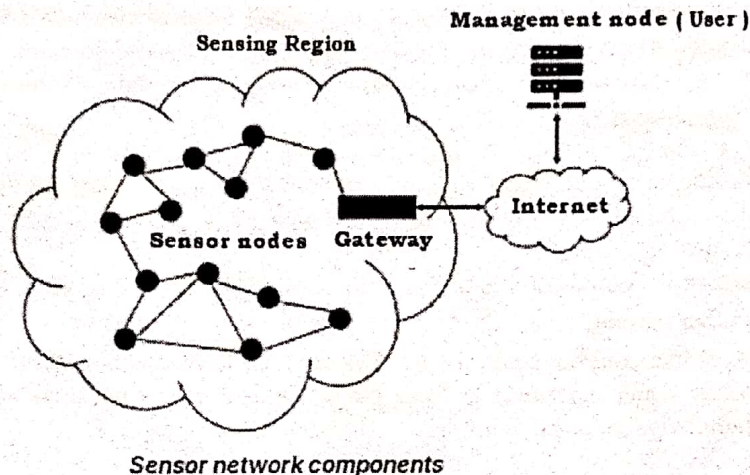


UNIT - II

Sensors Networks

Q. Types of Sensors

Sensor network : A sensor network is a group of sensors where each sensor monitors data in a different location and sends that data to a central location for storage, viewing, and analysis. There are many applications for sensor networks, from monitoring a single home, to the surveillance of a large city, to earthquake detection for the whole world.



Types of Sensors

- 1) **Temperature sensors:** Temperature sensors are a type of device used to measure temperature. They allow us to accurately monitor and record changes in temperature over time, which is critical for many industries including manufacturing processes, food storage, medical applications and more.

Use cases of temperature sensors:

- Controlling AC temperature or refrigerator cooling with temperature sensors.
- Monitoring air and water temperature in smart buildings or smart thermostats.
- Checking rise or fall in temperature of food storage areas in the food industry.
- Real-time monitoring of soil temperature and instant alerts are sent to farmers in agriculture.

- 2) **Pressure Sensors :** Pressure sensors are important sensors of IoT that help in measuring and monitoring of high and low-pressure levels in any environment. Pressure sensors provide accurate information in a variety of applications, including dangerous ones like drilling for crude oil. They are also used in advanced equipment like medical devices.

Use cases of pressure sensors:

- Identify leak detection in plumbing systems
- Measure altitude and airspeed in aircraft for smooth navigation and ensure safe flight operations.

3) Accelerometers

Accelerometers measure acceleration — the change in speed, direction and intensity of movement.

- Accelerometers are used to collect data from connected devices such as wearables, medical alert devices, cameras and cars to track activity.
- Tablets and smartphones also rely on accelerometers to know when to rotate displays based on the device's physical orientation.

- 4) **Air Quality Sensors :** Air quality sensors measure levels of pollution, carbon dioxide and other particulates in the air, then transmit their findings to the cloud.

5) Biomedical Sensors

Biomedical sensors measure a person's vital signs, like heart rate and oxygen level.

- Wearable devices like smart watches and arm bands can be equipped with biomedical sensors.
- These devices communicate the data they collect back to the wearer so they can monitor their own health.

6) Flow Sensors

Flow sensors measure how quickly a liquid or gas flows past a certain point in a tube or pipe. A flow rate that's too fast or too slow could indicate a problem, like a leak.

- Cities typically use flow sensors to help manage water systems and detect leaks.

7) **Humidity Sensors** : Humidity sensors monitor humidity, or the amount of water vapor in the air. These sensors are often used in smart building management and industrial settings to better manage comfort and energy use.

8) **Light Sensors** : Light sensors are used in smartphones to automatically adjust a screen's brightness according to a user's surroundings, as well as in cars to turn the headlights on or off depending on the time of day. Light sensors can also work in tandem with motion sensors to support home security systems.

9) **Vibration Sensors** : Vibration sensors pick up vibrations, recording their frequency, velocity, amplitude and other variables.

10) **Alcohol sensors**: as the name suggests it detects alcohol. Usually, alcohol sensors are used in breathalyzer devices, which determine whether the person is drunk or not. Law enforcement personnel uses breathalyzers to catch drunk-and-drive culprits.

11) Level Sensors

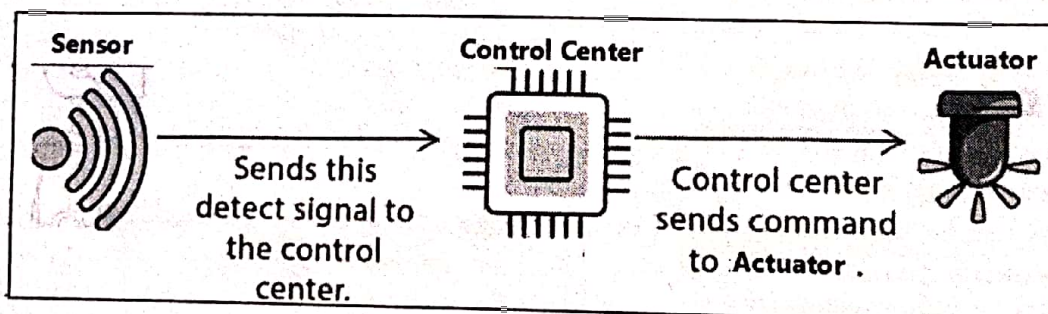
The sensors work by detecting and responding to changing levels of various things, such as liquid, solid, or granular substances within a container, tank

- Used in washing machines, dishwashers, and coffee makers to auto-control water levels.
- Enable environmental monitoring equipment to measure groundwater levels and river levels.

