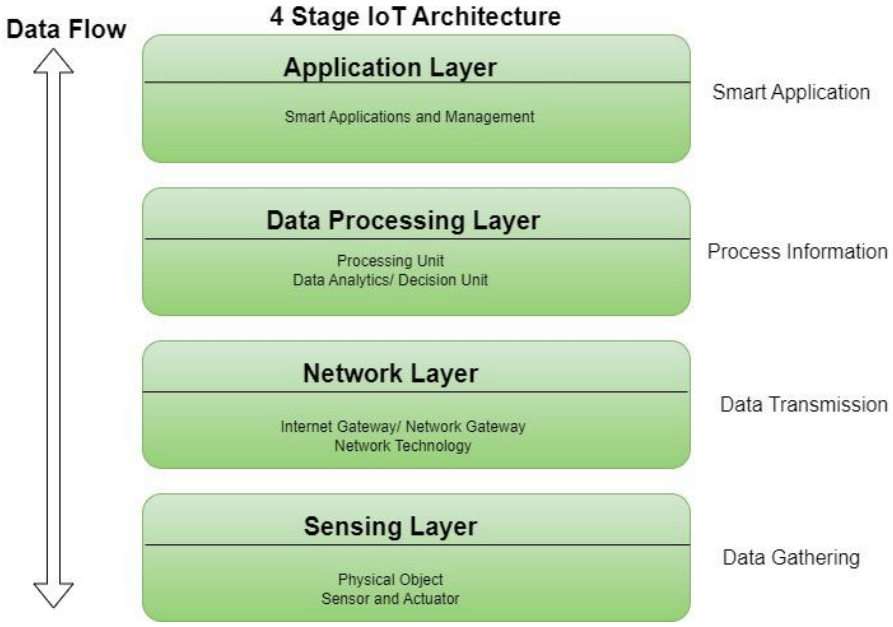
5. Ubiquitous & IOT

1. Explain the architecture of Internet of Things

- Internet of Things (IoT) technology has a wide range of applications and the use of the Internet of Things is growing so faster.

- The **Internet of Things (IoT)** refers to a network of **physical objects or "things"**—such as home appliances, vehicles, sensors, and wearable devices—that are embedded with **sensors, software, and connectivity** to collect and exchange data over the Internet.



1. Sensing Layer

This is the first layer that collects data from the physical world using sensors and devices like temperature sensors, cameras, or GPS modules. It detects changes and sends this data to the next layer for further processing.

2. Network Layer

This layer is responsible for transmitting the collected data from sensors to the cloud or other devices. It uses communication technologies like Wi-Fi, Bluetooth, 4G/5G, or Zigbee to enable connectivity and data flow.

3. Data Processing Layer

Here, the data is cleaned, stored, and analyzed to generate useful insights. It uses tools like data analytics, cloud computing, and AI to help make smart decisions based on the information gathered from devices

4. Application Layer

This is the topmost layer that users interact with through apps or dashboards. It displays the processed data in a meaningful way, allowing users to monitor or control devices, such as turning off lights or checking home security from their phone.

Advantages of IoT

- Execute multiple tasks at a time like a computer.
- Easiest internet connectivity
- Works on GUI (Graphical User Interface) mode because of HDMI port.
- Best suited for server-based applications i.e., can be connected via **SSH–Secure Shell**-to access the Rpi command line remotely and file sharing via **FTP–File Transfer Protocol**.
- More reliable for software applications.

Disadvantages of IoT

- Security concerns and potential for hacking or data breaches.
- Privacy issues related to the collection and use of personal data.
- Dependence on technology and potential for system failures.
- Limited standardization and interoperability among devices.
- Complexity and increased maintenance requirements.
- High initial investment costs.
- Limited battery life on some devices.
- Concerns about job displacement due to automation.
- Limited regulation and legal framework for IoT, which can lead to confusion and uncertainty.

