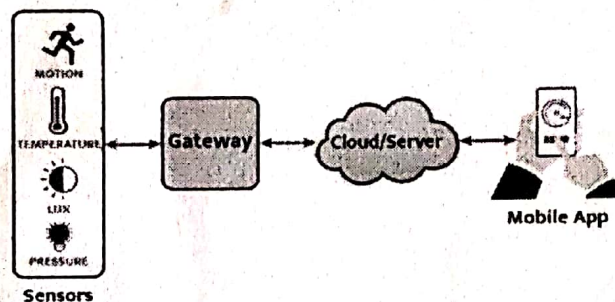
Internet of Things

IoT stands for “internet of things”. It is a connected network of physical devices with sensors, processing ability, software and other technologies that interconnect and share information with other devices and systems.

For example, a sensor measures the outside temperature, whereupon the smart device in which it is installed turns up the heating. All this happens automatically, without any active intervention by the user. This is possible thanks to the interaction of connected components such as microcontrollers, sensors and actuators that convert electrical impulses into pressure, movement, temperature or other mechanical variables.

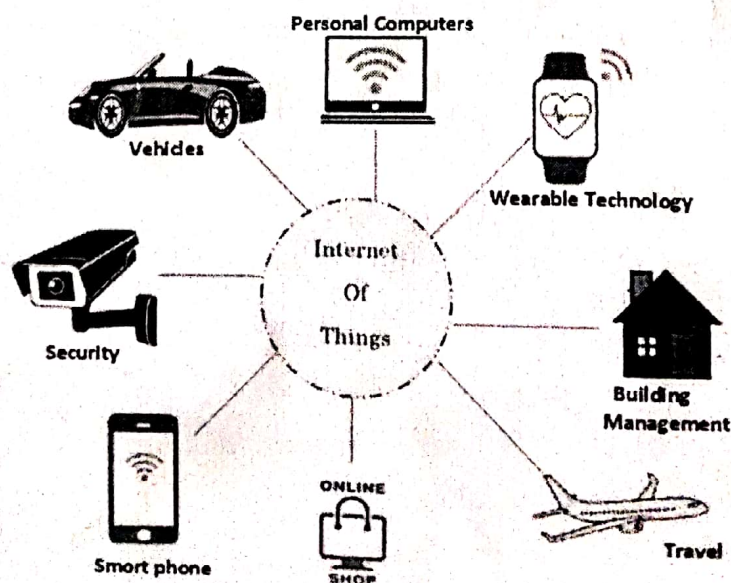
IoT systems are complex: They combine individual devices, databases and gateways that connect several networks. They are linked to the internet via a mostly wireless interface and send data or, conversely, receive commands.

Working of IoT



Some examples of IoT devices include:

- Smart home devices such as thermostats, lighting systems, and security systems.
- Wearables such as fitness trackers and smartwatches.
- Healthcare devices such as patient monitoring systems and wearable medical devices.
- Transportation systems such as connected cars and autonomous vehicles.



Characteristics of the Internet of Things (IoT)

1.Connectivity

- ✓ The most basic requirement for any IoT device is connectivity. IoT devices are physical objects embedded with sensors, software, electronics, and network connectivity that allow data exchange.
- ✓ This can be Wi Fi, Bluetooth, cellular, satellite, or another internet communication technology. Connectivity allows IoT devices to send and receive data.

2.Sensors

- ✓ Sensors are one of the defining components of IoT devices. It detect events or changes in the environment and provide corresponding outputs.
- ✓ Examples include temperature sensors, motion sensors, light sensors, etc. The sensor collects data and converts it into a digital signal to be processed.

3.Data Collection

- ✓ A major function of IoT devices is gathering data from their environments.
- ✓ The sensors enable the devices to collect various data types, from temperature, location, and movement data to camera imagery, sound recordings, and more.
- ✓ The data may be stored locally on the device or transmitted to the cloud.

4.Connectivity to Internal States

- ✓ Not only IoT devices can connect to external environments through sensors, but they can also connect to their internal states and communicate this data.
- ✓ This can include stats like battery life, network connectivity strength, CPU usage, etc.

5.Communication/Data Transmission

- ✓ For the full value of IoT to be realized, devices must communicate the data they collect. This happens through internet protocols like Wi-Fi, Bluetooth, LPWAN, and cellular communication.
- ✓ Gateways and hubs help connect devices to wider networks. The connectivity enables data gathering, analytics, and more.

6.Remote Monitoring and Control

- ✓ IoT allows users to remotely monitor and control devices through internet connections. For example, a smart home hub lets you control lighting, appliances, security systems, etc. from your phone.
- ✓ Industrial IoT networks have remote system monitoring and control. This enables centralized management.

7.Analytics

- ✓ With so much data being collected by IoT devices.
- ✓ Analytics processing helps gain insights from the data through dashboards, visualizations, reports, and more. Analytics drive greater value from IoT deployments.

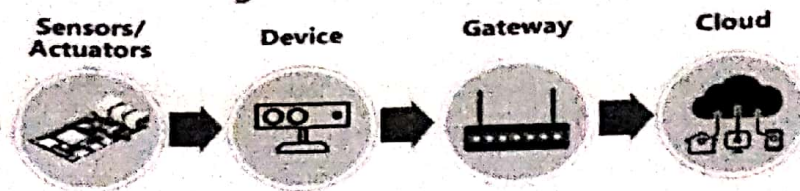
8.Uniqueness

- ✓ Each IoT device has a unique identifier on the network to distinguish it from others.
- ✓ This could be a serial number, IP address, MAC address, etc. The unique ID enables remote identification and management.

Q . IoT Architectures

IoT architecture refers to the tangle of components such as sensors, actuators, cloud services, Protocols, and layers that make up IoT networking systems. In general, it is divided into layers that allow administrators to evaluate, monitor, and maintain the integrity of the system. The architecture of IoT is a four-step process through which data flows from devices connected to sensors, through a network, and then through the cloud for processing, analysis, and storage. With further development, the Internet of Things is poised to grow even further, providing users with new and improved experiences.

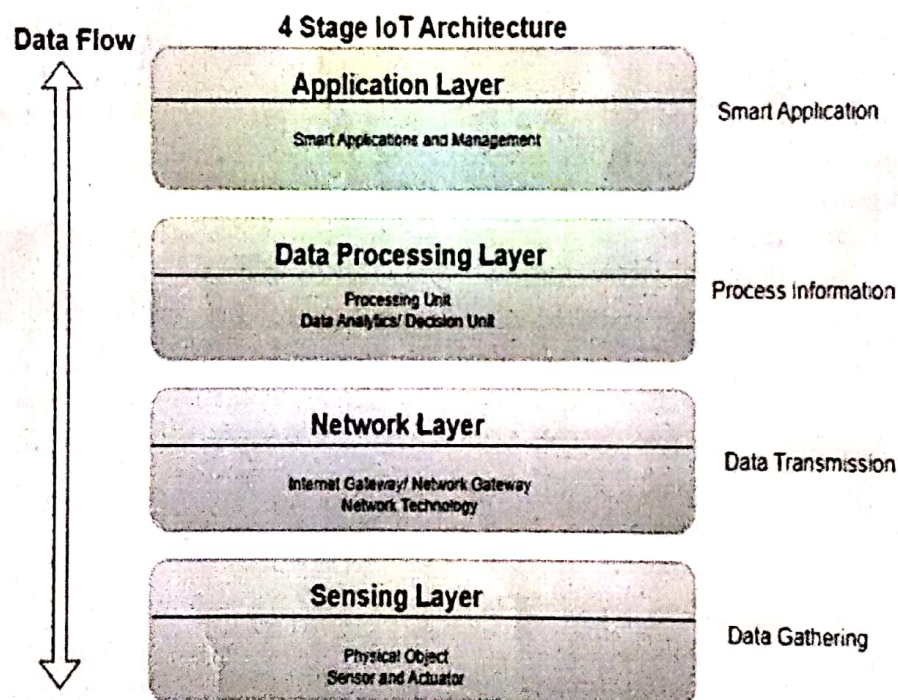
Stages of IoT Architecture



4 stages of IoT architecture

- 1) **Devices:** This stage is about the devices in IoT solutions, including the sensors or actuators in the perception layer. The data produced by these IoT system devices is then transmitted to the internet gateway stage.
- 2) **Internet gateways:** The internet gateway stage receives the raw data from the IoT devices and pre-processes it before sending it to the cloud.
- 3) **Edge computing:** Once the pre-processed data from the internet gateway is received, the object is to fully process data as quickly as possible. To do this effectively, an IoT system will often employ a process called edge computing. Edge computing involves processing data closer to the source of its generation (e.g., edge of a network vs centralized cloud servers).
- 4) **Cloud or data centers:** In this final stage, the data is stored for later processing. The application layer and business layers reside in this stage, where dashboards and management software can be fed through the data stored in the cloud.

Layers of IoT Structure

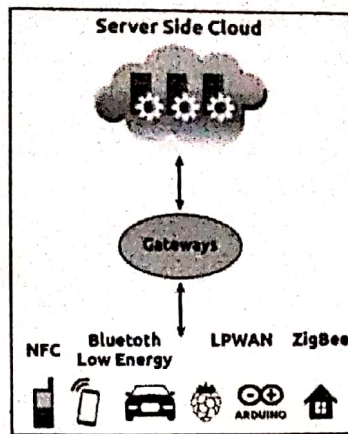


1. Sensing Layer:

- ✓ The first stage of IoT architecture. This layer includes sensors and actuators etc. which collect data from the different sources, processes it and then sends it over the network.
- ✓ This layer is responsible for sensing the physical environment, converting analog signals to digital data, and transmitting it to the next layer.