Q . Types of Actuators

An actuator is a device that converts energy into motion. It does this by taking an electrical signal and combining it with an energy source. In IoT, an actuator is responsible for the physical movement of an object. It can be a device that can move things and is powered using different sources such as the battery, electric, or manually-generated energy.

While an **actuator turns** an electrical signal into a **physical action**, a **sensor converts** a physical attribute into an **electrical signal**. The control system can be simple (fixed mechanical or electric system), software based (e.g. a printer driver, robot control system), a human or any other input.



Types of actuators in IoT

1) Hydraulic Actuator

- ✓ This actuator converts mechanical motion into linear, rotary or oscillatory motion.
- ✓ The hydraulic actuator consists of cylinder or fluid motor which uses hydraulic power to help mechanical operation.

- ✓ Liquids are nearly impossible to compress, hydraulic actuator maintains considerable force.
Limited acceleration of actuator restricts its usage.
Example: Hydraulic brake in vehicle

2) Pneumatic Actuator

- ✓ This actuator converts energy formed by vacuum or compressed air at high pressure into linear or rotary motion.
- ✓ They are responsible to convert pressure into force.

Examples:

- Rack and Pinion actuators used for valve controls of pipes
- Pneumatic brakes are very responsive to small pressure changes applied by the driver.

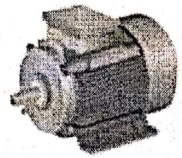
3) Electrical Actuator

- ✓ It is powered by motor which converts electrical energy into mechanical torque.
- ✓ Electrical energy is used to actuate equipments (e.g. solenoid valves) which control water flow in pipes with response to electrical signals.

Advantages: cheap, clean, speedy type of actuator.

Examples: Solenoid based electric bell ringing mechanism

Electric Motor



4) Mechanical Actuator

- ✓ It converts rotary motion into linear motion.
- ✓ It consists of gears, pulleys, rails, chains and other devices for its operation.

Examples: Rack and pinion mechanism and Crank shaft

5) Thermal Actuator

- ✓ This actuator can be actuated by application of thermal or magnetic energy.
- ✓ This actuator uses shape memory materials E.g. shape memory alloys

Advantages: Compact, light in weight, economical, offers high power density

Examples: Thermal actuator is thermostat, magnetic actuator is electro magnet

6) Smart Actuators

Function: Incorporate built-in intelligence for real-time monitoring and adaptive control.

Examples: AI-integrated robotic arms.

Applications: Industrial IoT (IIoT), autonomous systems, and smart infrastructure.

7) Micro Actuators : Purpose: Tiny actuators specifically engineered for applications at the microscale.

Ex: MEMS (Microelectromechanical Systems) actuators.

Applications: Wearable IoT devices, biomedical applications, and nanotechnology.

8) Stepper Motors: Provide precise control of angular position through discrete steps.

Ex: Camera focus adjusters, 3D printers.

Applications: Robotics, smart cameras, and automated machinery.

9) Servo Actuators

Function: Provide precise motion control using feedback systems.

Ex: Servo motors in robotic arms.

Applications: Autonomous vehicles, robotics, and drones.

10) Rotary Actuators : Rotary actuators can move a component in a circular direction. They convert energy into rotary or oscillatory movements.

Applications

- Rotary actuators are used in the field of aerospace to convert high-speed, low-torque rotary motion, through a gear train, into low-speed and high-torque motion.

Q . Examples and Working

Actuators are devices that convert electrical, hydraulic, or pneumatic energy into mechanical motion or force. They are essential components in many machines and systems that require controlled movement. Examples include electric motors, hydraulic cylinders, and pneumatic actuators.

Actuators Work: Actuators typically convert an input signal (like an electrical current, hydraulic pressure, or compressed air) into mechanical motion or force. The specific mechanism of how they work varies depending on the type of actuator.

Examples of Actuators in Action:

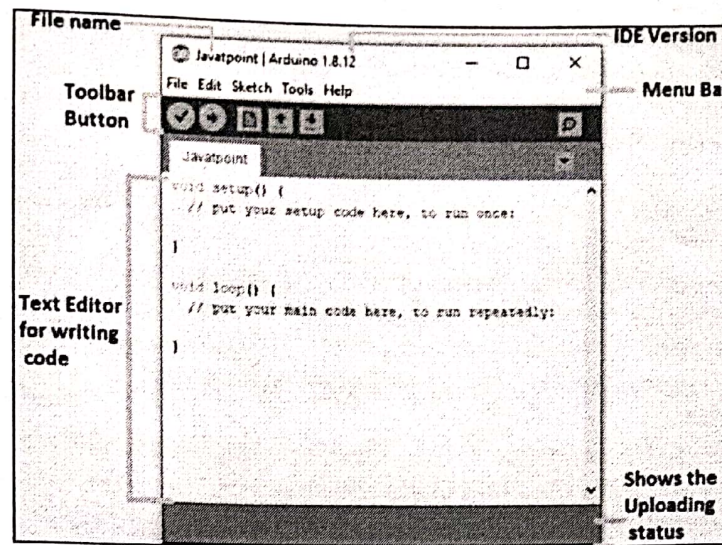
- **Electric motors:** Used in robotics, industrial automation, and automotive systems to control movement.
- **Hydraulic cylinders:** Used in heavy machinery and industrial automation for lifting and pushing heavy loads.
- **Pneumatic cylinders:** Used in manufacturing and automation for controlled movement and gripping.
- **Stepper motors:** Used in robotics, 3D printers, and industrial equipment for precise and controlled movements.
- **Solenoids:** Used in door locks, valves, and starter motors for simple push-pull actions.
- **Piezoelectric actuators:** Used in high-precision applications like micro-positioning and advanced sensors.
- **Thermal actuators:** Used in temperature control systems and various automation applications.

