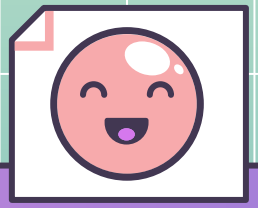


Preliminaries, Motivation and Related Work

What is IoT anyways?

What is IoT

IoT (Internet of Things) refers to the network of interconnected devices embedded with sensors, software, and communication capabilities that **collect and exchange data** .

Example: Smart refrigerators, wearable health monitors, connected cars.

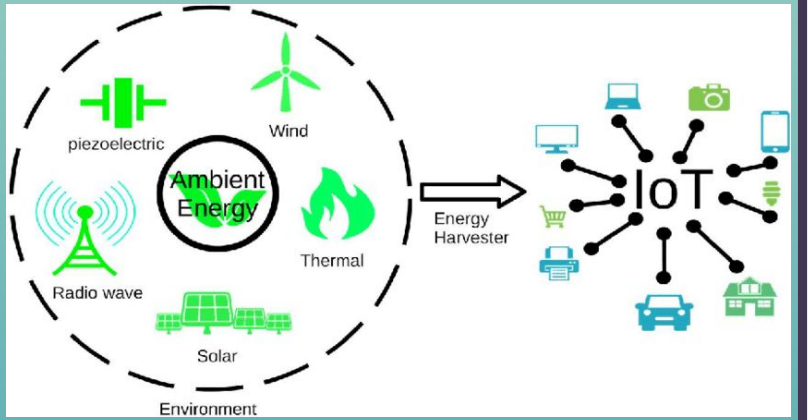
Key Features of IoT

- **Connectivity** (devices communicate via the internet)
- **Sensing** (devices gather data from environment)
- **Data** Processing (analyzing collected data)
- **Automation** (triggering actions based on conditions)

Definition and Scope

IoT is a layered ecosystem including **device-level** (sensors, edge), **network-level** (WSN, LPWAN), and **cloud/fog architecture** .

Recent work emphasizes interoperability across cloud, fog, and edge environments

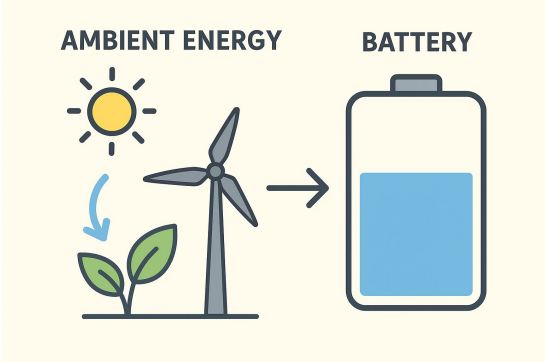


Emerging ecosystem models (e.g., **ambient IoT**)—billions of self-powered sensor nodes forming pervasive networks.

Ambient IoT?

Ambient IoT refers to the class of connected IoT devices that **harvest naturally available energy sources** such as magnetic electric fields, light, thermal differential, kinetic energy, and vibration to power them.