2. Transport layer / Network Layer :

- ✓ The transport layer, sometimes called the network layer . The network layer establishes communication between devices, gateways, and cloud infrastructure.
- ✓ It manages the connectivity, routing, and data transmission across the IoT network.
- ✓ Examples of network technologies that are commonly used in IoT include WiFi, Bluetooth and cellular networks such as 4G and 5G technology.



3. Data processing layer :

- ✓ The data processing layer, sometimes referred to as the middleware layer. The data processing layer of IoT architecture refers to the software and hardware components that are responsible for collecting, analyzing, and interpreting data from IoT devices.
- ✓ This includes such activities as data aggregation, protocol translation, and security enforcement to ready data for the application layer. In addition, message brokers, IoT platforms, and edge computing nodes may also be included in this layer.
- ✓ This layer handles tasks such as data normalization, security, and identity management.

4. Application Layer

- ✓ The application layer of IoT architecture is the topmost layer that interacts directly with the end-user. It is responsible for providing user-friendly interfaces and functionalities that enable users to access and control IoT devices.
- ✓ This layer includes various software and applications such as mobile apps, web portals, and other user interfaces that are designed to interact with the underlying IoT infrastructure.

Q . Physical & Logical Design of IoT

Physical & Logical Design of IoT

In IoT (Internet of Things), the physical design and logical design are two key aspects that define how an IoT system is structured and operates.

1. Physical Design of IoT : The physical design refers to the tangible components and hardware involved in an IoT system. It includes the physical devices, sensors, actuators, and communication modules that interact with the environment.

Components of Physical Design:

- ✓ **IoT Devices:** Sensors (temperature, humidity, motion, etc.), actuators (motors, relays).
- ✓ **Connectivity Modules:** Wi-Fi, Bluetooth, Zigbee, LoRa, and cellular networks.
- ✓ **Edge Devices:** Microcontrollers (ESP8266, Arduino), microprocessors (Raspberry Pi).
- ✓ **Gateways:** Devices that facilitate communication between IoT devices and the cloud.
- ✓ **Cloud/Data Centers:** Where the collected data is stored and processed.

Ex: A smart home system has sensors (motion, temperature) and actuators (smart lights, thermostats) connected via Wi-Fi, forming the physical layer of the IoT system.

2. Logical Design of IoT : The logical design focuses on how data flows, processes, and interacts within the IoT system. It defines the architecture, protocols, and software elements used to manage and analyze the IoT network.

Components of Logical Design:

- ✓ **Data Flow:** How data is collected, transmitted, and processed.
- ✓ **Communication Protocols:** MQTT, HTTP, CoAP, AMQP for device-cloud interaction.
- ✓ **IoT Services:** Cloud computing, data storage, analytics, and dashboards.
- ✓ **User Interface:** Web apps, mobile apps, and APIs for user interaction.
- ✓ **Security Measures:** Encryption, authentication, and secure data transmission.

Ex: In the smart home system, when a motion sensor detects movement, it sends data to a cloud server via MQTT. The cloud processes this data and triggers a response, like turning on the lights. This workflow defines the logical design.

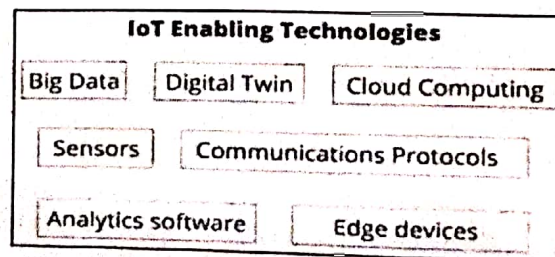
Both physical and logical designs are essential for building an effective IoT system, working together to ensure data collection, transmission, processing, and user interaction.

Key Differences Between Physical and Logical Design of IoT

ASPECT	PHYSICAL DESIGN	LOGICAL DESIGN
Definition	The hardware components of an IoT system.	The software architecture, protocols, and data management.
Focus	Sensors, actuators, gateways, and networks.	Data flow, communication protocols, security, and processing.
Example	A temperature sensor, ESP8266, and Wi-Fi module.	Using MQTT to send temperature data to a cloud dashboard.
Implementation	Involves assembling and configuring physical hardware.	Involves developing software, defining APIs, and managing cloud services.

Q . Enabling Technologies in IoT

IoT enabling technologies are crucial for connecting and managing devices in IoT's ecosystem. IoT-enabling technologies consist of big data, digital twins, cloud computing, sensors, communications protocols, analytics software, edge devices, etc.



❖ Wireless Sensor Networks (WSNs)

A wireless sensor network consists of distributed devices equipped with sensors that monitor environmental and physical conditions. A WSN comprises end-nodes, routers, and a coordinator:

- **End-Nodes:** Contain sensors and may also function as routers.
- **Routers:** Facilitate data transmission from end-nodes to the coordinator.

- **Coordinator:** Aggregates data from nodes and acts as a gateway to the internet.

Applications of WSNs in IoT:

- ✓ **Weather Monitoring:** Collects temperature, humidity, and atmospheric data.
- ✓ **Indoor Air Quality Monitoring:** Detects gas concentrations and air pollutants.
- ✓ **Soil Moisture Monitoring:** Helps in agriculture by tracking soil moisture levels.
- ✓ **Surveillance Systems:** Uses motion detection and video analytics for security.
- ✓ **Smart Grid:** Monitors and optimizes energy distribution.
- ✓ **Structural Health Monitoring:** Tracks vibrations and stress in buildings and bridges.

❖ **Cloud Computing**

Cloud computing provides on-demand resources such as computing, networking, and storage, enabling IoT devices to process and store large amounts of data efficiently. Users can access cloud services via various platforms, including desktops, tablets, and smartphones.

Cloud Computing Service Models:

- ✓ **Infrastructure as a Service (IaaS):** Provides virtualized hardware resources.
- ✓ **Platform as a Service (PaaS):** Includes development environments and frameworks.
- ✓ **Software as a Service (SaaS):** Delivers fully managed applications over the internet.

❖ **Big Data Analytics :**

Big data analytics processes vast amounts of data collected from IoT devices to uncover patterns and trends. It enhances decision-making and operational efficiency.

Examples of IoT-Generated Big Data:

- ✓ **Sensor Data:** Gathered from weather stations, industrial machines, and energy systems.
- ✓ **Health & Fitness Data:** Collected from wearable devices.
- ✓ **Location & Tracking Data:** Used in fleet management and smart transportation.
- ✓ **Retail Inventory Monitoring:** Tracks stock levels and customer preferences.

Key Characteristics of Big Data:

- ✓ **Volume:** Massive data generation and storage.
- ✓ **Variety:** Includes text, images, audio, and video data.
- ✓ **Velocity:** Real-time data collection and processing.
- ✓ **Veracity:** Ensures data quality and reliability.

❖ **Communication Protocols :**

Communication protocols form the backbone of IoT, enabling seamless data exchange. Standard organizations such as IETF, IEEE, ISO, and ITU-T govern these protocols.

Common IoT Communication Protocols:

- ✓ **MQTT:** Lightweight messaging for constrained devices.
- ✓ **CoAP:** Optimized for low-power and lossy networks.
- ✓ **AMQP:** Advanced messaging for scalable applications.

❖ **Embedded Systems :**

Embedded systems integrate hardware and software for specific functionalities within a larger system. They often include real-time operating systems (RTOS) for time-sensitive operations.

Components of an Embedded System:

- ✓ **Hardware:** Microprocessors, sensors, and actuators.
- ✓ **Application Software:** Controls device functionality.
- ✓ **RTOS:** Manages process scheduling and latency.

Q . History of IoT

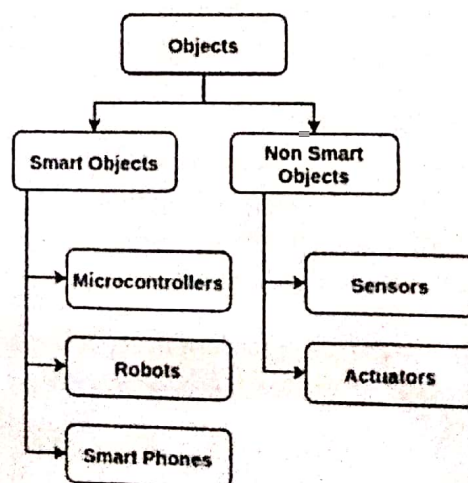
History of IOT

- **1970s:** The first wireless networks are developed, laying the groundwork for IoT technologies.
- **1980s:** The first commercial cellular networks are launched, opening up new possibilities for mobile devices and wireless data transmission.
- **1990s:** The first internet-connected devices appear, including early versions of smart home devices and wearable computers.
- **2000s:** The proliferation of broadband internet and wireless networks leads to an explosion in the number of connected devices. IoT technologies begin to be widely used in a variety of industries, from manufacturing to healthcare.
- **2004 – Smart Watch:** The advent of smartwatches introduced IoT to the wearable tech realm, offering fitness tracking and notifications on-the-go.
- **2007 – Smart iPhone:** Apple's iPhone became a game-changer, integrating IoT capabilities with apps that connected users to a myriad of services and devices, transforming smartphones into hubs.
- **2009 – Car Testing:** IoT entered the automotive industry, enhancing vehicles with sensors for real-time diagnostics, performance monitoring, and remote testing.
- **2011 – Smart TV:** The introduction of Smart TVs brought IoT to the living room, enabling internet connectivity for streaming, app usage, and interactive content.
- **2013 – Google Lens:** Google Lens showcased IoT's potential in image recognition, allowing smartphones to provide information about objects in the physical world.
- **2015 – Tesla Autopilot:** Tesla's Autopilot system exemplified IoT in automobiles, introducing semi-autonomous driving capabilities through interconnected sensors and software.
- **2020s:** The IoT landscape continues to evolve, with 5G networks beginning to be rolled out and new applications for IoT technologies emerging constantly.