Applications of Actuators:

- ✓ **Robotics:** For controlling movement and manipulation of robots.
- ✓ **Industrial automation:** For automating processes and controlling machinery.
- ✓ **Automotive:** For controlling steering, braking, fuel injection, and other functions.
- ✓ **Household appliances:** For controlling functions in washing machines, dishwashers, and refrigerators.
- ✓ **Manufacturing:** For positioning, holding, machining, and assembling components.
- ✓ **Medical devices:** For controlling movement and manipulation in medical procedures.
- ✓ **Smart homes:** For automating functions like adjusting blinds, controlling lighting, and adjusting bed positions.

Q . Arduino IDE and Board Types

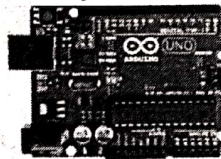
The Arduino IDE (Integrated Development Environment) is used to write the computer code and upload this code to the physical board. The Arduino IDE is very simple and this simplicity is probably one of the main reason Arduino became so popular. We can certainly state that being compatible with the Arduino IDE is now one of the main requirements for a new microcontroller board. Over the years, many useful features have been added to the Arduino IDE and you can now managed third-party libraries and boards from the IDE, and still keep the simplicity of programming the board. The main window of the Arduino IDE is shown below.



Types of Arduino Boards

1) Arduino UNO

- ✓ Arduino UNO is based on an ATmega328P microcontroller. It is easy to use compared to other boards, such as the Arduino Mega board, etc.
- ✓ The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header.
- ✓ It is the most used and of standard form from the list of all available Arduino Boards. It is also recommended for beginners as it is easy to use.



2) Arduino Nano

- ✓ The Arduino Nano is a small Arduino board based on ATmega328P or ATmega628 Microcontroller. The connectivity is the same as the Arduino UNO board.
- ✓ The Nano board is defined as a sustainable, small, consistent, and flexible microcontroller board.
- ✓ It is small in size compared to the UNO board. The devices required to start our projects using the Arduino Nano board are Arduino IDE and mini USB.
- ✓ The Arduino Nano includes an I/O pin set of 14 digital pins and 8 analog pins. It also includes 6 Power pins and 2 Reset pins.

3) Arduino Mega

- ✓ The Arduino Mega is based on ATmega2560 Microcontroller. The ATmega2560 is an 8-bit microcontroller.
- ✓ We need a simple USB cable to connect to the computer and the AC to DC adapter or battery to get started with it. It has the advantage of working with more memory space.
- ✓ The Arduino Mega includes 54 I/O digital pins and 16 Analog Input/Output (I/O), ICSP header, a reset button, 4 UART (Universal Asynchronous Receiver/Transmitter) ports, USB connection, and a power jack.

4) Arduino Micro

- ✓ The Arduino Micro is based on the ATmega32U4 Microcontroller. It consists of 20 sets of pins. The 7 pins from the set are PWM (Pulse Width Modulation) pins, while 12 pins are analog input pins.
- ✓ The other components on board are reset button, 16MHz crystal oscillator, ICSP header, and a micro USB connection.

5) Arduino Leonardo

- ✓ The basic specification of the Arduino Leonardo is the same as the Arduino Micro. It is also based on ATmega32U4 Microcontroller.
- ✓ The components present on the board are 20 analog and digital pins, reset button, 16MHz crystal oscillator, ICSP header, and a micro USB connection.

6) Arduino Due

- ✓ The Arduino Due is based on the 32-bit ARM core. It is the first Arduino board that has developed based on the ARM Microcontroller.
- ✓ It consists of 54 Digital Input/Output pins and 12 Analog pins. The Microcontroller present on the board is the Atmel SAM3X8E ARM Cortex-M3 CPU.
- ✓ It has two ports, namely, native USB port and Programming port. The micro side of the USB cable should be attached to the programming port.

7) Arduino Shields

- ✓ The Arduino shields are the boards, which can be plugged on the top of the PCB. The shields further extend the potential of the PCB's.
- ✓ The production of shields is cheap. It is also easy to use. There are various types of Arduino shields that can be used for different purposes. For example, the Xbee shield.

8) Arduino Lilypad

- ✓ The Arduino LilyPad was initially created for wearable projects and e-textiles. It is based on the ATmega168 Microcontroller.
- ✓ The functionality of Lilypad is the same as other Arduino Boards. It is a round, light-weight board with a minimal number of components to keep the size of board small.
- ✓ The Arduino Lilypad board was designed by Sparkfun and Leah. It was developed by Leah Buechley. It has 9 digital I/O pins.

9) Arduino Bluetooth

- ✓ The Arduino Bluetooth board is based on ATmega168 Microcontroller. It is also named as **Arduino BT board**.
- ✓ The components present on the board are 16 digital pins, 6 analog pins, reset button, 16MHz crystal oscillator, ICSP header, and screw terminals. The screw terminals are used for power.
- ✓ The Arduino Bluetooth Microcontroller board can be programmed over the Bluetooth as a wireless connection.

