

MAC PROTOCOL SURVEY

The Medium Access Control (MAC) protocol plays a crucial role in IoT networks by managing data transmission over a shared wireless medium. It helps in:

- **Efficient Channel Utilization:** Avoiding collisions and interference.
- **Energy Efficiency:** Reducing power consumption in battery-powered IoT devices.
- **Scalability:** Supporting a large number of connected devices.
- **Reliability:** Ensuring smooth communication with minimal data loss.

Classification of MAC Protocols in IoT

(A) Random Access Protocols

These protocols allow devices to transmit data whenever they have data to send, without a fixed schedule.

(i) ALOHA-Based Protocols

- **Pure ALOHA:** Devices transmit immediately but face high collision chances.
- **Slotted ALOHA:** Devices can only transmit at specific time slots, reducing collisions.

(ii) Carrier Sense Multiple Access (CSMA) Protocols

- **CSMA/CD (Collision Detection):** Used in wired networks (e.g., Ethernet), detects collisions and resends data.
- **CSMA/CA (Collision Avoidance):** Used in wireless networks (e.g., Wi-Fi), avoids collisions using RTS/CTS (Request to Send/Clear to Send) mechanism.

(iii) Variants of CSMA

- **Non-Persistent CSMA:** Devices wait for a random time before retrying transmission.
- **P-Persistent CSMA:** Used in slotted channels, allowing controlled transmission probabilities.

(B) Controlled Access Protocols

These protocols ensure orderly and collision-free communication by coordinating access.

(i) Polling

- A central master device queries each node in a round-robin fashion to check if it has data to send.
- Example: Bluetooth networks use polling to coordinate transmissions.

(ii) Token Passing

- A special control packet (token) is passed between devices. Only the device holding the token can transmit.
- Ensures fair access and collision-free communication.
- Used in industrial automation and sensor networks.

(C) Channelization Protocols

These protocols divide the communication medium into multiple channels to avoid interference.

(i) Time Division Multiple Access (TDMA)

- Time slots are allocated to each device for transmission.

- Used in real-time applications requiring synchronized data transmission.

(ii) Frequency Division Multiple Access (FDMA)

- Devices transmit over separate frequency bands.
- Used in satellite communications and cellular IoT networks.

(iii) Code Division Multiple Access (CDMA)

- Devices use unique codes to transmit data over the same frequency.
- Offers high security and resistance to interference.
- Used in mobile networks and IoT applications requiring secure communication.

Energy-Efficient MAC Protocols in IoT

Since many IoT devices operate on low power, MAC protocols are optimized for energy efficiency.

- **S-MAC (Sensor MAC):** Uses periodic sleep cycles to conserve energy in IoT sensor networks.

- **T-MAC (Timeout MAC):** Adjusts active time dynamically to reduce power consumption.
- **B-MAC (Berkeley MAC):** Uses adaptive preamble sampling to minimize energy wastage.

Comparison of MAC Protocols in IoT

MAC Protocol	Collision Avoidance	Energy Efficiency	Scalability	Latency
ALOHA	Poor	Low	High	High
CSMA/CA	Good	Moderate	High	Low
TDMA	Excellent	High	Low	Low
FDMA	Excellent	High	Moderate	Low
S-MAC	Good	High	High	High

Conclusion

Choosing the right MAC protocol in IoT depends on the application requirements:

- **For energy-constrained IoT devices** → Use S-MAC or T-MAC.
- **For high-throughput applications** → Use CSMA/CA or FDMA.
- **For real-time communication** → Use TDMA to ensure time synchronization.