Q . About Things in IoT

Here the word 'Things' refers to these machines or physical objects so it becomes important to understand what kind of objects can be connected via Internet. We can categorize these objects into categories –

1. Objects with intelligence or **Smart Objects**.
2. Objects without intelligence or **Non-Smart Objects**.

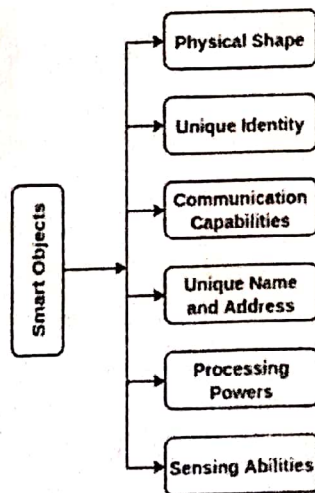


- 1) **Smart Objects** : "Smart objects are those physical and digital objects which can be identified, have sensing/actuating capabilities, processing and calculating powers, also storing, and networking capabilities."

Features of Smart Object :

Smart objects have some specific features which are necessary for calling a physical object as smart object. We will discuss these features below –

- Physical Shape** : As the word object refers to something which has some physical shape or size, so any Smart Object should have these physical features so that it can be deployed somewhere in the infrastructure.
- Unique Identifier** : Smart Objects should have a unique identity so they can be easily identified in the infrastructure. It is something that differs a specific object from other objects. This type of physical identity is used by humans for reasoning purposes.
- Communication Capabilities** : It must have communication capabilities so that it can send or receive data over internet or other networking technologies.
- Unique Name and Address** : Here the words, name, and address refer to networking address of the object such as IP address which is used for communication purposes. The address should be unique in the whole internet infrastructure. While the name is used by humans for reasoning purposes.
- Processing Powers** : Smart Objects have some basic computational and processing abilities to take decisions accordingly the environment.
- Sensing Capabilities** : It should have some sensing capabilities to know about the surroundings (Pressure, toxic gasses, temp. etc).



Ex: We are surrounded by smart objects in our daily life. For example, we all have our smartphones in our pockets. Smart fridge, Smart TV, Alexa voice assistant are some modern examples of smart objects which we use in our daily life. Micro-controllers like Arduino can be easily seen.

- 2) **Non-Smart Objects** : Non-smart objects are generally those objects which do not have intelligence and processing capabilities. Sensors and actuators are non-smart devices.
- Sensors** : Sensors are those electronic devices which are made of sensitive cells and have capabilities to measure or sense some physical or scientific quantity like temperature, pressure, the measure of any toxic gas, etc.
 - Actuators** : Actuators are those electronic devices which performs a specific task by collecting the information by sensors or like sensors over the internet. We can divide actuator into two parts –

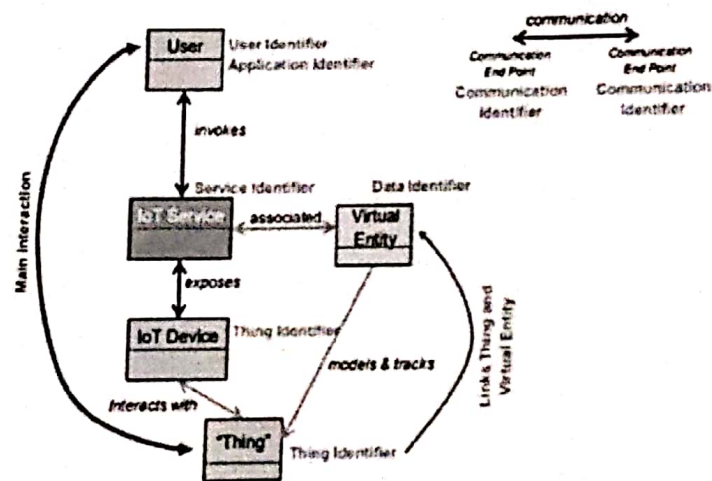
- ✓ **Mechanic Actuators** : These are those actuators which perform a task over themselves or any other object.
- ✓ **Actions** : Actions are performed by an object. Like sending e-mails, vibrations.

Q . The Identifiers in IoT

Identifiers are templates used to uniquely identify an entity in a system. An identifier has a string of characters used to identify any physical or virtual entity. For example, an IP address is an identifier of a computer connected to the network.

In an IoT system, both the device and the user must be clearly defined. Depending on the needs and suitability of the system, many different identifiers are used.

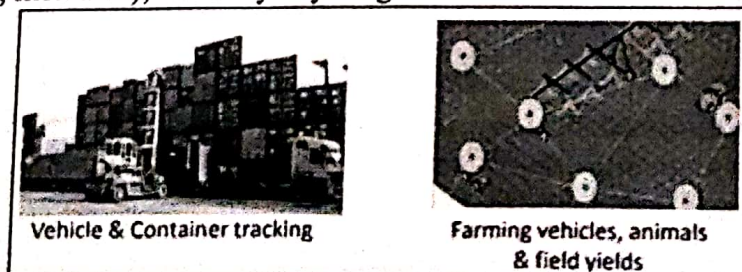
People identify in two general ways, based on the element of the entity to help distinguish it from other entities such as user fingerprints, face recognition, the other way is to create an identifier code such as serial number, barcode, or electromagnetic card.



Classification of Identifiers

Classification of Identifiers Identifiers are used for different purposes in IoT applications. These classes are defined in more detailed in the following sections.

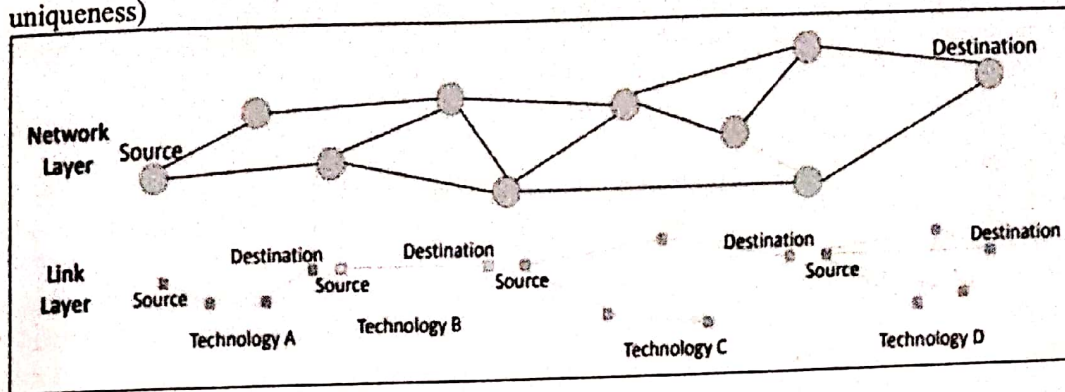
- 1) **Thing Identifier**: Thing identifiers identify the entity of interest of the IoT application. This can be for example any physical object (e.g. machines, properties, humans, animals, plants) or digital data (e.g. files, data sets, metadata); basically anything that one can interact with.



Ex:

Asset tracking : A company keeps track of all its assets (large and small, stationery and moveable) by checking regularly where they are. All assets have a thing identifier which is a barcode or RFID tag with a unique identifier attached.

- 2) **Application & Service Identifier:** Application and Service identifiers identify software applications and services. This also includes identifiers for methods on how to interact with the application or service (i.e. Application Programming Interfaces, Remote Procedure Calls)
- 3) **Communication Identifier :** Depending on the network size and routing approach the identifiers may have a structure that reflects the network topology
- IP addresses and phone numbers reflect topologies
 - MAC addresses don't reflect topologies (but have vendor information in order to ensure global uniqueness)



- 4) **User Identifier :** User identifiers identify users of IoT applications and services. Users can be humans, parties (e.g. legal entities) or software applications that access and interact with the IoT application or service.

Ex :

Human user : A human logs into an IoT system in order to get some data from or to control the thing of interest. The human has to identify itself (e.g. username, chip card, fingerprint) to the system. Depending on the security needs an additional authentication is performed.

- 5) **Data Identifier :** This class covers both identification of specific data instances and data types (e.g. meta data, properties, classes).

Ex :

Time series data set :

Sensor data from a thing is provided automatically in (constant) intervals. The data is stored as time series in the IoT platform for further use. Various applications may access these data for example for predictive maintenance, process optimization or forecasts. The data set needs an identifier that allows accessing it from the applications.

- 6) **Location Identifier :** This class is about Identification of locations within a geographic area (e.g. geospatial coordinates, postal addresses, room numbers).

Ex : Goods tracking A company wants to track the delivery of high value goods. A GPS receiver with a cellular network modem is part of the packet in which the goods are transported.

- 7) **Protocol Identifier :** Protocol identifiers inform for example communication protocols about the upper layer protocol they are transporting or applications about the protocol they have to use in order to establish a specific communication exchange.

Q. About the Internet in IoT

The internet plays a crucial role in IoT by enabling connectivity, data transmission, and remote control of devices. IoT devices, equipped with sensors and other technologies, use the internet to collect and transmit data, allowing for data analysis, automation, and informed decision-making.

Internet : The internet is a vast network of interconnected computers that communicate with each other using a standardized set of protocols. It's the backbone of the World Wide Web and allows for the sharing of information, communication, and various online services.

IoT : IoT refers to a network of physical objects, like appliances, vehicles, and sensors, that are embedded with technology to collect and exchange data with other devices and systems over the internet.