10) Arduino Diecimila

- ✓ The Arduino Diecimila is also based on ATmeg628 Microcontroller. The board consists of 6 analog pin inputs, 14 digital Input/Output pins, a USB connector, a power jack, an ICSP (In-Circuit Serial Programming) header, and a reset button.
- ✓ We can connect the board to the computer using the USB, and can power-on the board with the help of AC to DC adapter.
- ✓ The Diecimila was initially developed to mark the 10000 delivered boards of Arduino. Here, Diecimila means 10,000 in Italian.

11) Arduino Robot

- ✓ The Arduino Robot is called as the tiny computer. It is widely used in robotics.
- ✓ The board comprises of the speaker, five-button, color screen, two motors, an SD card reader, a digital compass, two potentiometers, and five floor sensors.
- ✓ The Robot Library can be used to control the actuators and the sensors.

Arduino Board	Processor	Memory	Digital I/O	Analogue I/O
Arduino Uno	16Mhz ATmega328	2KB SRAM, 32KB flash	14	6 input, 0 output

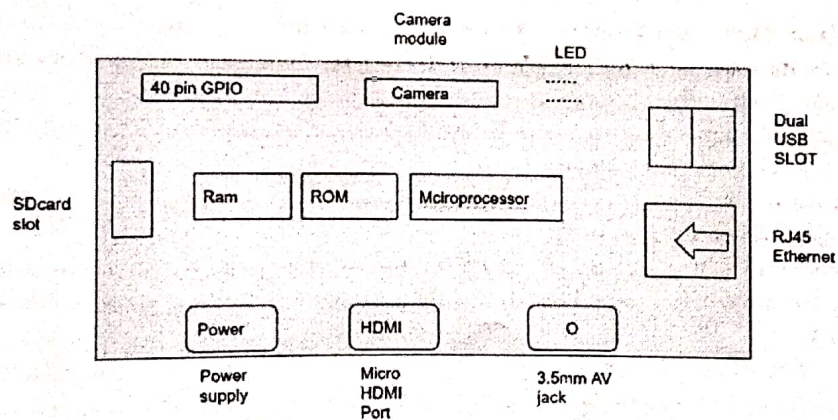
Arduino Due	84MHz AT91SAM3X8E	96KB SRAM, 512KB flash	54	12 input, 2 output
Arduino Mega	16MHz ATmega2560	8KB SRAM, 256KB flash	54	16 input, 0 output
Arduino Leonardo	16MHz ATmega32u4	2.5KB SRAM, 32KB flash	20	12 input, 0 output

Q . RaspberriPi Development Kit

Raspberry Pi is developed by Raspberry Pi Foundation in the United Kingdom. The Raspberry Pi is a powerful, low-cost device . The Raspberry Pi is an incredibly powerful, versatile and affordable tiny computer board that has helped to revolutionize the Internet of Things (IoT). With its robust processing capabilities, reliable connectivity options and low power consumption.

- Its small form factor allows for easy integration with other devices in IOT networks while also providing tremendous computing potential without overheating or using precious resources like energy.
- The original device had a single-core Processor speed of device ranges from 700 MHz to 1.2 GHz and a memory range from 256 MB to 1 GB RAM.
- **Used:** It also provides a set of general purpose input/output pins allowing you to control electronic components for physical computing and explore the Internet of Things (IoT).

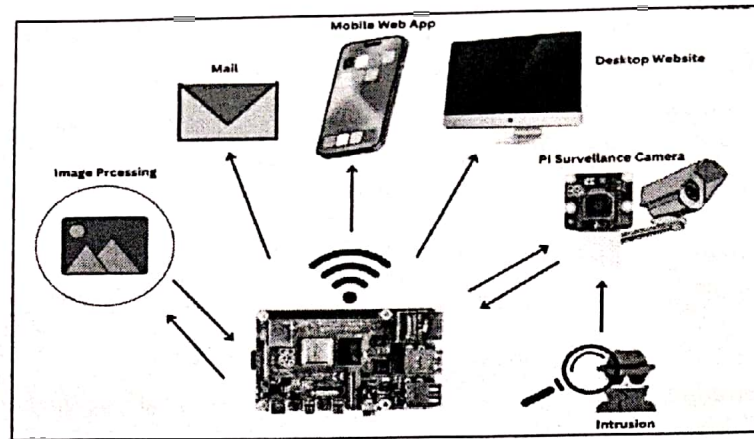
Raspberry pi Diagram :



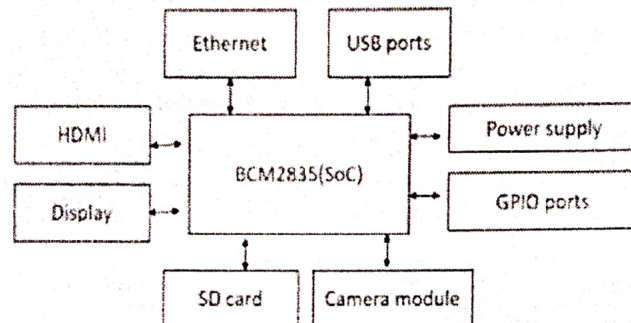
Raspberry Pi used in IoT :

The Raspberry Pi is a powerful tool for Internet of Things (IoT) applications. By connecting the small computing board to hardware components, it can collect and analyze data from various sensors in real-time.

The Raspberry Pi is the perfect platform for powering Internet of Things (IoT) devices. It's inexpensive, small in size, and extremely versatile. With built-in Bluetooth and Wi-Fi connectivity options, it can be easily integrated into almost any project or device without significant overhead infrastructure requirements.



