MAC Sub-Layer

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Limited Contention Protocols

- Contention model + collision free model?
- Idea: divide stations into groups, within which only a very small number are likely to transmit data.
- Avoid wastage due to idle periods and collisions

Adaptive Tree Walk Protocol

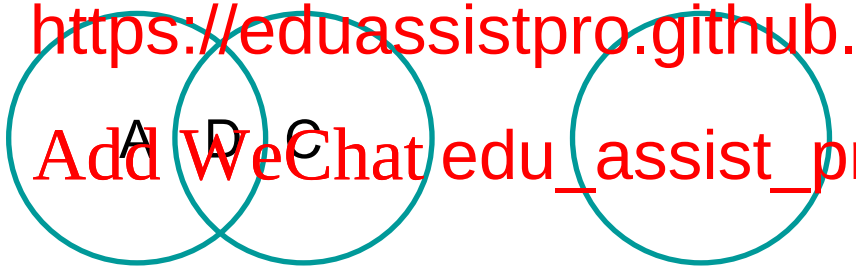
- All stations compete for right to transmit, if a collision occurs, binary division is used to resolve contention
- Stations are divided into groups to poll
  - Depth first search under nodes with poll collisions
  - Start search at lower levels if >1 station want to transmit

Example 1: D G
Slot 1 → D, G – collision
Slot 2 → D
Slot 3 → G

Example 2: B D G
Slot 1 → B, D, G – collision
Slot 2 → B, D - collision
Slot 3 → B
Slot 4 → D
Slot 5 → G

Wireless LAN Protocols

- Wireless complications: stations have coverage regions, which leads to **hidden** and **exposed terminal problems**.
- When a station is in the range of two transmitters or relays, interfer ption.



- Require **detection of transmissions around receiver, not just carrier sensing**.
- Transmission Protocols for Wireless LANs (802.11)
  - Multiple Access with Collision Avoidance for Wireless (MACAW)

Hidden and Exposed Terminals (1)

- **Hidden terminals** are senders that cannot sense each other but nonetheless collide at intended receiver
  - A and C are hidden terminals when sending to B
  - Want to pre

Hidden and Exposed Terminals (2)

- **Exposed terminals** are senders who can sense each other but still transmit safely (to different receivers)
  - B → A and C → D are exposed terminals
  - Desirably co rformance

MACA (1)

- MACA: Multiple Access with Collision Avoidance
- Sender asks receiver to transmit short control frame
- Stations nea ol frame
- Sender can then transmit eceiver

MACA (2)

MACA protocol grants access for A to send to B:

- A sends RTS to B [left]; B replies with CTS [right]
- A can send with exposed but no hidden terminals

A sends RTS to B; C and E hear and defer for CTS

B replies with CTS; D and E hear and defer for data

Ethernet

- MAC Sub-Layer Case Study
  - Classic Ethernet
  - Switched

Classic Ethernet

- Each type of Ethernet has a maximum cable length per segment.
- Multiple cable lengths can be connected by repeaters – a physical device which receives, amplifies and r th directions.

Ethernet Frame Format

- MAC protocol is 1-persistent CSMA/CD
  - Random delay (backoff) after collision is computed with BEB (Binary Exponential Backoff, i.e., random number 0 to $2^i - 1$)
- Frame format is still used with modern Ethernet

IEEE 802.3

- **Preamble** (7B) – synchronisation b and receiver
- **Start of Frame** (1B) – FLAG byte
- **Dest. & Source addresses** (6B + 6B) – to identify sender and receiver
- **Type or Length** (2B) – specifies which process to give the frame to
- **Data** (0~1500B)
- **Pad**(0~46B) – minimum size of an Ethernet frame is 64 Bytes
- **CRC** (4B) – 32 bits checksum

Classic Ethernet Minimum Frame Size

- Collisions can occur and take as long as 2τ to detect
  - τ is the time it takes to propagate over the Ethernet
  - Leads to a minimum frame size for reliable detection

MAC Addressing

- The MAC Address provides the unique identifier for a physical interface
- 48-bit number encoded in the frame, written in hexadecimal n

  e.g. 00:02:2D:

Ethernet Performance

$$\textbf{Channel Efficiency} = \frac{1}{1+(2BLe)/(cF)}$$

- F: frame length
- B: bandwidth
- L: cable length
- c: speed of signal propagation; e .71828
- Optimal case: e contention slots

- When cF is large, the channel efficiency will be high.
- Increasing network bandwidth or distance (BL) reduces the efficiency for a given frame size.

Switched Ethernet

- Hubs wire all lines into a single CSMA/CD domain
- Switches isolate each port to a separate domain
  - Much greater throughput for multiple ports
  - No need for C

Summary of Multiple Access Protocols

- Contention
  - ALOHA, Slotted ALOHA
  - Carrier Sense Multiple Access: 1-persistent, non-persistent, p
- Collision Free:
- Limited Contention: adaptive
- MACA/MACAW (for Wireless LANs): RTS and CTS