Modern Applications of IoT

- Smart Grids and energy saving
- Smart cities
- Smart homes/Home automation
- Healthcare
- Earthquake detection
- Radiation detection/hazardous gas detection
- Smartphone detection
- Water flow monitoring
- Traffic monitoring
- Smart door lock protection system
- Robots and Drones

2. Enabling Technologies Used in IoT.

1. Wireless Sensor Network
2. Cloud Computing
3. Big Data Analytics
4. Communications Protocols
5. Embedded System

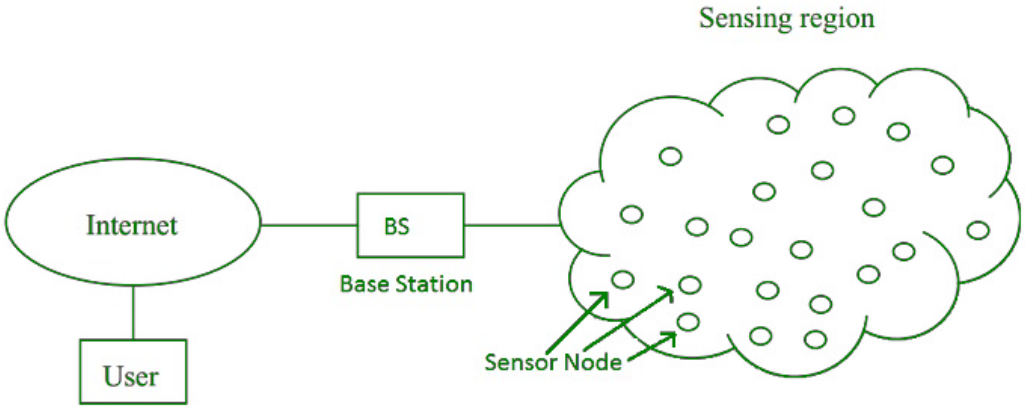
1. Wireless Sensor Network (WSN)

- **Wireless Sensor Network (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.

- A WSN is a collection of devices equipped with sensors to monitor physical or environmental conditions like temperature, humidity, or motion.

- These devices communicate wirelessly, passing data through routers to a central coordinator, which connects to the internet.



Wireless Sensor Network Architecture

- **Physical Layer**: This layer connects sensor nodes to the base station using technologies like radio waves, infrared, or Bluetooth. It ensures the physical communication between nodes and the base station.

- **Data Link Layer**: Responsible for establishing a reliable connection between sensor nodes and the base station. It uses protocols such as IEEE 802.15.4 to manage data transmission and ensure efficient communication within the network.

- **Application Layer**: Enables sensor nodes to communicate specific data to the base station. It uses protocols like ZigBee to define how data is formatted, transmitted, and received, supporting various applications such as environmental monitoring or industrial control.

WSN Network Topologies
Wireless Sensor Networks (WSNs) can be organized into different network topologies based on their application and network type. Here are the most common types:

- **Bus Topology**: In a Bus Topology, multiple nodes are connected to a single line or bus. Data travels along this bus from one node to the next. It's a simple layout often used in smaller networks.

- **StarTopology**: Star Topology have a central node, called the master node, which connects directly to multiple other nodes. Data flows from the master node to the connected nodes. This topology is efficient for centralized control.

- **Tree Topology**: Tree Topology arrange nodes in a hierarchical structure resembling a tree. Data is transmitted from one node to another along the branches of the tree structure. It's useful for expanding coverage in hierarchical deployments.

- **Mesh Topology**: Mesh Topology feature nodes interconnected with one another, forming a mesh-like structure. Data can travel through multiple paths from one node to another until it reaches its destination. This topology offers robust coverage and redundancy.

Types of Wireless Sensor Networks (WSN):

1. Terrestrial WSN
2. Underground WSN
3. Underwater WSN
4. Multimedia WSN
5. Mobile WSN
6. Wireless Body Area Network (WBAN)

Applications of WSN

- Internet of Things (IoT)
- Surveillance and Monitoring for security, threat detection
- Environmental temperature, humidity, and air pressure
- Noise Level of the surrounding
- Medical applications like patient monitoring
- Agriculture
- Landslide Detection

2. Cloud Computing

Cloud computing provides access to services like storage, servers, and applications over the internet. It supports IoT by offering scalable, on-demand infrastructure and platforms that store and process massive data collected by IoT devices.
Services:

- **IaaS:** Provides virtual machines and storage (e.g., AWS, Azure).
- **PaaS:** Provides platforms to develop apps (e.g., Google App Engine).
- **SaaS:** Software accessed via the internet (e.g., Gmail, Google Docs).