Some main blocks of Raspberry Pi:



Processor: Raspberry Pi uses Broadcom BCM2835 system on chip which is an ARM processor and Video core Graphics Processing Unit (GPU). It is the heart of the Raspberry Pi which controls the operations of all the connected devices and handles all the required computations.

- 1) **HDMI:** High Definition Multimedia Interface is used for transmitting video or digital audio data to a computer monitor or to digital TV. This HDMI port helps Raspberry Pi to connect its signals to any digital device such as a monitor digital TV or display through an HDMI cable.
- 2) **GPIO ports:** General Purpose Input Output ports are available on Raspberry Pi which allows the user to interface various I/P devices.
- 3) **Audio output:** An audio connector is available for connecting audio output devices such as headphones and speakers.
- 4) **USB ports:** This is a common port available for various peripherals such as a mouse, keyboard, or any other I/P device. With the help of a USB port, the system can be expanded by connecting more peripherals.
- 5) **SD card:** The SD card slot is available on Raspberry Pi. An SD card with an operating system installed is required for booting the device.
- 6) **Ethernet:** The ethernet connector allows access to the wired network, it is available only on the model B of Raspberry Pi.
- 7) **Power supply:** A micro USB power connector is available onto which a 5V power supply can be connected.
- 8) **Camera module:** Camera Serial Interface (CSI) connects the Broadcom processor to the Pi camera.
- 9) **Display:** Display Serial Interface (DSI) is used for connecting LCD to Raspberry Pi using 15 15-pin ribbon cables. DSI provides a high-resolution display interface that is specifically used for sending video data.

Benefits of IoT in Raspberry Pi

- 1) **Increased efficiency:** IoT in Raspberry Pi can allow businesses to automate processes, giving them greater opportunities for optimization and increased performance.

- 2) **Cost savings:** Automated processes mean that machines not only work faster but also require less human intervention, leading to more cost-effective operations overall.
- 3) **Real time sensor tracking :** Through the implementation of sensors within a connected network you have direct visibility over all activities taking place onsite allowing immediate action if needed be applied .

Q . RFID Principles and Components

RFID (Radio Frequency Identification) is a wireless communication technology that uses radio waves to automatically identify tagged objects or things. It transmits data from an RFID tag to an RFID reader using an antenna, enabling accurate and real-time tracking.

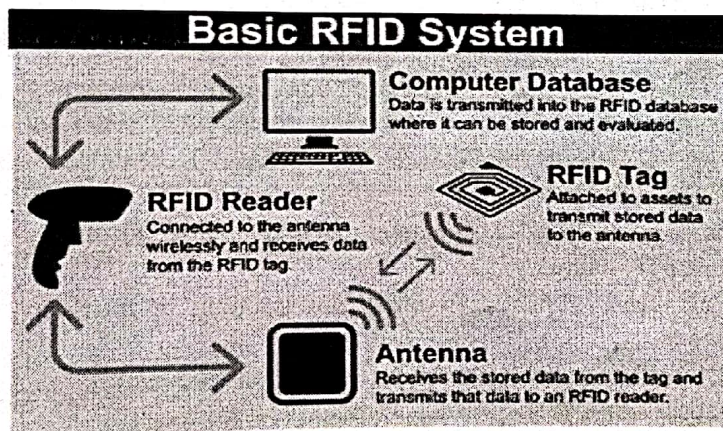
RFID technology is capable of storing, recovering, and re-recording a vast amount of data (up to four million characters and thousands of bytes) on a small chip and transmitting it through radio frequency or radio waves.

Ex :

Vehicle Tracking: RFID tags can be placed on vehicles such as cars, trucks, buses, and trains in order to track their location and movements. This information can be used for fleet management, traffic control, and security purposes.

The Principle of RFID

RFID is a "wireless communication technology", so its signals are transmitted without contact. A complete RFID system consists of three parts; electronic tags, readers (card readers), and application databases (back-end computers). Through wireless communication technology, the electronic tag transmits the data to the reader. The reader then transmits the data to the database, where it is processed and stored. Electronic tags and readers "identify" the electronic ID tag, and let the computer manage the corresponding information.



Types of RFID:

Depending upon the operational frequency, there are mainly three types of RFID systems. They are:

- 1) **Low Frequency (LF) RFID:** The range of operational frequency in the LF RFID system is 30 KHZ-300 KHZ. There is a short reading range (about 10 cm) and slow reading speed in this frequency range. Mostly, the LF RFID system is used in the application of access control and animal control.
- 2) **High Frequency (HF) RFID:** The range of operational frequency in an HF RFID system is 3 MHZ – 30 MHZ. HF RFID systems are Mostly commonly used in ticketing, payments, and data transfer applications.

- 3) **Ultra High Frequency (UHF) RFID:** The range of operational frequency in the UHF RFID system is 300 MHz – 3 GHz. UHF is used for very high data transmission rate. Most RFID projects currently use the UHF RFID systems and hence making it the fastest-growing market segment.

Components of RFID

1. RFID Tag

RFID tags are small devices that consist of an electronic microchip embedded inside and an antenna. The microchip has the unique identification number of the RFID tag.

Types of Tags

- a) **Passive Tags:** Does not have a power source, uses power from the reader to operate.
- b) **Battery-Assisted Passive Tags:** The logic circuit chip uses battery power. Need RF signals from the reader to activate and function.
- c) **Active Tags:** Uses a power source like a battery and does not require power from the source/reader.

2. Antenna

This is a device that transmits and receives radio waves between the RFID tag and reader. It can be integrated into the RFID tag or reader, or it can be a separate component.

