Internet-of-Things

Definition:

The **Internet of Things (IoT)** refers to a network of **physical objects ("things")** embedded with **sensors, software, and other technologies** to collect, exchange, and act on data over the **internet or other communication networks**—often without human intervention.

Key Characteristics:

1. **Interconnectivity** – Devices are connected to each other and to cloud services.
2. **Sensing** – Devices monitor physical conditions (temperature, motion, humidity, etc.).
3. **Data Processing** – Embedded processors analyze sensor data locally or in the cloud.
4. **Actuation** – Devices take action (e.g., turning on a fan) based on data analysis.
5. **Automation** – Many processes happen without human input (e.g., smart irrigation).

Basic IoT Architecture:

1. **Perception Layer**: Sensors and actuators (e.g., DHT11 sensor, camera).
2. **Network Layer**: Communication technologies (Wi-Fi, Bluetooth, ZigBee, LoRa, NB-IoT).
3. **Processing Layer**: Edge computing or cloud servers for data analysis and control.
4. **Application Layer**: End-user services (e.g., smart homes, wearable health monitors).

Example Use Case: Smart Home

- Devices: Smart thermostat, door sensors, lights, cameras.

- Function: Collect data (e.g., room temperature), send to cloud, process it, trigger actions (e.g., turn on AC when hot).
- Technologies used: Raspberry Pi, MQTT protocol, Wi-Fi, cloud services (AWS IoT, Azure IoT).

Common Communication Protocols:

- **MQTT**: Lightweight publish/subscribe protocol for low-power devices.
- **HTTP/HTTPS**: For web-based communication.
- **CoAP**: Designed for simple electronic devices.
- **Bluetooth, ZigBee, LoRa, NB-IoT**: For short- and long-range wireless communication.

Applications of IoT:

Domain	Application Example
Home	Smart bulbs, thermostats, security cameras
Agriculture	Soil moisture monitoring, automated irrigation
Healthcare	Wearable health monitors, remote diagnostics
Industry	Predictive maintenance, smart factories
Transportation	Fleet tracking, smart traffic systems
Environment	Pollution monitoring, weather stations

Benefits:

- Increased automation and efficiency
- Real-time monitoring and control
- Cost savings through predictive maintenance
- Enhanced user experience

Challenges:

- **Security & Privacy**: Devices must be secured to prevent unauthorized access.
- **Scalability**: Managing millions of devices reliably.
- **Interoperability**: Need for standard protocols across devices.
- **Power Consumption**: Battery management in remote sensors.

Example IoT System Using Raspberry Pi:

- **Scenario**: Smart Agriculture
- **Devices**: Soil moisture sensor + Raspberry Pi + Wi-Fi + Cloud dashboard
- **Workflow**:
    1. Sensor collects moisture data.
    2. Pi processes the data and sends it to the cloud.
    3. If moisture < threshold, irrigation is automatically turned on.