Role of the internet in IoT:

The internet is crucial for IoT because it provides the infrastructure for connecting and communicating between IoT devices. It allows IoT devices to:

- **Collect and transmit data:** Sensors embedded in IoT devices collect data from the physical world and transmit it to the cloud or other devices via the internet.
- **Communicate with each other:** IoT devices can communicate with each other directly or through a network, enabling automation, control, and data sharing.
- **Interact with other systems:** IoT devices can interact with cloud-based services, databases, and other systems, allowing for data analysis, decision-making, and remote control.
- **Connectivity:** The internet forms the backbone for IoT, enabling devices to connect with each other, cloud services, and users. This connectivity allows for real-time data exchange and interaction between devices.
- **Data Transmission:** IoT devices use the internet to transmit collected data to a central system or cloud server for processing and analysis. This data can include sensor readings, environmental conditions, and device status.
- **Remote Control and Automation:** The internet facilitates remote control and automation of IoT devices. Users can control and monitor devices remotely through applications or platforms.

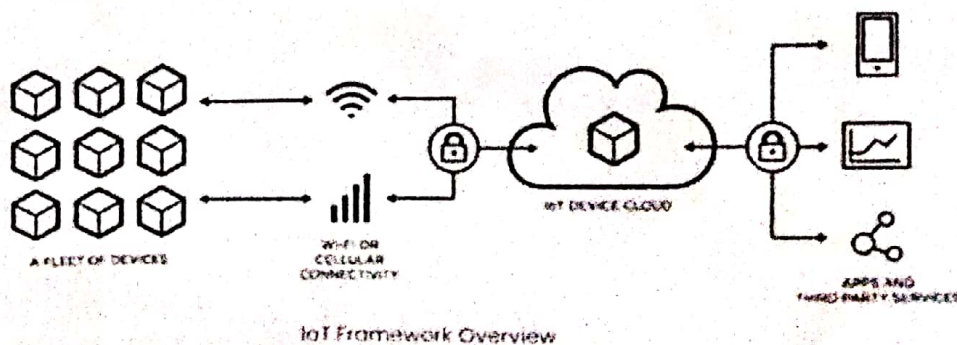
Ex:

- **Smart homes:** Devices like thermostats and security systems are controlled remotely through the internet.
- **Smart factories:** IoT sensors monitor equipment performance, and data is transmitted to cloud platforms for analysis.
- **Retail:** IoT devices track inventory levels and customer behavior, which helps retailers optimize store layouts and enhance customer experience.
- **Healthcare:** Wearable devices track health and fitness data, and the data is transmitted to doctors or health providers for monitoring.

Q . IoT frameworks

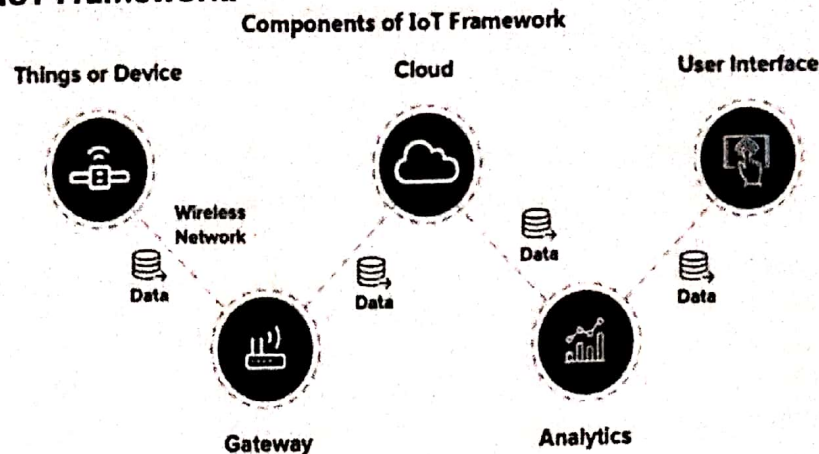
An **IoT framework** can be defined as a set of protocols, tools, and standards that provide a specific structure for developing and deploying IoT applications and services. In other words, an IoT framework gives you the basics for building your own application.

The Internet of Things (IoT) Framework can be described as being an ecosystem, comprising of several connected devices that communicate with each other, over the Internet. These connected devices usually work to transfer and sense data over the Internet, while requiring very little human intervention.



The IoT framework concept is also applied in the designing of different physical objects, such as thermostats, electrical devices, security and alarm systems, as well as vending machines.

Components of IoT Framework:



1) Device Hardware : The device hardware component of the IoT framework requires some basic knowledge on architecture. The user is also required to have an idea on the working of the different micro-controllers, as well the sensors. Examples : sensors, micro-controllers and controllers.

2) Device Software : In order for the device software of the IoT framework to function properly, the included writing applications are required to configure the controller, then operate them remotely. The user is required to have a basic understanding of how an API works inside the micro-controllers, as well how libraries are usually made for programming.

3) Communication and Cloud Platform : The cloud platform is one of the most crucial parts of the IoT framework. It calls for the basic knowledge of all communication, whether wireless or wired. The user is also required to have a good understanding of IoT integration, cloud technology.

4) Cloud Application : The cloud application is a type of software program, which mainly consists of components that can be accessed quite easier and faster. These components can be either local or even cloud-based.

List of IoT Framework

1. KAA IoT

- Kaa IoT is an open-source framework with flexible services to help users set up their IoT infrastructure.
- These include services related to device connectivity and management, data collection, data processing and analytics, data visualization, alerts and notifications, configuration management, and more.
- One of the great things about being open source is that users can customize their existing Kaa features, add new features, and replace their existing Kaa features with select third-party ones.

Features:

- ✓ Remote monitoring
- ✓ Unlimited device connections

2. Cisco IoT Cloud Connect

- Cisco IoT Cloud Connect provides robust, automated, and highly secure connectivity for the enterprise.
- The Cisco Kinetic IoT platform manages IoT data to extract, move, and compute the data. As Cisco is famous for its security services, it protects IoT deployment against threats with a secure IoT architecture.

3. ZETTA IoT

- a) Zetta is a server-oriented platform developed based on the REST, NodeJS, and the Siren hypermedia-API-strip flow-based reactive programming philosophy. After being abstracted as REST APIs, they are connected with cloud services.
- b) These internet services include tools for visualizing machine analytics and support, such as Splunk. It builds a geo-distributed network through connectivity with systems like Heroku to endpoints like Arduino and Linux hackers.

Features:

- ✓ A secure connection between network devices
- ✓ Can easily integrate with smartphone, device, and cloud apps

4. DeviceHive IoT

- a) DeviceHive is another rich IoT open-source platform distributed under the Apache 2.0 license and can be used and changed free of charge. It provides deployment options for **Docker and Kubernetes** and can be downloaded and used by public and personal clouds.
- b) You can run batch analysis and machine learning above and beyond your device information. DeviceHive supports several libraries, including Android and iOS.

5. Oracle IoT

- a) We surely include Oracle, a worldwide software company known to offer its top level of database management and business software solutions, as we compare the top Internet-of-Things platforms.
- b) Oracle offers its flexible environment outstanding company possibilities to create company applications. Oracle supports the processing and builds large-scale IoT networks with very wide data.

6. SAP IoT

- a) The SAP Internet of Things cloud platform has everything you need to build and handle an IoT application. The SAP platform provides a convenient environment to remotely manage and monitor all connected devices of your IoT system.
- b) We can connect remote devices directly or through cloud service in the SAP Platform. SAP can use IoT information to create machine learning and artificial intelligence applications while maintaining recent technological trends.

Q . IoT and M2M

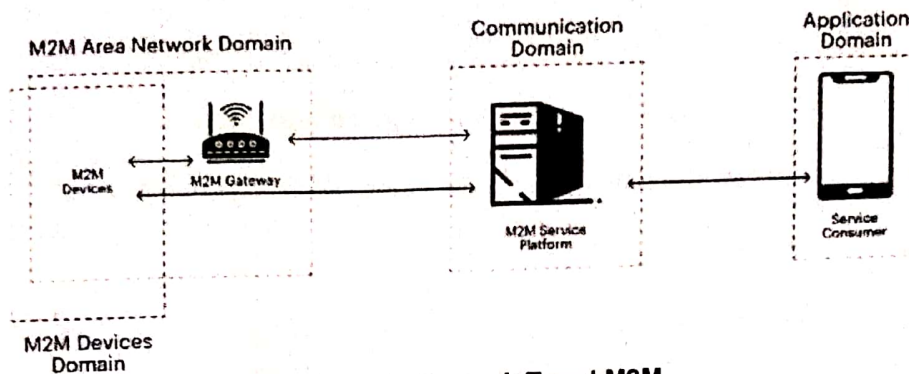
M2M is only subset of IoT

1. Internet of Things : IOT is known as the Internet of Things where things are said to be the communicating devices that can interact with each other using a communication media. Usually every day some new devices are being integrated which uses IoT devices for its function. These devices use various sensors and actuators for sending and receiving data over the internet. It is an ecosystem where the devices share data through a communication media known as the internet. IoT is an ecosystem of connected physical object that are accessible through internet. IoT means anything which can be connected to internet and can be controlled or monitored using internet from smart devices or PC.

2. Machine to Machine : This is commonly known as Machine to machine communication. It is a concept where two or more than two machines communicate with each other without human interaction using a wired or wireless mechanism. M2M is a technology that helps the devices to connect between devices without using internet. M2M communications offer several applications such as security, tracking and tracing, manufacturing and facility management.

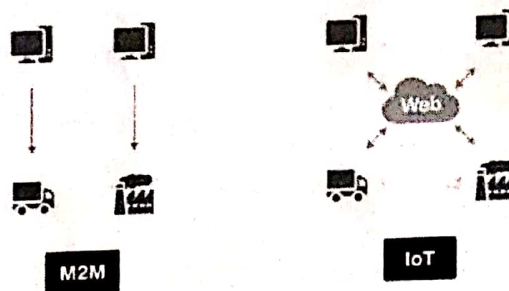
- M2M is also named as Machine Type Communication (MTC) in 3GPP (3rd Generation Partnership Project).
- M2M is communication could carried over mobile networks, for ex- GSM-GPRS, CDMA EVDO Networks .
- In M2M communication, the role of mobile networks is largely confined to server as a transport networks.