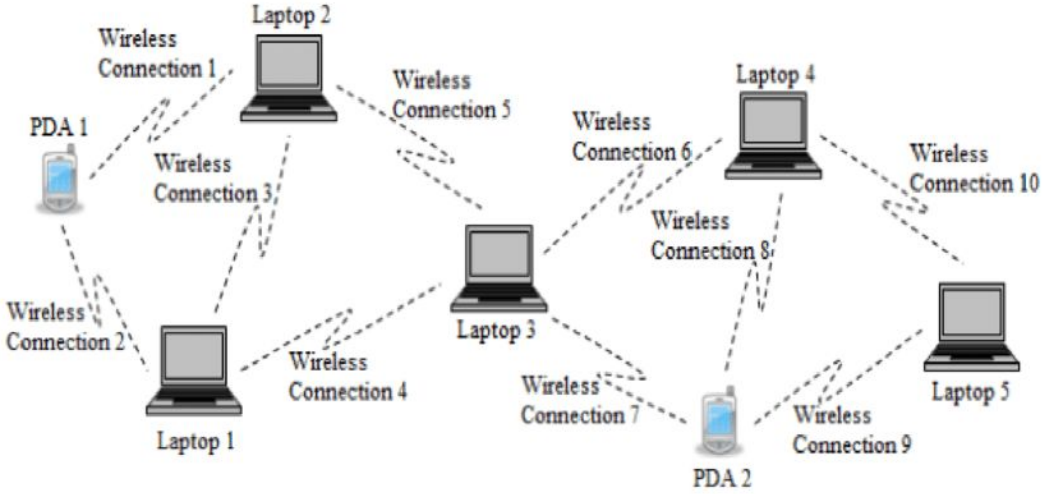
These sources, also referred to as Ambient sources of energy, can reduce the dependency on and potentially even replace the need for batteries, leading to products with flexible form-factors lower BOM costs and vastly longer product lifetimes.



Ad hoc and Sensor Network

Ad Hoc Networks

Ad hoc networks are **decentralized**, **wireless networks** formed spontaneously without any fixed infrastructure like routers or access points. Nodes communicate directly, often forwarding data for one another in a multi-hop fashion.



Key Characteristics of Ad Hoc Network

- **Infrastructure-less:** No central coordinating device or permanent structure.
- **Decentralized and Self-Organizing:** Each node independently helps in routing and managing the network.
- **Dynamic Topology:** Nodes can move, join, or leave the network anytime, making the network constantly change.
- **Multi-Hop Communication:** Nodes relay messages for others, allowing end-to-end communication over multiple hops.

Types of Ad Hoc Networks

Mobile Ad Hoc Network (MANET)

-Nodes are mobile, autonomous, and self-configuring. Used in scenarios like emergency response and tactical communication.

Example:

Military & Defense

Battlefield Communication: MANETs allow soldiers on the move to transmit information, coordinate units, and maintain communications without needing fixed infrastructure or towers, which can be vulnerable.

Emergency Services & Disaster Recovery

Search and Rescue: During natural disasters like earthquakes or fires, MANETs provide a flexible, self-configuring network to exchange information where traditional infrastructure is destroyed.

MANET Pros and Cons

Pros:

- **Infrastructure-less:** Can be deployed anywhere without a fixed network.
- **Self-organizing:** Automatically adapts to network changes and failures.
- **Cost-effective:** Eliminates the expense of fixed infrastructure, like routers and access points.
- **Decentralized:** Has no single point of failure, improving fault tolerance.
- **High mobility:** Allows for rapid and flexible deployment in temporary situations.

Cons:

- **Security risks:** The lack of a central firewall makes the network vulnerable to attacks.
- **Limited resources:** Nodes typically have restricted battery power, processing, and memory.
- **Dynamic topology:** The constant movement of nodes makes routing complex and unstable.
- **Lower performance:** Wireless links have less bandwidth and higher error rates than wired networks.
- **Scalability issues:** Performance can decline as more nodes join the network.

Internet-based MANET (iMANET)

Internet based mobile ad hoc network (iMANET) is an emerging technique that combines a wired network (e.g. Internet) and a mobile ad hoc network (MANET) for developing a ubiquitous communication infrastructure.

- Support internet protocols, such as TCP/IP and UDP
- iMANET employs a network-layer routing protocol to connect mobile nodes set up distributed routes automatically

Examples :

→ Disaster recovery teams not only communicate locally but also send data to **cloud servers** for analysis.

→ Smart vehicles (VANET) not only share traffic data with nearby cars but also upload it to the **city's central traffic management system** .

→ Healthcare workers in remote areas can send patient data through iMANET to a hospital database connected to the internet.

Vehicular Networks (VANET)

Vehicles and roadside devices form temporary networks, enabling vehicle-to-vehicle communication.

