Wireless Sensor Devices & WSNs

Key Components, Topologies, and IoT Applications

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Sensor Nodes: Building Blocks of WSNs

Core Components:

- **Microcontroller (MCU)**: ESP32, Arduino (low-power processing).
- **Transceiver**: Zigbee, LoRa, BLE (wireless communication).
- **Power Source**: Battery, solar, energy harvesting.

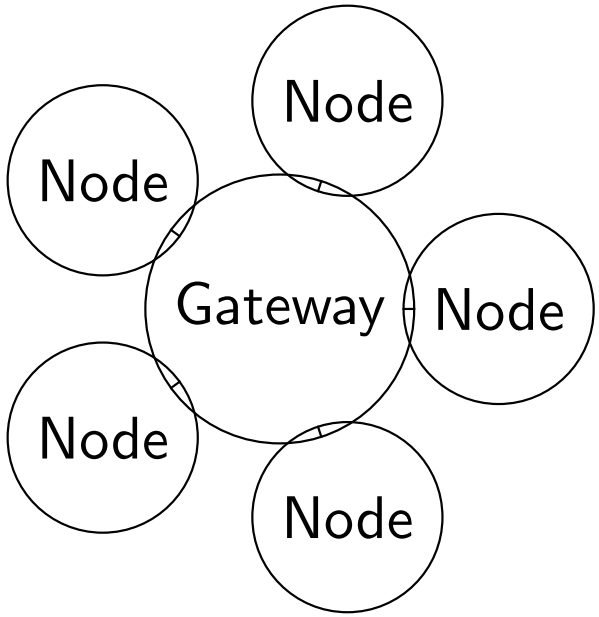
Key Constraints

- Energy: Limited battery life.
- Memory/Compute: Minimal RAM/CPU for cost efficiency.

WSN Topologies

Common Topologies:

- **Star**: Single gateway (e.g., Wi-Fi).
- **Mesh**: Self-healing (e.g., Zigbee).
- **Hybrid**: Mix of star/mesh.



Trade-offs

Mesh = better reliability, Star = simpler but single point of failure.

Use Cases & Challenges

Applications:

- **Smart Agriculture**: Soil moisture sensors + LoRaWAN.
- **Industrial IoT**: Predictive maintenance in factories.

Challenges:

1. Energy efficiency (sleep modes, energy harvesting).
2. Network lifetime (battery replacement costs).
3. Security (e.g., rogue node attacks).

Smart Farming Example

Soil sensor $\rightarrow$ LoRaWAN gateway $\rightarrow$ Cloud dashboard.

Constraints of Sensor Nodes

Challenges

- **Energy**: Limited battery life
- **Memory**: Small RAM/Flash
- **Computation**: Low CPU power
- **Cost**: Mass deployment needs

Optimizations

- Sleep/wake cycles
- Data aggregation
- Lightweight protocols (CoAP)

Summary

- Sensor nodes = MCU + transceiver + power (constrained resources).
- WSNs use star/mesh topologies for scalability.
- Critical for agriculture, industry, but face energy/security hurdles.

Questions?