1. **RFID Reader :** The RFID reader is one of the significant hardware components in the RFID system, which reads information from the RFID devices/tags and connects to the network to transfer the information to the database.
2. **Software :** RFID technology uses specific software depending on service providers. This software controls the RFID reader, initiates a scan, retrieves information from the tags, and stores the information on a local computer or sends it to the cloud storage.

Applications of RFID in IoT

- RFID tags are useful in cameras, GPS, and other smart sensors when utilised in the IoT. They can help with identifying and locating items. It's a low-cost approach to make household items seem "smart", as many companies are now entering the smart home market.
- **Healthcare:** Used for patient tracking, equipment management, and ensuring the authenticity of medications.
- **Asset Tracking:** Companies can monitor their assets' location and status, preventing loss and optimizing utilization.
- **Supply Chain Management:** Enhances visibility and accuracy in tracking products throughout the supply chain.
- **Access Control:** Used in security systems for granting or restricting access to buildings, rooms, or devices.
- **Retail:** Enables efficient stock management, theft prevention, and improved customer experience through smart shelves and automated checkouts.

Q . Wireless Sensor Networks: History and Context

- 1) To understand the tradeoffs in today's WSNs, it is helpful to briefly examine their history. Like many advanced technologies, the origin of WSNs can be seen in military and heavy industrial applications, far removed from the light industrial and consumer WSN applications that are prevalent today.
- 2) The first wireless network that bore any real resemblance to a modern WSN is the Sound Surveillance System (SOSUS), developed by the United States Military in the 1950s to detect and track Soviet submarines.

- 3) This network used submerged acoustic sensors – hydrophones – distributed in the Atlantic and Pacific oceans. This sensing technology is still in service today, albeit serving more peaceful functions of monitoring undersea wildlife and volcanic activity.
- 4) Echoing the investments made in the 1960s and 1970s to develop the hardware for today's Internet, the United States Defense Advanced Research Projects Agency (DARPA) started the Distributed Sensor Network (DSN) program in 1980 to formally explore the challenges in implementing distributed/wireless sensor networks.
- 5) With the birth of DSN and its progression into academia through partnering universities such as Carnegie Mellon University and the Massachusetts Institute of Technology Lincoln Labs, WSN technology soon found a home in academia and civilian scientific research.
- 6) Governments and universities eventually began using WSNs in applications such as air quality monitoring, forest fire detection, natural disaster prevention, weather stations and structural monitoring.
- 7) Then as engineering students made their way into the corporate world of technology giants of the day, such as IBM and Bell Labs, they began promoting the use of WSNs in heavy industrial applications such as power distribution, waste-water treatment and specialized factory automation.

WSN Technology Transitions Although the technology for large-volume industrial and consumer applications did not exist in the 20th century, both academia and industry recognized the potential for such networks and formed joint efforts to solve the engineering challenges. Examples of these academic/industrial initiatives include:

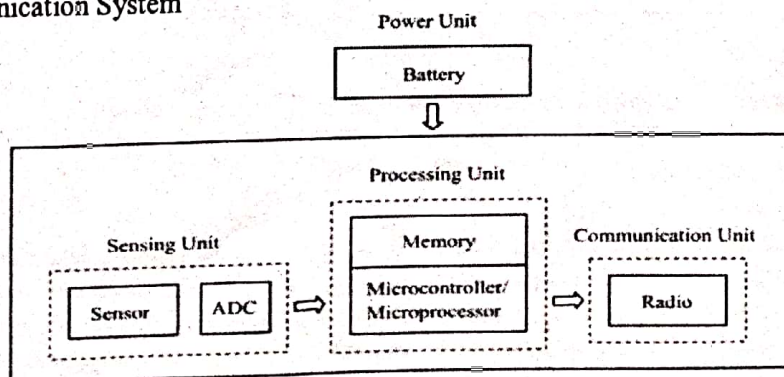
- UCLA Wireless Integrated Network Sensors (1993)
- University of California at Berkeley PicoRadio program (1999)
- μ Adaptive Multi-domain Power Aware Sensors program at MIT (2000)
- NASA Sensor Webs (2001)
- ZigBee Alliance (2002)
- Center for Embedded Network Sensing (2002)

Q. The node

In sensor networks, a node is a fundamental, autonomous device that gathers data from the physical world, processes it, and transmits it wirelessly. These devices are typically small, self-contained, and equipped with one or more sensors, along with communication and processing capabilities.

Sensor Node : A Sensor Node in a WSN consists of four basic components. They are:

- ✓ Power Supply
- ✓ Sensor
- ✓ Processing Unit
- ✓ Communication System



The sensor collects the analogue data from the physical world and an ADC converts this data to digital data. The main processing unit, which is usually a microprocessor or a microcontroller, performs intelligent data processing and manipulation.

A communication system consists of a radio system, usually a short-range radio, for data transmission and reception. As all the components are low-power devices, a small battery like CR-2032, is used to power the entire system.

