Wifi Training Assignment 4

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Problem1:

The MAC layer is responsible for managing protocol access to the physical network medium. It sits in the Data Link Layer (Layer 2) of the OSI model and works closely with the Physical layer (Layer 1). It performs addressing, frame delimiting, error detection, access control, and coordination of how data is placed and received from the medium.

Problem2:

802.11 MAC Header Frame Format includes:

- Frame Control (2 bytes): Indicates frame type, subtype, and flags (e.g., To/From DS, retry, more fragments).
- Duration/ID (2 bytes): Network allocation vector or association ID.
- Address 1 (6 bytes): Destination address.
- Address 2 (6 bytes): Source address.
- Address 3 (6 bytes): BSSID or another address depending on the frame type.
- Sequence Control (2 bytes): Contains fragment number and sequence number.
- Address 4 (optional, 6 bytes): Used in WDS (Wireless Distribution System) frames.
- QoS Control (optional, 2 bytes): Present in QoS data frames.
- HT Control (optional, 4 bytes): Used in HT (High Throughput) transmissions.
- Frame Body: Variable-length payload.
- FCS (4 bytes): Frame Check Sequence for error checking.

Problem3:

MAC Layer Functionalities:

- Management Plane:
    - Beacon generation
    - Authentication & Association
    - Scanning (Passive/Active)

        - Roaming
        - Load balancing
- Control Plane:
        - RTS/CTS (Request to Send/Clear to Send)
        - Acknowledgements (ACK)
        - NAV setting
        - Power Save Poll (PS-Poll)
- Data Plane:
        - Frame aggregation/disaggregation
        - Fragmentation
        - Error detection & retransmission
        - Encryption/decryption
        - QoS prioritization

Problem4:

Scanning Types:

- Passive Scanning: STA listens for beacon frames from APs. No transmission initiated by the STA.
- Active Scanning: STA sends Probe Requests to solicit Probe Responses from APs.
- Scanning is used to discover available networks, select the best AP, and during roaming.

Problem5:

Client Association Process:

- Scanning: STA detects available APs.
- Authentication: STA sends authentication request; AP responds.
- Association: STA sends association request; AP responds with success/failure.
- After association, STA is part of the BSS and can send/receive data frames.

Problem6:

EAPOL 4-Way Handshake:

Step 1: AP sends ANonce to STA.

Step 2: STA derives PTK using PMK, SNonce, ANonce, and both MAC addresses; sends SNonce to AP.

Step 3: AP derives PTK, sends GTK encrypted with PTK to STA.

Step 4: STA sends confirmation to AP.

Key Purposes:

- PMK (Pairwise Master Key): Base key from authentication.
- PTK (Pairwise Transient Key): Derived from PMK and used for unicast.
- GTK (Group Temporal Key): Used for multicast/broadcast.

Problem7:

Power Saving in MAC Layer:

- Mechanism: STA informs AP it is entering Power Save mode via frame flags.
- AP buffers data for sleeping STA and indicates buffered traffic via TIM in beacon frames.
- Types:
    - Legacy Power Save (802.11): Uses beacon and PS-Poll.
    - U-APSD (Unscheduled Automatic Power Save Delivery): Trigger-based.
    - TWT (Target Wake Time, 802.11ax): Negotiated sleep/wake intervals for efficient scheduling.

Problem8:

Medium Access Control Methodologies:

- DCF (Distributed Coordination Function): CSMA/CA with random backoff.
- PCF (Point Coordination Function): Poll-based access using a central coordinator.
- HCF (Hybrid Coordination Function): Combines DCF and PCF with QoS support.
- EDCA (Enhanced Distributed Channel Access): Prioritizes traffic categories.
- TXOP (Transmission Opportunity): Grants a time window for transmission.

Problem9:

Block ACK Mechanism:

- Allows acknowledgment of multiple data frames with a single Block ACK frame.
- Reduces overhead by avoiding multiple ACKs.
- Improves throughput, especially in high-bandwidth or aggregated frame scenarios.

Problem10:

- A-MSDU aggregates multiple MSDUs into a single MPDU to reduce overhead.
- A-MPDU aggregates multiple MPDUs into one PHY transmission for better efficiency.
- A-MSDU in A-MPDU combines A-MSDU aggregated frames inside multiple MPDUs, which are then aggregated into a single A-MPDU.
- A-MSDU reduces header overhead but has stricter error handling (entire A-MSDU retransmitted on failure).
- A-MPDU allows selective retransmission of failed MPDUs due to individual CRCs.
- Combining A-MSDU within A-MPDU offers a balance of efficiency and reliability.