Machine-to-Machine Communication



Difference between IoT and M2M

M2M vs. IoT: main difference

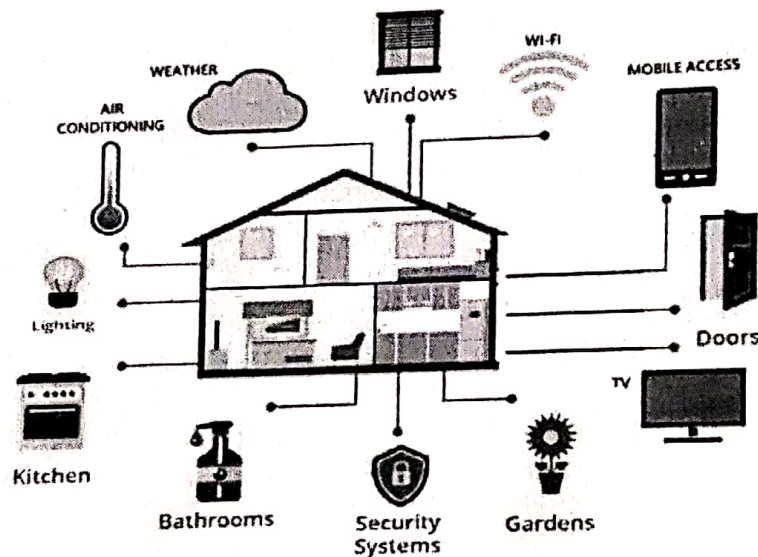


Basis	M2M	IoT
Connection Type Used	Simple device-to-device communication usually within an embedded software at the client site.	Devices use IP networks to communicate.
Communication	Communication directly between machines.	IoT sensors automation.
Communication Protocol Used	Communication technology techniques and traditional protocols.	Internet protocols like HTTP, FTP and Telnet.
Intelligence	Observation of some degree of intelligence.	Objects are responsible for decision-making.
Technology	Hardware-based.	Hardware and Software-based.
Data Sharing	Data sharing among communicating parties only.	Data sharing between other applications to improve the end-

		user experience.
Scope	Deployed in a closed system.	Connects to a larger network.
Open API Support	No open API support.	Supports open API integration.
Internet	An internet connection is not required	An internet connection is required
Components	Device, area networks, gateway, Application server.	Devices/sensors, connectivity, data processing, user interface
Examples	Sensors, data, information, etc.	Smart cities, Big data, etc.

Q . Applications of IoT: Home Automation

Home automation means you can control your electronic devices automatically. You can connect these devices to the internet and ultimately control various aspects of your home remotely. Besides making your life easier, home automation provides numerous benefits like potential energy efficiency and improved security.



Lighting

- ✓ Today, home lighting can automatically adjust to personal needs.
- ✓ When you enter your home, the lighting can be turned on automatically without the necessity to press a button. When you leave your home, the system can turn the lights off automatically to save energy, and you don't have to worry about it.
- ✓ All the home lighting can be connected to your smartphone, laptop, and other connected devices. Consequently, you can configure your app so that your light turns on when your alarm rings in the morning.

Bathrooms

- ✓ Special sensors can monitor movement in the bathroom, and turn off the water automatically if no one is there.
- ✓ Smart shower controllers can also identify people and set up their preferred water temperature and pressure, and even limit the time in the shower to control water consumption. With automated jacuzzis, users can take a bath without having to manually adjust their preferred temperature and air-jet regime, or select their favorite music, as the app will do all that automatically – all they have to do is to relax and enjoy the bath.

Gardens

- ✓ For those users who are interested in growing vegetables, fruit, and herbs at home, sensors can be exceptionally beneficial. The technology allows users to check on the app if the temperature is right, and if the plant is properly hydrated and receiving the necessary amount of sunlight.
- ✓ The app can monitor the current state of the soil, identify if there is enough moisture in it, and turn on a smart irrigation system if needed.
- ✓ When the amount of moisture reaches the optimal level, the sensor detects it and stops the watering system, thus avoiding overuse of water.

Kitchen

- ✓ With artificial intelligence technology, IoT devices can make the cooking process safer and easier. Smart sensors can ensure that everything is OK in your kitchen: they can check for smoke and carbon monoxide, or that the temperature and humidity levels are right.
- ✓ Special built-in programs monitor if the users have enough products in the fridge (and reorder them if needed), give advice on recipes, and calculate the nutritional value of meals. There are even smart spoons that remind users to be mindful of eating slowly.

Security Systems

- ✓ When you leave your home, do you always check that the doors and windows are closed, and that the TV, computer, and electrical appliances are off? Smart security systems will do that for you with the help of special sensors.
- ✓ These controllers can automatically lock the door when you go out, close the shutters, turn off electronic devices and make sure that your home is protected against human and animal trespassers.

Temperature Control

- ✓ With temperature control automation, you can adjust the temperature in your home to a level that is most comfortable for you. Users can program smart thermostats to control the temperature based on their preferences and settings, and they can even recognize your current activity and adjust the temperature accordingly.
- ✓ For example, users can use the app to automatically raise the temperature in their bath or shower or lower it to help them stay calm during at-home exercises like yoga, pilates, or other physical activities.

Doors and Windows

- ✓ In the future, keys will no longer be necessary for our doors. Doors may utilize facial recognition technology to unlock your house, and anyone entering who is not recognized as a resident will need to be identified. You could even program the doors to open as you approach your home and close as you leave.
- ✓ Opening a door could trigger a chain reaction in other home appliances, leading to the opening of other doors when authorized users are detected, or the automatic turning on of the TV or coffee maker.
- ✓ Bright windows can be programmed to respond to various events and signals from other devices. With such a system, the windows can automatically detect and close themselves when necessary, eliminating the need for you to worry about losing them when leaving the house.

Home Routine

- ✓ By utilizing AI and ML technologies, you can manage your home's temperature, lighting, and security system. The technology can notify you of necessary purchases through an online app, search for information online, provide news updates, order meals, schedule appointments, and even book lodging or travel arrangements.

- ✓ You can monitor the status of your home automation from anywhere. By using the app, you can verify the functionality of your lighting, security, and other internet-connected devices while you are out and about, visiting your parents or friends.

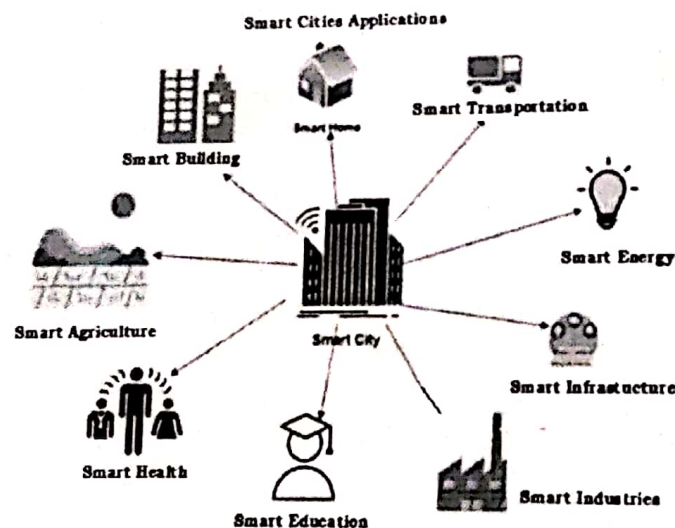
Smart Fans

- ✓ Like smart lighting, you can control your smart fans remotely. The manufacturer may provide a remote controller or a smartphone app.
- ✓ You can point anywhere to operate the fan. Also, you can control multiple fans across rooms with a single application. You can change the fan's speed from the comfort of your sofa or bed. You can also utilise the automatic timer feature where the fan turns off after a pre-set time.

Q . Smart Cities

IoT's impact extends beyond individual homes to entire cities, making urban life smarter and more efficient. Smart city applications involve various sectors, including transportation, government services, traffic management, healthcare, agriculture, water and energy management, and waste disposal. IoT-driven solutions create a sustainable living environment by resolving urban challenges, improving infrastructure, and enhancing security and development.

There are many cities in the world that are working on incorporating IoT applications and becoming smarter such as Singapore, Geneva, Zurich, Oslo, etc.



1. Traffic Management

- ✓ IoT sensors can be installed on traffic lights, roadways, and vehicles to collect data on traffic patterns, congestion, and accidents.
- ✓ This data can be used to optimize traffic flow, reduce congestion, and improve road safety. These solutions utilize sensors and GPS data from the rider's smartphone to report the location and speed of a vehicle.

2. Air Pollution

- ✓ Air pollution is a major problem in many metropolitan cities where the particulate matter in the air is so high it is damaging to the lungs in the long run. But IoT along with machine learning can be used to reduce air pollution.
- ✓ This is possible by collecting data related to city pollution like emissions from vehicles, pollen levels, airflow direction, weather, traffic levels, etc using IoT from various sources and then calculating pollution forecasts to see the trends in pollution so they can be controlled.

3. Healthcare

- ✓ Healthcare is an extremely important aspect of life, especially in current times when non-communicable diseases like heart problems and cancer are increasing in big cities while there are still a lot of deaths from infectious diseases in poorer places.
- ✓ In such a situation, IoT technology can surely help in enhancing the healthcare system so that the best healthcare is received by everybody.
- ✓ Another application of IoT and sensors in healthcare is remote patient monitoring wherein patients can be monitored 24/7 and emergency responders called if there are any problems.

4. Public Transport

- ✓ Traffic data can be collected and analysed using IoT devices to help city planners improve the flow of traffic, reducing congestion and making journeys quicker and smoother.
- ✓ It is very convenient when the trains and buses are connected with a single app and you know exactly when the next service will arrive and how long you need to wait. In addition to that, predictive analytics can be used to optimize the routes of public transport which provide maximum benefit and minimum cost.