Key characteristics of a sensor node:

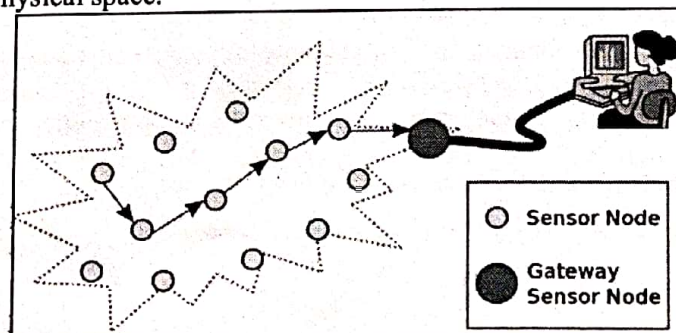
- **Data Acquisition:** Equipped with sensors to detect environmental parameters like temperature, humidity, or pressure.
- **Data Processing:** Processes the data collected by the sensors, potentially performing calculations or filtering.
- **Wireless Communication:** Transmits data wirelessly to other nodes or a central base station.
- **Power Source:** Often battery-powered, requiring energy efficiency.
- **Miniaturization:** Designed for compact size and weight, enabling deployment in various locations.

Applications:

- ✓ **Environmental Monitoring:** Tracking pollution levels, weather patterns, or air quality.
- ✓ **Smart Agriculture:** Monitoring soil conditions, crop health, and water usage.
- ✓ **Industrial Automation:** Tracking machine performance, detecting faults, or controlling processes.
- ✓ **Smart Cities:** Monitoring traffic flow, pollution levels, or energy consumption.

Q . Connecting nodes

A Wireless Sensor Network (WSN) is a network of interconnected sensor nodes that communicate with each other wirelessly to collectively gather and transmit data from their surrounding environment. These sensor nodes are equipped with various types of sensors, processing capabilities, and wireless communication modules, allowing them to monitor, collect, and transmit data from different points in a physical space.



Elements of WSN

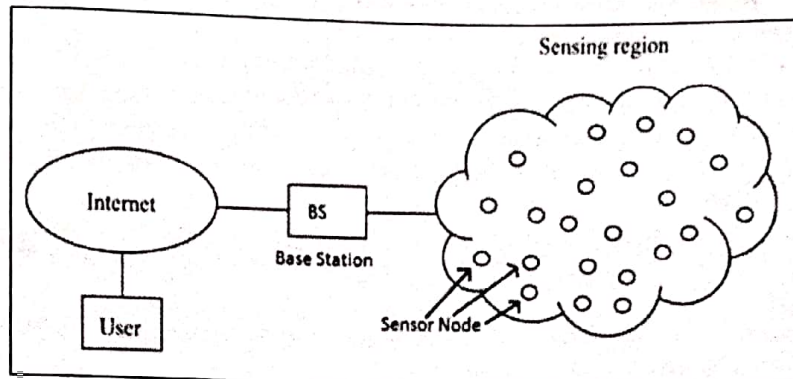
A typical wireless sensor network is made up of two parts. They are as follows:

- ✓ Sensor Node
- ✓ Network Architecture

Network Architecture

The networking of these sensor nodes is requirements is to ensure when a large number of sensor nodes are put in a broad region to cooperatively monitor a physical environment. A sensor node in a WSN uses wireless communication to connect not only with other sensor nodes but also with a Base Station. The base station delivers orders to the sensor nodes, and the sensor nodes collaborate to

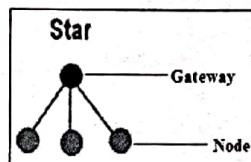
complete the task. The sensor nodes relay the data back to the base station after gathering the required information.



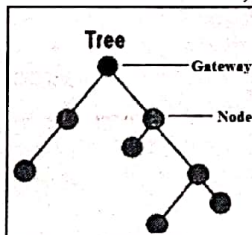
Network Topologies in WSN

A few alternative network topologies utilized in WSNs are listed below.

Star Topology : Every node in the network is connected to a single central node, known as a hub or switch, in a star architecture.

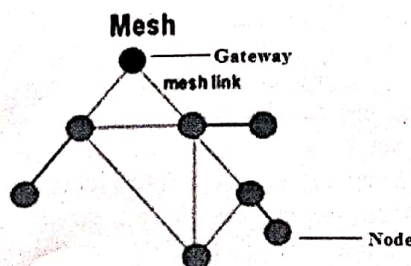


Tree Topology : A tree topology is a hierarchical network in which the top node is a single root node, which is connected to numerous nodes at the next level, and so on.



Mesh Topology : In a mesh topology, apart from transmitting its own data, each node also acts as a relay for transmitting data of other connected nodes. Fully Connected Mesh and Partially Connected Mesh were the two types of mesh topology.

Therefore, each node is connected to every other node in fully connected mesh topology. In partially connected mesh topology, a node is connected one or more neighboring nodes.



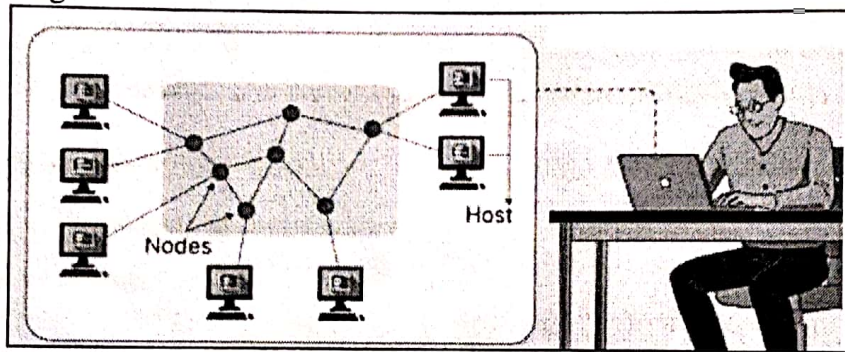
Key characteristics of wireless sensor networks include:

1. **Sensor Nodes:** Sensor nodes are small, autonomous devices equipped with sensors that can measure physical parameters such as temperature, humidity, pressure, light, motion, sound, and more.