3. Big Data Analytics

Big Data Analytics involves processing huge amounts of diverse data generated by IoT devices. It includes steps like data cleaning, processing, and visualization to extract insights and support decision-making.
Example: Banking transactions, fitness trackers, GPS tracking in logistics.

4. Communication Protocols

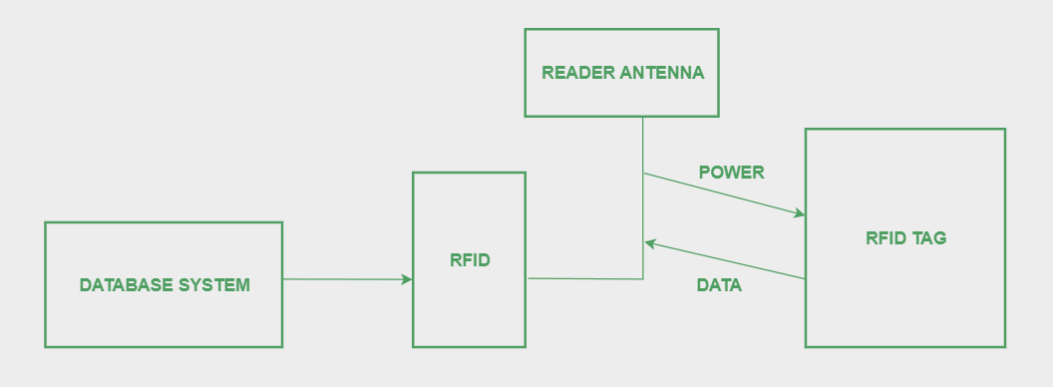
These are rules that enable data exchange between IoT devices and systems. They ensure that devices can connect and communicate reliably, and include protocols for data formatting, addressing, and routing.
Example protocols: MQTT, CoAP, Bluetooth, Wi-Fi, ZigBee.

5. Embedded Systems

An embedded system combines hardware (like sensors and processors) and software to perform specific tasks. It is the core of smart devices, collecting and sending data to the network or cloud.
Examples: Digital cameras, smart thermostats, industrial machines, IoT routers.

3. **Radio Frequency Identification (RFID):-**

- **Radio Frequency Identification (RFID)** is a wireless technology that uses radio waves to identify and track things or people.
- It works by attaching small tags to objects, which store information. When an RFID reader sends out radio signals, these tags respond with their stored data—even without needing to see the tag directly.
- RFID helps quickly find and track items like products in stores, equipment in factories, or even people entering a building.
- It's faster and more convenient than scanning barcodes because it doesn't need to be pointed directly at the tag.



Working:-

1. Scanning Antenna:-

The scanning antenna sends out radio waves to detect nearby RFID tags. It acts like a transmitter and receiver, enabling wireless communication between the tag and the reader. This is the part that "talks" to the tags.

2. Transceiver

The transceiver controls the sending and receiving of radio signals through the antenna. When combined with the antenna, it forms the RFID reader that activates tags and collects their data. It processes signals for further use.

3. RFID Reader

The RFID reader is a device made up of the antenna and transceiver. It can be fixed in place or portable and connects to a network. The reader sends signals to tags and receives their responses, converting them into usable data.

4. Transponder (RFID Tag)

The transponder is the RFID tag attached to an object, containing stored information. When activated by the reader's signal, it sends back its data wirelessly. Tags can be passive or active depending on whether they have their own power source.

5. Read Range Factors

The distance at which an RFID tag can be read depends on the type of tag, reader, frequency used, and environmental interference. Tags with their own batteries (active tags) generally have a longer read range than passive tags.