5. Water Management

- ✓ IoT-enabled smart water management systems aim to optimize water usage, detect leaks, and improve overall water resource management.
- ✓ Sensors can be used to monitor water levels, pipe conditions, tank pressures, etc. in municipal water pipelines and tanks to optimize water management.

6. Agriculture

- ✓ The agricultural sector benefits significantly from IoT applications, addressing the increasing demands of a growing population. IoT offers intelligent solutions, such as automated monitoring, to help farmers optimise their operations.
- ✓ IoT technology aids in precise fertilisation, efficient water usage, timely harvest, soil analysis, and livestock monitoring.

7. Waste Management

- ✓ Waste management systems in a city can be optimized so that there is efficient waste collection and disposal which helps in keeping the city clean and hygienic.
- ✓ But IoT technology with sensors in the waste bins can be used to find when the bins are full and dispose of them accordingly.

8. Parking

- ✓ Smart parking meters can be used to collect data about the availability of parking spaces in a city. This data can then be used to help drivers find a parking space more quickly and reduce congestion.

9. Industrial Use

- ✓ IoT is pivotal in enhancing industrial processes and efficiency. In the industrial sector, IoT applications involve data analysis, sensors, tracking devices, and machinery to optimise operations.
- ✓ This technology provides businesses with accurate, transparent, and efficient means of production and maintenance. It enables the identification of areas that require attention or repair, leading to a more sustainable approach in industrial operations.

10. Infrastructure

- ✓ Smart infrastructure is a very important part of creating a smart city. This includes using IoT along with sensors to use technology intelligently which can save energy and cost for a city.
- ✓ An example of this is using smart streetlights along the roads that only turn on when they detect motion and stay off the rest of the time. This will definitely save energy and reduce the cost to the city.

Q . Energy

IoT Applications in Energy Sector

In the energy sector, IoT has diverse applications. IoT provides a wide variety of control and design functions in energy consumption and management. **Smart Energy Systems** are used for residential and commercial purposes.

some of the major applications of IoT in energy resources.

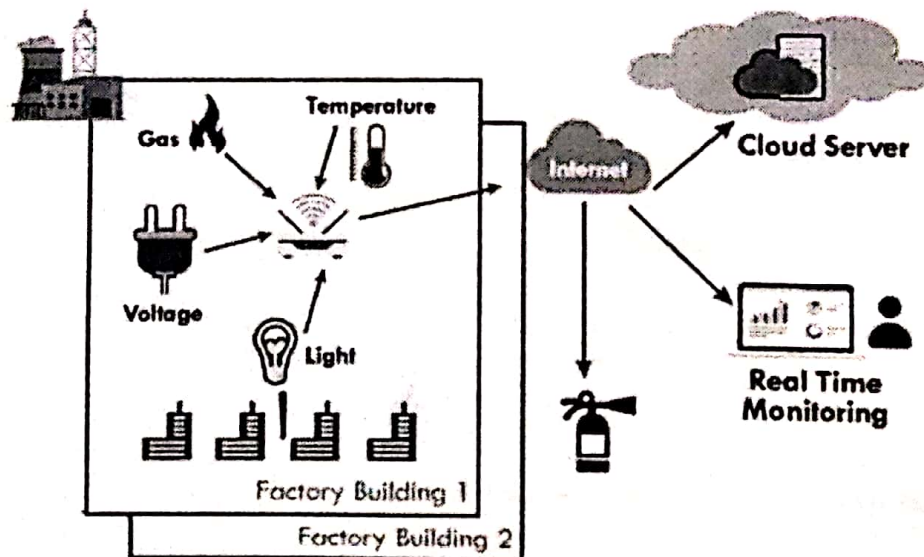
1. Residential Energy : Rising technology means costs in consumption also increase. IoT offers ways to reduce consumption and reduce the costs in energy usage. For example, IoT enables lightning systems to switch off or dim the lightning when they sense the absence of human beings.

2. Commercial Energy : IoT energy management in the commercial sector involves the reduction of energy consumption. IoT offers systems that monitor consumption and reduce usage in an effective way. It helps both small and larger corporations. It helps in the optimization of power and at the same time improves the functionality.

Commercial Energy manages the energy resources by providing cost effective methods. IoT handles the issues in the same way business organizations interact with business networks to offer solutions.

3. Energy system management : Energy management is a process through which organizations ensure the energy flow is conservative, efficient and less harmful to the environment. IoT is helping in building solutions that conserve energy. Intelligent energy management systems monitor the energy sources for any business. Methods such as reduced energy bills, reduced carbon footprints and increased energy efficiency all contribute to an optimized energy consumption.

4. Automated process : Automation of processes in an industry involves using sensors and webcams for monitoring and security purposes. This reduces the need for human intervention. IoT technology monitors machine performance to ensure better production quality. In addition, automated processes raise alerts and send signals before the occurrences of any incident, this increases on-site safety.



5. Smart Energy Meters : Smart energy meters allow the usage of energy more effectively which leads to lesser consumption and better performance. These are similar to the traditional meters but in addition smart energy meters interact remotely with the utility. It records and sends information every 15 minutes. In case of a power outage, the smart meters notifies the user immediately. It quickly dispatches members to resolve issues and get back on track.

6. Zero Net Energy Buildings : IoT is also helping build concepts such as zero net energy buildings. Renewable energy resources are the only source of contribution for energy consumption in such buildings. Sources such as solar and wind generate power and electricity in these buildings. This leads to less dependency on non-renewable resources.

Ex:

- ✓ Smart meters for electricity and gas
- ✓ IoT-enabled wind turbines and solar panels
- ✓ Remote diagnostics of grid components
- ✓ Energy-efficient building automation systems

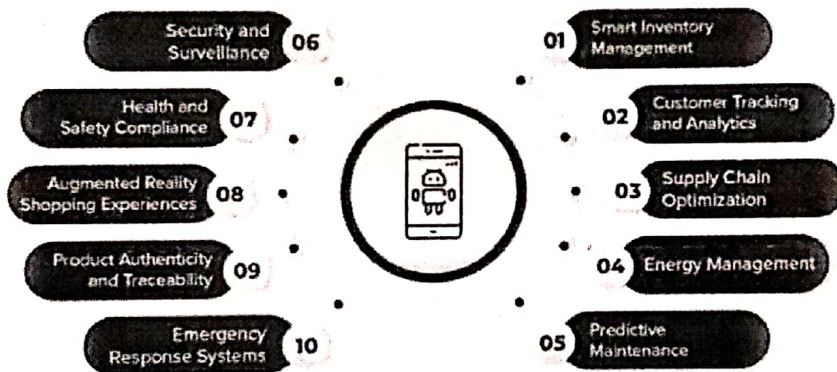
Benefits of IoT in energy management

- Reduced energy waste
- Improved predictive maintenance
- Real-time monitoring of assets
- Enhanced demand forecasting
- Better grid stability and outage management

Q . Retail Management

In the retail sector, IoT has emerged as a transformative technology with the potential to revolutionize the shopping experience. By connecting physical objects within a **retail environment**, IoT enables retailers to gather valuable data, automate processes, and provide personalized services to customers.

Applications of IoT in the Retail Sector



1. Smart Shelves for Real-Time Inventory Management : Smart shelves use sensors to track stock levels in real-time. When products run low, the system alerts store management to restock.

Benefits:

- Prevents products from running out.
- Reduces overstock and saves space.
- Helps with better planning using real-time data.

2. Enhanced Customer Experience with Personalized Marketing : The use of IoT in retail industry helps stores to track customer preferences as well as behaviors. By allowing them to send personalized offers or promotions.

Benefits:

- Engages customers with tailored offers.
- The application of IoT in retail industry increases sales by suggesting relevant products.
- Improves customer loyalty and satisfaction.

3. Smart Checkout Solutions : IoT solutions for retail allow for automatic payments as customers leave the store by eliminating long queues.

Benefits:

- Reduces waiting times for customers.

- Lowers the need for cashiers.
- Speeds up the payment process.

4. Optimized Supply Chain Management : IoT sensors track the movement of products from warehouses to stores. As well as application of IoT in retail industry improves inventory management

Benefits:

- Provides real-time tracking of goods.
- Reduces overstocking and stockouts.
- Makes the supply chain more efficient.

5. Energy Management Solutions : IoT for retailing industry monitors and also manages energy usage in stores, optimizing lighting, refrigeration, and more.

Benefits:

- Cuts energy costs.
- Supports sustainability goals.
- Provides insights into energy usage.

6. Smart Mirrors and Fitting Rooms : IoT-powered smart mirrors let customers virtually try on clothes as well as in getting recommendations, without changing outfits.

Benefits:

- application of IoT in retail industry makes shopping more interactive.
- Saves time in fitting rooms.
- Increases the chance of sales with personalized suggestions.

7. Predictive Maintenance of Equipment : These sensors monitor store equipment and also predict when maintenance is needed, preventing breakdowns.

Benefits:

- In retail IoT use cases reduce the risk of equipment failure.
- Lower repair costs.
- Keeps store operations running smoothly.

8. In-Store Analytics : These devices collect data on customer movements, product interactions, and also time spent in in-store areas.

Benefits:

- Provides insights into customer behavior.
- The application of IoT in retail industry also helps to improve store layout and design.
- Allows for better marketing strategies.

9. Automated Replenishment Systems : IoT sensors detect when stock is low and automatically order more products.

Benefits:

- The Internet of things in retail industry keeps shelves stocked without manual effort.
- Reduces mistakes in inventory management.
- Ensures a steady supply of products.

10. Security and Loss Prevention : IoT security systems generally use smart cameras and sensors to prevent theft and ensure store safety.