2. **Wireless Communication:** Sensor nodes communicate with each other using wireless communication technologies, such as radio frequency (RF) communication. This enables data transmission without the need for physical wired connections.
3. **Ad Hoc Network:** WSNs are typically ad hoc networks, meaning that nodes can self-organize and form a network without the need for a centralized infrastructure or pre-existing network infrastructure.
4. **Data Collection:** Sensor nodes continuously collect data from their environment based on the sensors they are equipped with. The collected data can provide insights into various phenomena and conditions in the environment.
5. **Data Fusion:** Data fusion or data aggregation is a process in which data collected from multiple sensor nodes are combined, processed, and summarized to provide more accurate and comprehensive information.
6. **Distributed Processing:** Sensor nodes often have limited processing capabilities, so data processing and analysis are typically distributed across the network.

Q . Networking Nodes

In networking, a node is any device that is connected to a network and is capable of sending or receiving data. In networking, a node is any device that is connected to a network and is capable of sending or receiving data.



Some common examples of network nodes include:

- ✓ Computers
- ✓ Servers
- ✓ Routers
- ✓ Switches
- ✓ Access Points

Nodes play an important role in networking because they are the building blocks of a network. Hence, understanding the working of nodes becomes crucial for setting up and maintaining a network. Network administrators also need to understand how nodes interact and how data is transmitted across the network in order to identify and troubleshoot problems that occur on the network.

Types of Nodes in Networking

- **End Nodes:** These nodes are the devices that are located at the edges of a network and allow users to access the network. Some examples of end nodes are desktops, laptops, smartphones, tablets, and other devices that connect to the network to send and receive data.
- **Intermediary Nodes:** These nodes are devices that are located between end nodes and facilitate communication between them. Some examples of intermediary nodes are routers, switches, and access points. The main objective of these types of nodes is to direct traffic between end nodes while ensuring that data is sent to the correct destination.
- **Data communications nodes:** These nodes are the devices that transmit data over a network. Some examples of data communication nodes are modems, switches, and routers. The main objective of this type of node is to encode, decode, and direct data packets to their intended destinations.

- **Telecommunication nodes:** These nodes are the devices that transmit voice and data signals over a telecommunications network. Some examples of telecommunication nodes are cell towers, telephone exchanges, and satellite stations. The main objective of this type of node is to maintain the connection between end users and facilitate communication between them.
- **Cable TV network nodes:** These nodes are the devices that transmit television signals over a cable network. Some examples of cable TV network nodes are cable modems, set-top boxes, and headend equipment. The main objective of this type of node is to decode television signals and distribute them to end users.
- **Distributed network nodes:** These types of nodes are used in a distributed network architecture, where data processing and storage are distributed across multiple nodes. Some examples of distributed network nodes are peer-to-peer networks and blockchain networks. The main objective of this type of node is to ensure that data is processed and stored securely.

Importance of Nodes in Networking

- ✓ Nodes in computer network provide various network services, such as file sharing, email, web hosting, etc.
- ✓ The nodes ensure that network resources are used efficiently by directing traffic and minimizing congestion.
- ✓ Nodes are the fundamental building blocks of a network that allows devices to communicate and share data with each other.
- ✓ The nodes enable communication between devices by directing traffic while also ensuring that data is sent to the correct destination.
- ✓ Nodes in computer network increase the reliability and security of a network by providing redundancy and implementing security measures.

Q . WSN and IoT

IoT (Internet of Things) and WSN (Wireless Sensor Networks) are related but distinct concepts. IoT refers to the broader network of interconnected devices, while WSN is a specific type of network within IoT that focuses on data collection from sensors. IoT can use various communication technologies, including WSNs, to connect devices and share data, often involving the internet. WSNs, on the other hand, typically operate on local wireless protocols without a direct internet connection. WSN is subset of IOT.

IoT (Internet of Things):

- **Broader Definition:** IoT encompasses a wide range of interconnected devices, objects, and systems that can communicate and exchange data.
- **Internet Connectivity:** IoT devices often connect to the internet to enable data processing, storage, and analysis in the cloud.
- **Data-Driven Decisions:** IoT facilitates data-driven decision-making by providing real-time insights into various aspects of the physical world.

Ex: Smart home devices, wearable fitness trackers, industrial sensors, and connected vehicles are all examples of IoT devices.

WSN (Wireless Sensor Networks):

- **Specific Focus:** WSNs are networks of wireless sensors used to monitor and collect data from their environment.
- **Local Communication:** WSNs typically use local wireless communication protocols (like Zigbee, LoRa, BLE) to transmit data, often without relying on the internet.
- **Data Collection:** WSNs are primarily used for collecting data from sensors, which can then be used for various applications.

Ex: Environmental monitoring, industrial process control, and military surveillance are common applications of WSNs.

Key Differences:

Feature	IoT	WSN
Scope	Covers smart homes, industries, cities, healthcare, and more.	Limited to monitoring environments
Focus	Data-driven decisions, smart applications, interconnected devices	Data collection from sensors, monitoring environmental conditions, and various applications
Communication	Two-way communication between devices. Can use various communication technologies, including WSNs	Usually one-way data transmission . Primarily uses local wireless protocols (Zigbee, LoRa, etc.)
Components	Sensors, nodes, gateway	Sensors, cloud, software, and smart devices.
Connectivity	Requires internet for communication.	May or may not connect to the internet.
Architecture	IOT has a gateway that can connect to internetworks (having routers, switches, APs, etc.).	WSN consists of a network of only sensors