Challenges of RFID

- Cost
- Interference
- Privacy
- Standardization:

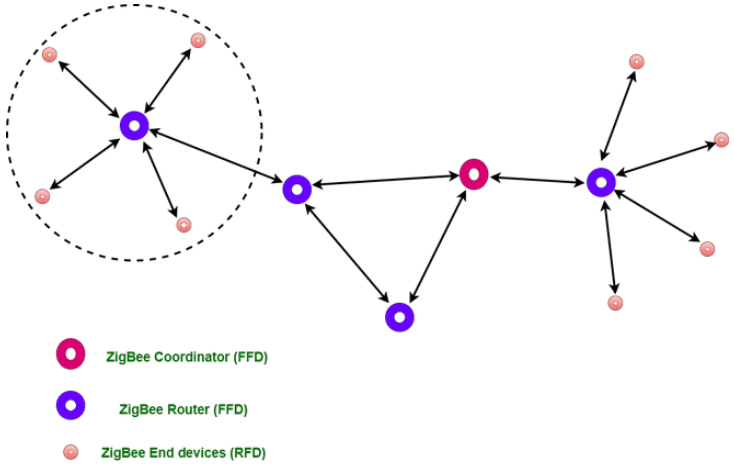
Application of RFID

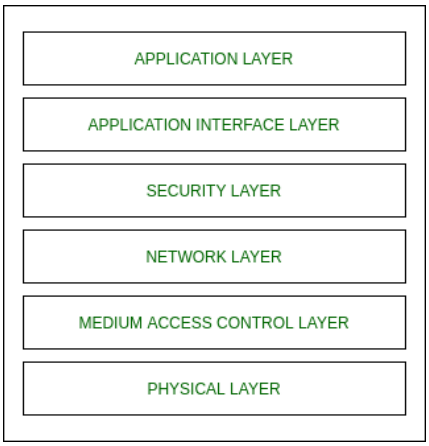
- Inventory Management:
- Asset Tracking:
- Supply Chain Management:
- Access Control:
- Retail:
- Healthcare

Feature	Passive RFID Tags	Active RFID Tags	Semi-Passive (Semi-Active) RFID Tags
Definition	Tags that have no internal power source and rely entirely on the reader's radio waves for power.	Tags with their own battery that actively transmit signals to the reader.	Tags with a battery that powers the tag's circuitry but rely on the reader's signal for communication.
Power Source	No internal battery; powered by reader's signal	Has its own battery	Has a battery to power the chip, but not for communication
Read Range	Short (up to a few meters)	Long (up to hundreds of meters)	Medium (longer than passive, shorter than active)
Size & Cost	Small and inexpensive	Larger and more expensive	Moderate size and cost
Lifespan	Long (no battery to deplete)	Limited by battery life	Longer than active, limited by battery life
Communication	Powered by backscatter from reader's signal	Transmits signals actively	Uses battery to power circuitry but relies on reader to communicate
Usage Examples	Inventory tracking, access control	Real-time location tracking, asset monitoring	Environmental monitoring, temperature sensing
Complexity	Simple	More complex	Moderate complexity

4. ZigBee Technology:-

- ZigBee is a wireless communication technology designed for low-power, low-data-rate applications, especially useful in devices that need to run for a long time on small batteries.
- It is based on the IEEE 802.15.4 standard and is widely used in home automation, smart lighting, sensor networks, and IoT devices.
- ZigBee allows many devices to form a mesh network, where each device can communicate directly or through other devices, making the network reliable and scalable.
- It is ideal for applications that require secure, simple, and cost-effective wireless control and monitoring.
- ZigBee is an open, global, packet-based protocol designed to provide an easy-to-use architecture for secure, reliable, low power wireless networks.





Types / Components ZigBee Devices:

1. ZigBee Coordinator (ZC)

This is the main device in the ZigBee network. It starts the network, manages devices, and stores information about the network. There is only one coordinator in each ZigBee network.

2. ZigBee Router (ZR)

Routers help pass data between devices and extend the range of the network. They can forward messages and allow new devices to join the network, helping to create a mesh structure.

3. ZigBee End Device (ZED)

These devices communicate only with their parent (coordinator or router) and do not route data for other devices. They are usually simple devices like sensors or switches and are designed to save power by sleeping when not active.

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
- Extremely low-duty cycle.
- 3 frequency bands with 27 channels.
-

Features of Zigbee:

1. Stochastic addressing: A device is assigned a random address and announced. Mechanism for address conflict resolution. Parents node don't need to maintain assigned address table.