Benefits:

- Helps reduce theft and losses.
- Keeps customers and staff safe.
- Monitors stores in real-time for quick response.

Q . Logistics

IoT in logistics, short for the Internet of Things, represents the integration of physical devices within the logistics and transportation industry network that communicate and exchange data without human intervention.

APPLICATIONS OF IOT IN LOGISTICS

IoT technology transforms the logistics process, advancing various aspects of operations with its innovative applications. Here are some key areas where IoT makes a significant impact:

- **Real-Time Tracking:** IoT enables logistics companies to track shipments and assets in real-time, providing up-to-the-minute location data. This capability enhances route management and improves delivery accuracy.
- **Inventory Management:** With IoT devices such as RFID tags and sensors, companies can automate inventory tracking and management. This technology ensures accurate stock levels and alerts when supplies are low, leading to efficient inventory management.

Internet of Things technologies also facilitates the development of smart warehouse systems, which allow companies to:

- ✓ Prevent losses,
- ✓ Ensure safe storage of goods, and
- ✓ Efficiently locate items in the warehouse.
- **Vehicle Tracking:** IoT solutions offer precise tracking of each vehicle in a logistics company by communicating with logistics managers and providing data on location, speed, and route efficiency.
- **Predictive Maintenance:** By analyzing vehicle data, IoT systems can predict when a vehicle might require maintenance before a breakdown occurs, thereby minimizing downtime.
- **Driver Behavior Monitoring:** IoT devices can monitor driving patterns and behaviors, providing feedback that can lead to safer driving practices and improved fuel efficiency.
- **Drone-based delivery systems**

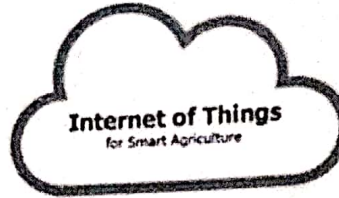
When it comes to package delivery – particularly within the fields of logistics, retail, e-commerce, and agriculture – drones, or unmanned aerial vehicles (UAVs), are the new medium. For example, the online retail giant and web service provider Amazon has announced that Amazon Prime Air is preparing to offer drone delivery in the U.S. Alongside the application of drones, the implementation of IoT in logistics can ensure:

- ✓ Automated process execution,
- ✓ Cost-effective delivery, and
- ✓ Fast, hazard-free delivery of goods.

Q . Agriculture

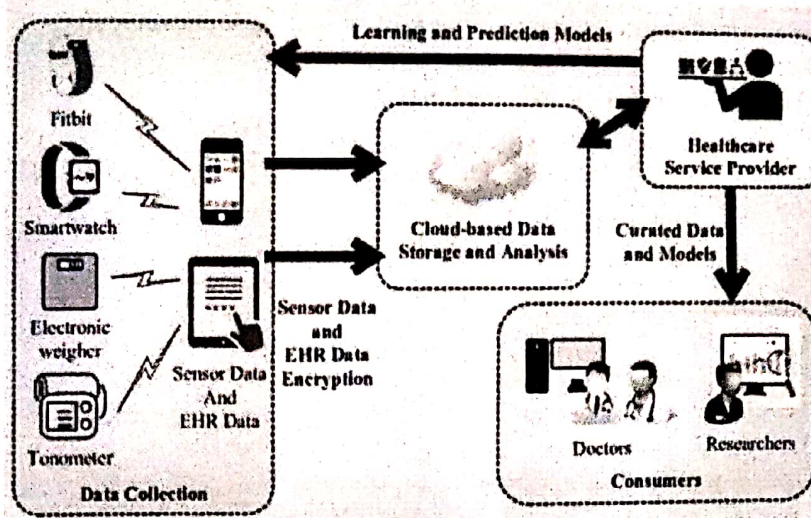
Agriculture is another important domain for IOT. IOT systems play an important role for crop and soil monitoring and give a proper solution accordingly. IOT leads to smart farming. Using IOT, farmers can minimize waste and increase productivity. The system allows the monitoring of fields with the help of sensors. Farmers can monitor the status of the area.

IoT Applications in Agriculture :



- 1) **Greenhouse Automation:**
IoT sensors and actuators are vital in greenhouse automation. They monitor and control crucial environmental factors such as temperature, humidity, and lighting. By maintaining optimal conditions, IoT enables careful cultivation, accelerates plant growth, and boosts overall greenhouse productivity.
- 2) **Predictive Analytics for Smart Farming:**
By collecting and analyzing data from various sources, including weather patterns, soil moisture levels, and crop health sensors, IoT empowers farmers with predictive analytics. This input enables making informed decisions regarding irrigation, crop rotation, disease prevention, and resource allocation.
- 3) **Agricultural Drones:**
IoT sensors and cameras support gathering data on crop health, plant density, and irrigation needs. It enables the farmers to analyze & identify problem areas, take proactive measures, and optimize their farming practices. It leads to increased yield and a reduction in resource wastage.
- 4) **Monitoring Climate Conditions:**
The installation of IoT weather stations across farms helps collect accurate data on temperature, humidity, wind speed, and rainfall. This input can be used in real-time to make precise irrigation schedules, pest control, and crop management decisions.
- 5) **Precision Farming:** It is made possible by combining data from different sources, such as soil sensors, satellite imagery, and machine vision. And this data-driven approach enables farmers to optimize pesticide & water usage for higher crop yields.
- 6) **Smart Pest Control:** IoT devices can precisely detect pests using sensors and image recognition technology. Early detection enables farmers to implement targeted pest control measures, thereby minimizing crop damage and reducing the need for excessive pesticide usage.
- 7) **Farm Management:** These systems enable farmers to consolidate and manage all their data in a suitable location. From crop yields and livestock records to financial information and inventory levels, the system is a centralized hub for planning schedules and optimizing resource use.
- 8) **Livestock Tracking and Geofencing:** With IoT-enabled tracking devices, farmers can monitor the location and behavior of their livestock in real time. Geofencing allows them to set virtual boundaries and receive alerts if animals stray beyond designated areas. This technology ensures better management of grazing patterns and enhances animal welfare.

Q . Health and Lifestyle

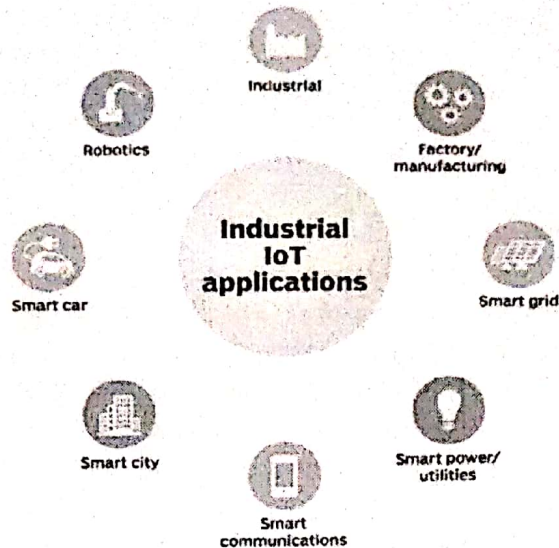


- 1) **Glucose Monitoring:** Patients who suffer from diabetes can have devices with sensors implanted in them, just below their skin. The sensors in the devices will send information to a patient's mobile phone when his or her glucose levels get too low and will record historical data for them too. 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.
- 2) **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.
- 3) **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.
- 4) **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.
- 5) **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.
- 6) **Depression and Mood Monitoring:** IoT-based mood awareness solutions use integrated sensors to collect health data such as heart rate, blood pressure, and sleep patterns. These enable healthcare providers to supplement traditional mental healthcare. Through these smart devices, healthcare service providers can gather in-depth mental wellness metrics, identify patterns earlier, and take targeted actions to drive better patient outcomes.

- 7) **Mobile Healthcare:** Mobile apps for healthcare IoT devices transfer basic health data concerning the medical conditions or physical activities of patients to smartphones. These apps help physicians give prompt online consultations and enable patients to monitor various health metrics independently without professional assistance.
- 8) **Tracking Patients, Staff and Medical Assets:**
Using IoT devices like RFID tags, BLE (Bluetooth Low Energy) beacons, or wireless ID cards with RTLS (Real-Time Location Systems), medical facilities can track patients and staff & locate inventory/assets. It helps them manage patient admissions and enhance hospital security, locate relevant staff members in case of emergencies and also optimize the reallocation of free resources.
- 9) **IoT for Hospitals :** IoT technologies enhance operational efficiency in hospitals by streamlining processes such as equipment tracking and infection control. IoT-enabled devices ensure that hospitals maintain optimal hygiene levels, reducing the risk of infections.
- 10) **Asset Tracking:** IoT helps track medical equipment like wheelchairs, ventilators, and infusion pumps.
- 11) **Environment Control:** IoT systems monitor and regulate temperature, humidity, and refrigeration systems for medications.
- 12) **IoT for Patients :** IoT devices have significantly improved the quality of life for patients, especially elderly individuals and those with chronic conditions. Devices such as wearables and monitoring sensors help patients track their health metrics, like heart rate and blood pressure, and even manage daily activities.
- 13) **Wearables:** Smartwatches, fitness bands, and health monitoring devices provide real-time data and personalized health insights.
- 14) **Alerts for Families:** IoT devices can notify family members of any irregularities in the patient's health metrics, ensuring prompt intervention.
- 15) **IoT for Patients :** Wearable devices such as fitness bands and other wirelessly connected devices track and monitor health parameters such as heartbeats and oxygen saturation in individual patients.
- 16) **IoT for doctors :** Data collected from IoT devices can help physicians identify the best treatment process for patients by using wearables and other home monitoring equipments, etc.
- 17) **IoT for Hospitals :** IoT devices tagged with sensors can be used for tracking real time location of medical equipment like wheelchairs, defibrillators, nebulizers, oxygen pumps, and other monitoring equipment.

