Chapter 9 Overview

- Packets, frames, and bits
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- Passive scanning
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- Active scanning
- Authentication
- Association
- Authentication and association states
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Packets, Frames, and Bits

• At the Network layer, an IP header is added to the data that came from layers 4–7
• At the Data-Link layer, a MAC header is added and the IP packet is encapsulated inside a frame
• When the frame reaches the Physical layer, a PHY header with more information is added to the frame
Data-Link Layer

• Two sublayers
  – 802.2 Logical Link Control (LLC) sublayer
  – 802.11 Media Access Control (MAC) sublayer

• Data handed off to the LLC becomes known as the MAC Service Data Unit (MSDU)

• When handed to the MAC sublayer, the MSDU is encapsulated in a MAC Protocol Data Unit (MPDU).

802.11 MPDU

• MAC Header
• Frame Body
• Frame Check Sequence (FCS)
Physical Layer

- Two sublayers
  - Physical Layer Convergence Procedure (PLCP) sublayer
  - Physical Medium Dependent (PMD) sublayer
- PLCP Service Data Unit (PSDU) is a view of the MPDU from the Physical layer
- PLCP Protocol Data Unit (PPDU) adds a preamble and PHY header to the PSDU
802.11 and 802.3 Interoperability

- 802.3 frames have a maximum size of 1,518 bytes with a maximum data payload of 1,500 bytes.
- 802.11 frames are capable of transporting frames with an MSDU payload of 2,304 bytes of upper-layer data.
- When the IP packets are passed down to 802.11, even though the maximum size of the MSDU is 2,304 bytes, the size will be limited to the 1,500 bytes of the IP packets.

802.11 MAC address types

- Individual Address
- Group Address
  - Multicast-Group Address
  - Broadcast Address
802.11 MAC header

- Five MAC address fields in the layer 2 header
  - Source Address (SA)
  - Destination Address (DA)
  - Transmitter Address (TA)
  - Receiver Address (RA)
  - Basic Service Set Identifier (BSSID)

Three 802.11 Frame Types

- Management Frames
  - Used by wireless stations to join and leave the basic service set (BSS)

- Control Frames
  - Assist with the delivery of the data frames and are transmitted at one of the basic rates

- Data Frames
  - Carry the actual data that is passed down from the higher-layer protocols.
Beacon Management Frame

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Stamp</td>
<td>Synchronization information</td>
</tr>
<tr>
<td>Spread Spectrum Parameter Sets</td>
<td>FHSS, DSSS, HR-DSSS, ERP, OFDM, HT, or VHT-specific information</td>
</tr>
<tr>
<td>Channel Information</td>
<td>Channel used by the AP or IBSS</td>
</tr>
<tr>
<td>Data Rates</td>
<td>Basic and supported rates</td>
</tr>
<tr>
<td>Service Set Capabilities</td>
<td>Extra BSS or IBSS parameters</td>
</tr>
<tr>
<td>SSID</td>
<td>Logical WLAN name</td>
</tr>
<tr>
<td>Traffic Indication Map (TIM)</td>
<td>A field used during the Power Save process</td>
</tr>
<tr>
<td>QoS Capabilities</td>
<td>Quality of service and Enhanced Distributed Channel Access (EDCA) information</td>
</tr>
<tr>
<td>Robust Security Network (RSN) Capabilities</td>
<td>TKIP or CCMP cipher information and authentication method</td>
</tr>
<tr>
<td>Vendor Proprietary Information</td>
<td>Vendor-unique or vendor-specific information</td>
</tr>
</tbody>
</table>

Passive Scanning

![Diagram of passive scanning with access points and beacons](image-url)
Active Scanning

Authentication

- Open System Authentication
  - Null authentication because no exchange or verification of identity takes place between the devices
- Shared Key Authentication
  - The client station sends an authentication request to the AP
  - The AP sends a cleartext challenge to the client station in an authentication response.
  - The client station then encrypts the cleartext challenge and sends it back to the AP in the body of another authentication request frame.
  - The AP then decrypts the station’s response and compares it to the challenge text
Association

- Means that the client station can send data through the AP and on to the distribution system medium.
- Occurs after Shared Key or Open System authentication
- Three states
  - State 1: initial start state, unauthenticated and unassociated
  - State 2: authenticated and unassociated
  - State 3: authenticated and associated (pending security mechanisms)

Authentication and association states
Basic and Supported Rates

- Specific data rates can be configured for any AP as \textit{required rates}.
- The 802.11-2012 standard defines \textit{required rates} as basic rates.
- To successfully associate with an AP, the station must be capable of communicating by using the configured basic rates.
- \textit{Supported rates} are data rates that the AP offers to a client station, but the client station does not have to support all of them.