2. Link Management: Each node maintains quality of links to neighbors. Link quality is used as link cost in routing.

3. Frequency Agility: Nodes experience interference report to channel manager, which then selects another channel

4. Asymmetric Link: Each node has different transmit power and sensitivity. Paths may be asymmetric.

5. Power Management: Routers and Coordinators use main power. End Devices use batteries.

Zigbee Applications:

- Home Automation
- Medical Data Collection
- Industrial Control Systems
- meter reading system
- light control system
- Commercial
- Government Markets Worldwide
- Home Networking

Advantages of ZigBee

- Low power consumption
- Mesh networking support
- Low cost
- Secure communication
- Supports many devices

Disadvantages of ZigBee

- Low data rate
- Limited range
- Interference from other devices
- Complex network setup

5. Social Networks:-

- **Social networks** show how people are connected to each other, like friends, family, or coworkers. These connections are drawn as dots (people) and lines (relationships), which together form a kind of map called a **Sociogram**.
- All these connections can be organized in a table called a **Sociomatrix**, which helps store and study who is connected to whom.
- **Social Network Analysis (SNA)** means studying these connections using math and graphs. It helps us understand how groups or people interact, share information, or influence each other. Special tools are used to look at these networks and find important patterns or relationships.

Benefits of Social Networks

- **Enhanced Communication:** Enables easy and instant interaction across distances.
- **Information Sharing:** Facilitates quick spread of news, ideas, and knowledge.
- **Networking Opportunities:** Helps in building personal and professional connections.
- **Collaboration:** Supports teamwork and collective problem-solving.
- **Support Systems:** Provides social and emotional support through communities.

Graph Properties of Social Networks

- **Nodes:** Represent individuals or entities in the network.
- **Edges:** Represent relationships or connections between nodes.
- **Degree:** The number of connections a node has.
- **Path:** A sequence of edges connecting two nodes.
- **Clustering Coefficient:** Measures how connected a node's neighbors are to each other.
- **Centrality:** Indicates the importance of a node based on its position in the network.
- **Density:** The ratio of actual connections to possible connections in the network.

A. Social Networking Site: Twitter

1. **Introduction**
   Twitter is a widely used social networking platform launched in 2006 that allows users to post short messages called **tweets** limited to 280 characters.

2. **Tweets**
   Tweets can include text, images, videos, links, and hashtags. They are the main form of communication on Twitter.

3. **Followers and Following**
   Users can **follow** others to see their tweets on their timeline and be followed by others to share their updates.

4. **Retweets and Likes**
   Users can **retweet** to share others' tweets with their followers and **like** tweets to show appreciation.

5. **Replies and Mentions**
   Twitter allows users to reply to tweets and mention other users by tagging their usernames using "@", enabling conversations and interactions.

6. **Hashtags and Trends**
   Hashtags (#) categorize tweets around topics or events, making it easier to search and participate in discussions. Trending topics highlight what's currently popular worldwide or regionally.

7. **User Profiles**
   Each user has a customizable profile displaying their tweets, profile picture, bio, location, website link, and followers/following counts.

8. **Direct Messaging (DM)**
   Twitter offers a private messaging feature where users can communicate one-on-one or in groups privately.

9. **Lists**
   Users can create or subscribe to lists—curated groups of Twitter accounts to organize content and follow specific interests.

10. **Spaces**
    Twitter Spaces allows live audio conversations, similar to a virtual room where users can speak or listen.

11. **Verification**
    Certain accounts receive a blue checkmark badge to indicate verified identity, often used by celebrities, brands, and public figures.

12. **Use Cases**
    Twitter is used for personal expression, marketing, customer service, news sharing, political communication, activism, and entertainment.

13. **Real-Time News and Events**
    It is a major platform for breaking news and live event updates, often faster than traditional media.

14. **Global and Public Platform**
    Most tweets are public, allowing users worldwide to access and interact with content, enhancing global communication.

15. **Limitations and Challenges**
    The 280-character limit encourages brevity but can restrict detailed explanations. It also faces issues with misinformation, harassment, and privacy concerns.

B. Social Networking Site: Facebook

1. **Introduction**
   Facebook is a popular social networking platform launched in 2004 that allows users to connect, share, and communicate with friends, family, and communities online.

2. **User Profiles**
   Users create personal profiles including photos, bio, education, work, and interests to share information about themselves.

3. **Friend Connections**
   Users send and accept friend requests to build their network and interact with friends' posts, photos, and updates.

4. **News Feed**
   The News Feed shows a continuously updated list of posts, photos, videos, and links shared by friends, pages, and groups users follow.