Q . Industrial IoT

The Industrial Internet of Things is about deploying sensors and smart machines to capture and move data, sense changes in temperature, flow or volume, automate procedures for efficiency, accuracy and safety, deliver data into the right hands for analysis and decision making, and ensure that all of those processes happen on time, reliably and securely.



Digital/Connected Factory :

- The machinery that is embedded with an IoT system can transfer information related to operations to the people such as the original equipment manufacturers and to field engineers.
- This way process automation and optimization is made advantageous by enabling operation managers and factory heads to remotely manage the factory units.

Facility Management :

- The IoT sensors placed inside manufacturing equipment triggers alerts based on condition-based maintenance. Most of the machine tools are critical and are designed to function between a specific temperature and vibration ranges.
- Whenever an equipment deviates from its prescribed parameters, IoT sensors can actively monitor machines and send an alert.

Production Flow Monitoring :

- IoT in manufacturing is capable of monitoring an entire production line be it from the refining process completely down to the packaging of final products. Because this complete monitoring of the process takes place in real-time.

Plant Safety and Security :

- A workers' safety and security in the plant improve by IoT combined with big data analysis.
- The IoT system monitors some Key Performance Indicators (KPIs) of health and safety, such as the number of injuries, frequent rates of illness, vehicle incidents, and property damage or any kind of loss incurred during daily operations.

Quality Control :

- A product cycle has various stages, IoT sensors collect a mixture of product data and other third-party synchronized data from the stages of a product cycle.
- This data contains information on the composition of raw materials used in the making of a product, the temperature & working environment, different wastes, the importance of transportation etc. On the final making of the products.

Logistics and Supply Chain Optimization :

- In this industrial IoT applications, it provides access to real-time supply chain information by tracking materials in transit, products, and equipment as they move through the supply chain.
- Through effective reporting manufacturers are able to collect and feed the delivery information into systems like ERP, PLM etc.
- If the plants get to connect to the suppliers, all the concerned parties in the supply chain can trace interdependencies, manufacturing cycle times and material flow.

Smart packaging :

- Smart packaging is an application of the internet of things that uses forms of technology to package products and does more than storing the products. It allows users to interact with the package and resolve their queries regarding the product, product or delivery.
- IoT and packaging work together include sensors, QR code and other options. The main goal is to interact with the consumer and collect necessary data.

Remote Monitoring and Control :

- IoT sensors can perform some elements of assembly line inspectors' role by checking machinery for performance issues or defects and alerting managers when there's a problem.
- For example, if a water pump breaks and starts to leak, you can receive an alert and engage shutdown protocols right from your device, regardless of location.

Q . Legal challenges

LEGAL CHALLENGES:

• Data Privacy and Protection:

- ✓ Internet of things (IoT) devices lack the important security measures to avert data breaches. IoT devices transmit and collect vast amount of sensitive and personal data. Because of which concern regarding privacy arises.
- ✓ Improper IoT security can lead towards botnet attacks, reputational damage, device hijacking, data breaches, network issues, financial problems, etc.

• Data Ownership:

- ✓ Data ownership is a very complicated issue because IoT devices can collect and store information about people. IoT devices often gather sensitive information about users, such as their location, health data, and financial information, rendering this data susceptible to hacking and other cyber threats.
- ✓ Even without breaches, there is a persistent risk of data being misused or shared without the user's consent. Difficulty in authenticating users, lack of encryption, misuse and sharing are some problems which are related to data ownership.

• Security:

- ✓ High volume of problems are discovered regularly in IoT systems. Because of which security challenges are arising. Lack of visibility, open source code vulnerabilities, limited security integration, weak passwords, overwhelming data volume, poor testing, etc are some security issues in IoT systems.
- ✓ IoT and security requirements can only be accomplished with an integrated solution that delivers visibility, segmentation, and protection throughout the entire network infrastructure.

• Jurisdiction:

- ✓ Jurisdiction is the most crucial problem which emerges between the device producers and clients. Devices can be situated in many areas and in few cases outside the regional limits of a country.
- ✓ Therefore it is very important for the device producers to review the laws of the country where they are going to sell their devices to prevent problems like borderless data flow, data sovereignty and jurisdictional conflicts.

• Product Liability and Consumer Protection:

- ✓ Product liability is a complex issue in IoT. The product liability is a region of law wherein makers, wholesalers, providers, retailers, and other people who make items accessible to general society are considered liable for the sufferings those items cause to property and on bodily injury.
- ✓ The rule of strict liability is being used by Courts for the cases of product liability. Because the rule of strict liability is very consumer friendly.

- ✓ There are various of laws in India for the protection of consumers against product liability like the Consumer Protection Act, 1986, the Legal Metrology Act, 2009.

Q . IoT design Ethics

Ethical considerations are crucial in IoT design to ensure responsible development and deployment of connected devices and services. Key aspects include privacy, security, data ownership, transparency, and accountability. Addressing these concerns helps build trust and fosters responsible innovation.

Key Ethical Considerations in IoT Design:

- 1) **Privacy:** IoT devices often collect vast amounts of personal data, raising concerns about data breaches and misuse. Ethical design requires robust data protection measures, transparency about data collection practices, and informed consent from users.
- 2) **Security:** IoT devices are vulnerable to cyberattacks, which can compromise user data and lead to safety risks. Ethical design emphasizes secure device architecture, strong encryption, and ongoing security updates.
- 3) **Data Ownership:** Users should have control over their data and how it's used. Ethical design ensures that users have the right to access, modify, and delete their data, and that it's not used without their consent.
- 4) **Transparency:** Users should be informed about what data is being collected, how it's being used, and who has access to it. This fosters trust and enables users to make informed decisions about using IoT devices.
- 5) **Accountability:** Developers, manufacturers, and service providers should be held accountable for the ethical implications of their designs and for any harm caused by their products or services. This can be achieved through clear policies, regulatory compliance, and user support mechanisms.

Challenges and Processes for Ethical Design

- 1) **Understanding the needs and values of users:**
Involving users in the design process can help ensure that IoT devices meet their needs and preferences while respecting their values.
- 2) **Translating these needs and values into an ethical design:**
This involves considering factors like trust, safety, and privacy, and incorporating them into the design specifications.
- 3) **Demonstrating that these needs and values are taken into account:**
This can be achieved through clear communication, transparent data practices, and accountability mechanisms.
- 4) **Establishing a clear framework for transparency and accountability:**
This includes defining roles and responsibilities, setting ethical guidelines, and implementing mechanisms for addressing concerns and complaints.

Q . IoT in Environmental Protection

The applications of IoT in environmental monitoring are broad – environmental protection, extreme weather monitoring, water safety, commercial farming, and more. In these applications, sensors detect and measure every type of environmental change.

Smart Energy Management :

- ✓ IoT devices help in managing a wide range of electricity supply chains. This includes electric utilities, their energy consumption and supply from both distributors and consumer ends.
- ✓ The energy usage monitoring is concerned, then it can be observed that the wireless utility meters deliver the energy consumption data at building areas, individual and industrial assets. Having these data-driven insights help companies and individuals to monitor their energy consumption and optimize it to achieve environmental sustainability.

Air Quality Monitoring

- ✓ Poor quality air has significant ramifications on food and vegetation, renewable energy, weather and water. However, the innovative and low-cost IoT sensors have enabled the municipalities to monitor the air quality index.
- ✓ In this way also the root cause of air pollution is tracked in real-time and municipalities implement corrective measures to reduce air pollution which makes the environment clean for human beings.

Smart Waste Management

- ✓ An increase in the global population is also giving rise to the amount of garbage humans produce. The inconsistent and inefficient waste collection has made the situation more miserable.
- ✓ IoT, with its network of wireless sensors, can combat waste and garbage collection issues by enabling facility managers to access real-time data about trash receptacles. The facility managers can decide which waste containers need to be emptied first after knowing about their current fill levels.
- ✓ With this information, the waste management companies can optimize their waste collection schedule, as well as lower the environmental footprint by limiting the unnecessary mobility of the waste collection trucks.

Fleet Management

- ✓ The focus on different fuel types and their impact on the environment and air quality has been increased significantly.
- ✓ Vehicle health, driver behavior, idle time, fuel consumption and location all play a vital role in calculating the total emission produced by the fleet. The critical insight into these metrics can be accessed with the help of wireless IoT sensors equipped in the fleets.
- ✓ The data from the sensors can provide useful insight into vehicle maintenance, improve driver behavior and optimize routes.
- ✓ For instance, IoT sensors provide a real-time location for more responsive and accurate route planning. This ultimately reduces the harmful emission resulting in the time spent by the vehicle idling in traffic.

5. Smart Water Monitoring

- ✓ Nearly, 20-30% of drinking water is wasted by pipe leaks in municipalities. Wireless connectivity and IoT sensors have substantially reduced the cost of gathering and analyzing the data from different water equipment such as valves, pumps or entire water processes like irrigation.
- ✓ With the help of installing IoT leak detection sensors in plants or buildings, water leaks can be detected along with controlling the water quality and monitoring the fill levels.
- ✓ The intelligent system can immediately alert the facility managers if any sign of a water leak is detected so that remedial actions can be taken on time.
- ✓ These IoT systems if installed on a larger scale can reduce water waste and can save the land from increasing water crisis.

6. Smart Agriculture

- ✓ The availability of natural resources such as arable land and freshwater is continuously decreasing due to an increase in the global population.
- ✓ Smart farming systems powered by IoT technologies can help in achieving environmental sustainability. The smart devices gather data about the factors such as soil conditions etc.
- ✓ The analytics of the collected data provides useful insight about various farming practices namely, fumigation, fertilization, irrigation and seeding etc.
- ✓ Smart agriculture reduces error-prone and inefficient human interventions along with minimizing water, chemical and other resource utilization.