Real-world use

In smart cities, cars equipped with wireless modules form Vehicular Ad Hoc Networks (VANETs) to exchange traffic information. If one car detects an accident, it broadcasts the warning to nearby vehicles to prevent pile-ups.

Toyota and BMW test VANET-based systems to enable vehicle-to-vehicle (V2V) communication for road safety and autonomous driving.

Wireless Sensor Networks (WSNs)

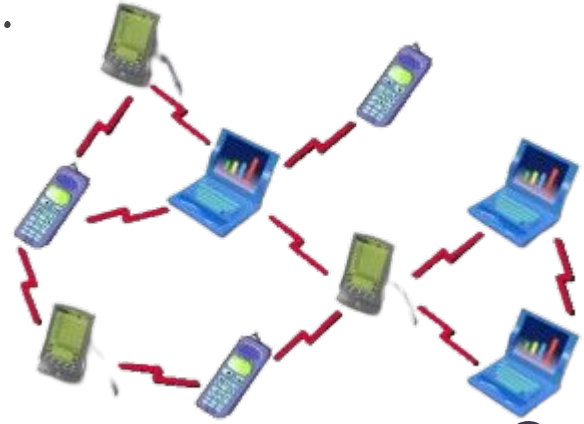
Refer to networks of specialized, widely spaced sensors that track and document the physical state of the surroundings and send the information they gather to a central point. Environmental parameters like temperature, sound, pollution levels, humidity, and wind can all be measured by WSNs.

Forest fire detector

Soil moisture sensor

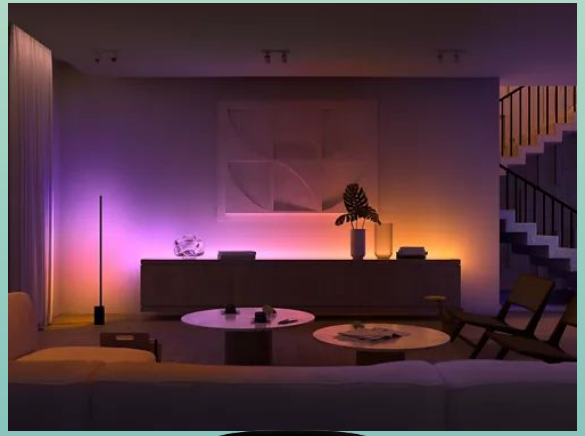
Smartphone Ad Hoc Network (SPAN)

- Employ existing hardware, such as Wi-Fi and Bluetooth
- Software (protocols) used in smartphones to create peer-to-peer (P2P) networks
- Does not rely on cellular carrier networks, wireless access points or traditional network infrastructure.
- Support multihop communication



IoT Application

1. **Smart Homes:**
   A. Smart lighting systems (e.g., Philips Hue, Xiaomi Yeelight)
   B. Smart thermostats (e.g., Nest, Ecobee)
   C. Smart appliances (refrigerators, washing machines, voice assistants like Alexa/Google Home)



IoT Application

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- Sensors: Motion sensors, temperature sensors, voice recognition.
- Connectivity: Wi-Fi, Zigbee, Z-Wave for device-to-device and device-to-cloud communication.
- Data Processing: Cloud servers analyze user habits (e.g., preferred room temperature).
- Automation: Devices automatically adjust (e.g., lights turn off when no one is in the room).

IoT Application

2. Healthcare (IoMT – Internet of Medical Things)
   a. Wearable health monitors (Fitbit, Apple Watch, smart blood pressure cuffs).
   b. Remote patient monitoring systems.
   c. Smart pill dispensers.

- **Sensors:** Measure heart rate, blood oxygen, ECG, glucose levels.
- **Connectivity:** Bluetooth, Wi-Fi, and increasingly 5G for real-time data.
- **Data Processing:** Data sent to cloud or hospital servers; AI analyzes abnormalities.
- **Automation:** Alerts sent to doctors/patients if health metrics cross danger thresholds.