5. **Posts and Sharing**
   Users can post text updates, photos, videos, links, and check-ins. They can also like, comment on, and share posts to spread content.

6. **Groups and Pages**
   Facebook allows users to create or join groups based on interests, hobbies, or causes, and to follow pages of businesses, celebrities, or organizations.

7. **Messaging**
   Facebook Messenger is an integrated feature for private messaging, voice calls, and video calls with friends and contacts.

8. **Events**
   Users can create, invite, and RSVP to events, making it easier to organize social gatherings and meetings.

9. **Marketplace**
   Facebook Marketplace enables users to buy and sell goods locally, providing a platform for e-commerce.

10. **Privacy Controls**
    Users can control who sees their posts and personal information through privacy settings, choosing from public, friends, or custom groups.

11. **Notifications**
    Facebook sends notifications about new friend requests, messages, comments, likes, and other activities to keep users informed.

12. **Advertising and Business Use**
    Businesses use Facebook for targeted advertising, brand promotion, customer engagement, and analytics.

13. **Live Streaming**
    Facebook Live allows users and pages to broadcast live videos to their audience in real-time.

14. **Security and Challenges**
    Facebook faces challenges like misinformation, fake accounts, data privacy concerns, and content moderation issues.

15. **Global Reach**
    Facebook connects billions of users worldwide, making it one of the largest social networking platforms with diverse cultural and social communities.

Social Networking in Facebook / Twitter:-

1. **Building Connections**
   Facebook allows users to connect with friends, family, colleagues, and new people by sending and accepting friend requests.

2. **Profile Sharing**
   Users create profiles where they share personal information, photos, interests, and updates to express themselves and stay connected.

3. **News Feed Interaction**
   The News Feed displays posts, photos, and videos from friends and pages, enabling users to like, comment, and share content to interact socially.

4. **Groups and Communities**
   Facebook groups bring people with similar interests together, fostering discussions, support, and collaboration.

5. **Messaging and Communication**
   Through Facebook Messenger, users can chat privately, make voice and video calls, enhancing one-on-one or group communication.

6. **Events and Invitations**
   Users can create and invite others to events, making it easier to organize social gatherings and maintain relationships.

7. **Sharing Life Moments**
   Facebook encourages sharing of life events, achievements, and everyday moments, strengthening social bonds.

8. **Pages and Following**
   Users can follow public pages of celebrities, brands, or causes, joining larger social conversations beyond their immediate circle.

9. **Real-Time Interaction**
   Features like Facebook Live enable users to broadcast and interact in real-time with friends and followers.

10. **Social Support and Networking**
    Facebook provides a platform for emotional support, advice, and networking opportunities for personal and professional growth.

6. What is a Cloudlet?

A **Cloudlet** is a small-scale cloud data center located at the edge of the Internet, closer to the end user. It provides **low-latency computing services** by bringing processing power near to the mobile devices or IoT devices.

Cloudlets act as intermediaries between mobile users and large cloud data centers, helping to offload compute-intensive tasks like augmented reality, real-time analytics, and video processing.

They are especially useful in **mobile edge computing** where speed, low latency, and localized processing are important.

Feature	Cloud	Cloudlet
Definition	Centralized computing system providing resources over the Internet	Mini cloud data center located near the user or at the network edge
Location	Far from the end user (usually at centralized data centers)	Close to the end user, often within local networks
Latency	Higher latency due to distance and congestion	Low latency due to proximity
Scalability	Highly scalable with vast computing resources	Limited scalability with smaller infrastructure
Use Case	Suitable for general-purpose, large-scale applications	Ideal for mobile, IoT, and latency-sensitive applications
Deployment Cost	High (due to data centers, cooling, power, etc.)	Relatively low (smaller infrastructure and localized deployment)
Internet Dependency	Heavily depends on stable Internet connectivity	Can function locally with intermittent or no Internet
Example Applications	Web hosting, big data, enterprise services	Augmented reality, real-time analytics, autonomous vehicles

