# Medium Access Control (MAC) Protocols - Study Notes

## 1. Introduction to MAC Protocols

### Data Link Layer Structure

- **Position**: Second layer in OSI model
- **Two Sub-layers**:
  - **LLC (Logical Link Control)**: Handles frame synchronization, error detection/correction, flow control
  - **MAC (Medium Access Control)**: Controls access to shared medium

### Purpose of MAC Protocols

- Control access to shared communication links
- Prevent collisions when multiple stations transmit simultaneously
- Manage how and when stations can transmit data

## 2. Network Topologies and MAC Need

### Point-to-Point Links

- Direct connection between two stations
- No need for MAC protocols
- Each station has dedicated link

### Shared Medium (Bus/LAN)

- Multiple stations share same communication link
- **Problem**: Collisions occur when multiple stations transmit simultaneously
- **Solution**: MAC protocols coordinate access

## 3. Classification of MAC Protocols

### A. Random Access Protocols

- **Characteristic**: No priority system, stations compete for access
- **Key Protocols**:

#### 3.1 ALOHA

- **Pure ALOHA**:
  - Stations transmit whenever they have data

    - Maximum throughput: 18.4% (0.184)
- **Slotted ALOHA**:
    - Time divided into slots
    - Stations can only transmit at slot boundaries
    - Maximum throughput: 36.8% (0.368)

#### 3.2 CSMA (Carrier Sense Multiple Access)

- Stations listen before transmitting
- Better performance than ALOHA

#### 3.3 CSMA/CD (Collision Detection)

- Used in Ethernet
- Detects collisions during transmission
- Stops transmission when collision detected

#### 3.4 CSMA/CA (Collision Avoidance)

- Used in wireless networks
- Tries to avoid collisions before they occur

### B. Controlled Access Protocols

#### 3.1 Polling

- **Central Controller**: One station acts as controller
- **Process**: Controller polls each station to check if it has data to transmit
- **Advantage**: No collisions
- **Disadvantage**: Overhead of polling messages

#### 3.2 Token Passing

- **Token Ring**: Special control frame (token) circulates
- **Rule**: Only station holding token can transmit
- **Process**:
    - Station receives token
    - If has data, transmits and then passes token
    - If no data, immediately passes token
- **Key Concepts**:
    - Early Token Release

- Delayed Token concepts
- Token holding time

### C. Channelization Protocols

#### 3.1 FDMA (Frequency Division Multiple Access)

- **Method**: Frequency band divided into fixed channels
- **Allocation**: Each station assigned specific frequency channel
- **Usage**: Station uses assigned frequency for transmission

#### 3.2 TDMA (Time Division Multiple Access)

- **Method**: Time divided into fixed time slots
- **Allocation**: Each station assigned specific time slot
- **Usage**: Station can only transmit during its assigned time slot

## 4. Important Performance Metrics

### Key Formulas and Concepts

- **Vulnerable Time**: Time period during which collision can occur
- **Throughput**: Measure of successful data transmission
- **Efficiency**: Ratio of useful transmission time to total time
- **Transmission Time vs Propagation Time**: Important for calculating efficiency

### Efficiency Considerations

- **CSMA efficiency** depends on ratio of transmission time to propagation time
- **Token Ring efficiency** depends on token circulation time
- **Channelization protocols** can achieve theoretical maximum efficiency

## 5. Exam Important Points

### High Priority Topics

- **CSMA and CSMA/CD**: Most frequently asked
- **ALOHA protocols**: Pure vs Slotted comparison
- **Token Ring**: Delay calculations, early/delayed token release
- **Throughput and efficiency calculations**
- **Numerical problems**: Formula applications

### Key Numerical Concepts

- Maximum throughput values for different protocols
- Efficiency calculations
- Vulnerable time calculations
- Token circulation time in token ring

## 6. Summary

MAC protocols are essential for managing access to shared communication media. The three main categories each serve different purposes:

- **Random Access**: Best for light traffic, simple implementation
- **Controlled Access**: Eliminates collisions, good for heavy traffic
- **Channelization**: Provides guaranteed bandwidth, suitable for real-time applications

Understanding the trade-offs between throughput, efficiency, and implementation complexity is crucial for selecting appropriate MAC protocols for different network scenarios.