Topic 6: Data Link Layer

Converts digital bits to physical bits for hop-to-hop delivery over a single medium (wired/wireless)

Addressing:

- Uses MAC address (48-bit globally unique identifier managed by IEEE)
- Format: ex. 6E-3F-BB-22-A0-0F
- First 3 pairs: Organizational Unique Identifier
- Last 3 pairs: Network Interface Card
- MAC addresses survive a single hop and can't be used to fool beyond one hop

Protocols:

- 802.3 Ethernet (wired): simple header and data protocol
- 802.11 WiFi (wireless): complex protocol with 100+ message types
- Due to different physical properties, protocols differ (WiFi needs authentication, password, etc.)
- Ethernet focuses on throughput; WiFi needs complexity for connection handling

Header Information:

- Preamble: alternating 0s and 1s for synchronization between sender and reciever
- Destination and Source MAC addresses
  - Lets us know who the sender/reciever is
- EtherType: specifies protocol in payload
  - 0x0800 = IPv4, 0x86DD = IPv6, 0x0806 = ARP, 0x8100 = VLAN tagged frame
- CRC/FCS: uses CRC32 hash for data integrity
- Interframe: prevents collisions
- Integrity vs Reliable delivery
  - Integrity: detect errors; Reliable delivery: ensure delivery via retransmissions
  - Ethernet provides integrity, not reliability

DLL Devices:

- Network Switch (replaced hub):
  - Adds CPU, memory for queuing messages
  - Switch = passive; forwards on behalf of devices
  - Uses Switch Device Discovery Algorithm:
    - Records SRC MAC + Physical Port into FIB
    - If DEST MAC found in FIB, forward on that port
    - Else fallback to hub mode: forward to all except source port
  - FIB builds MAC-port mapping over time
  - Header stays unchanged across switches
  - Expiry field prevents memory monopolization
  - Multiple devices can map to one port

Management Frames:

- Connection/disconnection,
- Beacon: Router constantly emits a beacon sending information for a device to connect
- Probe: Probing for a network that was connected to previously, to reconnect to it
- Association: allows us to interact with the network to get network resources or provide resources to other devices through the network

Control Frames:

- Deals with lossy nature of WiFi
- Acknowledgement: ensures reliable delivery (unlike Ethernet)
- Block Ack: acknowledge multiple messages with a single acknowledgement
- RTS/CTS: solves hidden node problem; signals other devices to hold transmission
  - Ugly solution in contrast to CSMA
  - Sender sends request to send, Receiver sends clear to send
  - Signals to devices outside of the senders range to wait and switch to RTC + CTS
- Costly vs CSMA
  - CSMA is faster, the extra messages cost bandwith and doesn't send actual data