7. Explain:-

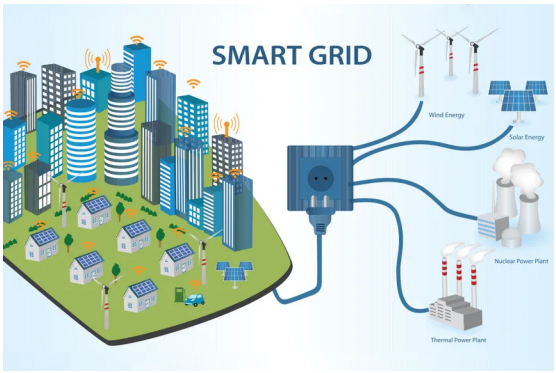
i) Smart Power Grid:

A **Smart Power Grid** is an advanced electrical grid system that uses **digital communication technologies, sensors, automation, and real-time data analysis** to efficiently generate, transmit, distribute, and consume electricity.

Unlike the traditional grid, which is one-way (from power plant to consumer), the smart grid enables **two-way communication** between the utility and consumers.

It helps improve energy efficiency, reduce outages, integrate renewable energy sources (like solar and wind), detect faults quickly, and enable users to monitor and manage their energy usage.

Key Features of Smart Power Grid



- Real-time monitoring and control
- Automatic fault detection and self-healing
- Integration of renewable energy sources
- Advanced metering infrastructure (smart meters)
- Demand-side management (user control over usage)
- Improved reliability, security, and energy efficiency

Components in the Diagram

1. **Power Sources** – Includes both traditional (coal, hydro) and renewable (solar, wind).
2. **Power Generation** – Produces electrical energy.
3. **Transmission Lines/Substations** – High-voltage lines for long-distance power transport.
4. **Distribution Network** – Delivers electricity to homes, industries, and businesses.
5. **Smart Meters** – Measure and report real-time power usage to users and the utility.
6. **Control Center** – Processes data, controls the grid, detects faults, and manages resources.
7. **Consumers** – Residential, commercial, and industrial users who also act as **prosumers** (producers + consumers).

ii) Inventory Management:-

IoT helps in **automating and optimizing inventory control** in warehouses and stores. Smart sensors, RFID tags, and IoT-based scanners are used to:

- Track the **location and quantity** of goods in real-time.
- Send alerts when stock is low or when there's **unauthorized movement** of items.
- Improve **accuracy and reduce human error** in managing inventory.
- Enable **automatic reordering** by integrating with supply systems.

Example: A retail store uses smart shelves with weight sensors to detect when a product is running out and notifies the manager or automatically places a new order.

iii) Route Generation & Scheduling

IoT is used in logistics and transportation to generate **efficient routes** and manage **delivery schedules** in real-time. With the help of GPS, traffic sensors, and connected devices:

- Vehicles can get **optimal routes** based on traffic, weather, or road conditions.
- Companies can monitor delivery vehicles and **adjust schedules dynamically**.
- Reduces **fuel consumption, delivery time**, and improves customer satisfaction.
- Prevents delays through **predictive maintenance** and real-time alerts.

Example: A delivery service uses IoT devices in trucks to monitor routes and reroute them in real time to avoid traffic jams or roadblocks.

iv) Cyber-Physical System (CPS):-

- A **Cyber-Physical System (CPS)** is a smart system that integrates **computational (cyber) components** with **physical processes**.
- These systems are connected through a **network** and are capable of **monitoring, controlling, and interacting** with the physical world using real-time data.
- In simple terms, CPS is where the **digital world (software, computation, and communication)** meets the **physical world (machines, sensors, devices, etc.)**.

Key Components of CPS:

1. **Sensors and Actuators**
    - **Sensors** collect data from the physical environment (e.g., temperature, motion, pressure).

- **Actuators** perform actions based on decisions (e.g., moving a robotic arm, opening a valve).

2. **Embedded Systems / Controllers**
   - These are small computers that process sensor data and control actuators.
   - They contain the **logic and decision-making capabilities**.
3. **Communication Networks**
   - Ensure **data exchange** between devices, systems, and cloud platforms.
   - Can use wired or wireless technologies like Wi-Fi, Bluetooth, ZigBee, etc.
4. **Computational Unit / Cloud System**
   - High-level data processing, storage, analytics, and decision-making.
   - Sometimes uses **AI or machine learning** to enhance performance.
5. **Human-Machine Interface (HMI)**
   - Allows users to interact with the system (e.g., dashboards, alerts, manual controls).