Roaming and Reassociation

- Decision to roam is currently made by the client station.
- As the client station moves and the signal drops below a predetermined threshold, the client station will attempt to connect to another AP and roam from its current BSS to a new BSS.
- The client will send a \textit{reassociation request frame} to the new AP.
Reassociation process

Disassociation and Deauthentication

- Notifications, not requests
- Can be sent by client or AP
- Cannot be refused by either party, except when management frame protection (defined in 802.11w) is negotiated
ACK Frame

- Smaller fragments reduce retransmission overhead
Protection Mechanism

• In order legacy 802.11 stations to coexist in the same BSS, the 802.11g devices enable the protection mechanism, also known as 802.11g Protected mode.
• Three configuration modes for 802.11g APs
  – 802.11b-Only Mode
  – 802.11g-Only Mode
  – 802.11b/g Mode
• In mixed-mode an 802.11g device will first perform a NAV distribution by transmitting a RTS/CTS exchange with the AP or by transmitting a CTS-to-Self using a data rate and modulation method that the 802.11b HR-DSSS stations can understand.

RTS/CTS

• Mechanism that performs a NAV distribution and helps prevent collisions from occurring. This NAV distribution reserves the medium prior to the transmission of the data frame.
• Used primarily in two situations
  – When a hidden node exists
  – As a protection mechanism
RTS/CTS duration values

RTS/CTS frame exchange

RTS duration = CTS/Data/ACK exchange
CTS duration = Data/ACK exchange
DATA duration = ACK
ACK duration = 0 (exchange is over)

Station 3 does not hear the RTS but does hear the CTS and resets the NAV timer for the Data/ACK exchange.

Station 2 hears the RTS and resets the NAV timer for the CTS/Data/ACK exchange.
CTS-to-Self

- Used strictly as a protection mechanism
- One of the benefits of using CTS-to-Self over RTS/CTS as a protection mechanism is that the throughput will be higher because fewer frames are being sent.
- Better suited for use by an AP

Data Frames

- 15 subtypes
  - Most common data frame is the simple data frame, which has MSDU upper-layer information encapsulated in the frame body
  - Null function frame is used by client stations to inform the AP of changes in Power Save status by changing the Power Management bit
Power Management

- 802.11 standard includes a power-management feature that can be enabled to help increase battery life
- Two legacy power-management modes
  - Active mode
  - Power Save Mode
- Client will notify the AP that it is enabling Power Save mode by changing the Power management field to 1.
- AP will store the clients data in a buffer
- A traffic indication map (TIM) is a list of all stations that have undelivered data buffered on the AP

Power Management

- Because beacons are transmitted at a consistent predetermined interval known as the target beacon transmission time (TBTT), all stations know when beacons will occur
- When the station receives the beacon, it checks to see whether its AID is set in the TIM
- If so, the station will remain awake and will send a PS-Poll frame to the AP
- AP receives the PS-Poll frame and will send the buffered unicast frame to the station.
Delivery Traffic Indication Message

- A delivery traffic indication map (DTIM) is used to ensure that all stations using power management are awake when multicast or broadcast traffic is sent.
- A TIM or DTIM is transmitted as part of every beacon.
- All stations will wake up in time to receive the beacon with the DTIM.
- If a station’s AID was in the DTIM, the station will remain awake and will send a PS-Poll frame and proceed with retrieving its buffered unicast traffic from the AP.

Announcement Traffic Indication Message

- A recurring period of time used in an IBSS when all devices must be awake to exchange this information is known as the announcement traffic indication message (ATIM) window.
- If a station has buffered data for another station, it will send a unicast frame known as an ATIM frame to the other station.
- Informs the station that it must stay awake until the next ATIM window so that it can receive the buffered data.
WMM Power Save and U-APSD

- IEEE 802.11e amendment introduced an enhanced power-management method called automatic power save delivery
- Two APSD methods are defined
  - Scheduled automatic power save delivery (S-APSD)
  - Unscheduled automatic power save delivery (U-APSD).
- Wi-Fi Alliance’s WMM Power Save (WMM-PS) certification is based on U-APSD
  - Goal of WMM-PS is to have client devices spend more time in a doze state and consume less power

Legacy power management limitations

- Client must first wait for a beacon with a TIM and must also send a unique PS-Poll frame to the AP for every single buffered unicast frame
WMM-PS

- Uses a trigger mechanism to receive buffered unicast traffic based on WMM access categories
- Access-category queues are voice, video, best effort, and background
- Client station sends a trigger frame related to a WMM access category to inform the AP that the client is awake
- Trigger frame can also be an 802.11 data frame, thus eliminating the need for a separate PS-Poll frame
- AP will then send an ACK to the client and proceed to send a frame burst of buffered application traffic during a transmit opportunity (TXOP)
802.11n Power Management

- 802.11n-2009 amendment also defines two new power-management methods.
- Spatial multiplexing power save (SM power save)
  - Purpose is to enable a MIMO 802.11n device to power down all but one of its radio chains
- Power save multi-poll (PSMP)
  - An extension of automatic power save delivery (APSD),

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