Working of Cyber-Physical System:

1. **Sensing:** Sensors collect data from the physical environment (e.g., speed, temperature).
2. **Computation:** Data is processed in embedded systems or cloud platforms to make decisions.
3. **Control:** Actuators act based on the processed data (e.g., slow down a motor, adjust temperature).
4. **Feedback Loop:** The system continuously monitors and adjusts its operations to maintain optimal performance.

Examples of Cyber-Physical Systems:

- **Smart Grids** – Optimize energy distribution and usage using real-time data.
- **Autonomous Vehicles** – Use sensors, AI, and controls to drive safely without human input.
- **Industrial Automation** – Robots and machines that adapt based on sensor feedback.
- **Smart Homes** – Devices like thermostats, lights, and alarms that respond to conditions and user behavior.
- **Healthcare Devices** – Wearables that monitor health and adjust medication or alert doctors.

8. GPS (Global Positioning System):-

GPS stands for **Global Positioning System**. It is a **satellite-based navigation system** that allows a GPS receiver to determine its **exact location (latitude, longitude, and altitude)** anywhere on Earth, **24/7**, and under any weather conditions.

Main Components of GPS:

1. **Space Segment (Satellites):**
    - About **24–32 satellites** orbit the Earth.
    - They continuously transmit signals containing their location and time.
2. **Control Segment (Ground Stations):**
    - Located around the world.
    - Monitor and control satellite operations, ensuring accuracy and proper functioning.
3. **User Segment (Receivers):**
    - Devices like smartphones, GPS trackers, cars, etc.
    - Receive signals from satellites to calculate the user's exact position using **triangulation**.

How GPS Works:

1. A GPS receiver picks up signals from at least **4 satellites**.
2. It measures the **time delay** from each signal to calculate the distance from each satellite.
3. Using **triangulation**, it determines the precise position of the user on Earth.

Applications of GPS:

- **Navigation**: For cars, ships, airplanes, and pedestrians.
- **Mapping**: Creating and updating digital maps.
- **Tracking**: Real-time vehicle and asset tracking.
- **Surveying**: Precise land measurements.
- **Agriculture**: For precision farming.
- **Emergency Services**: Location tracking for rescue and disaster response.

Advantages of GPS:

- Works **anywhere** on Earth, 24/7.
- Provides **accurate** positioning.
- Free to use for civilians.
- Useful in **real-time navigation and tracking**.

Limitations:

- Signals may be weak in **indoor or underground** locations.
- Accuracy may drop in areas with **tall buildings (urban canyons)** or **dense trees**.
- Can be affected by **weather conditions** or **atmospheric disturbances**.

9. Supply Chain Management (SCM):

- Supply Chain Management (SCM) is the process of planning, managing, and controlling the flow of goods, services, information, and finances from raw material suppliers to the final customer.
- It ensures that the right product reaches the right place at the right time, in the most efficient and cost-effective way.

Key Components of Supply Chain:

1. **Suppliers** – Provide raw materials needed for production.
2. **Manufacturers** – Convert raw materials into finished goods.
3. **Warehouses** – Store products before they are shipped to retailers/customers.
4. **Distributors** – Transport goods from manufacturers to retailers.
5. **Retailers** – Sell products to end consumers.
6. **Customers** – Final users of the product or service.

Main Functions of SCM:

1. **Procurement** – Sourcing raw materials and services.
2. **Production** – Manufacturing the product efficiently.
3. **Inventory Management** – Keeping the right stock at the right level.
4. **Logistics** – Transportation and delivery of goods.

5. **Information Flow** – Sharing real-time data among all partners.
6. **Customer Service** – Ensuring customer satisfaction.

🔷 Benefits of Supply Chain Management:

- Reduces **costs** and **waste**.
- Improves **efficiency** and **productivity**.
- Enables **faster delivery** and **real-time tracking**.
- Increases **customer satisfaction**.
- Supports **data-driven decisions** using IoT and analytics.

🔷 Technologies Used in SCM:

- **IoT** – Real-time tracking of goods.
- **RFID** – Automated inventory tracking.
- **Big Data Analytics** – Forecasting demand and managing supply.
- **AI & Machine Learning** – Smart logistics and route planning.
- **Cloud Computing** – Centralized data access and coordination.