MAC Sub-Layer

COMP90007 Internet Technologies

Lecturer: Ling Luo

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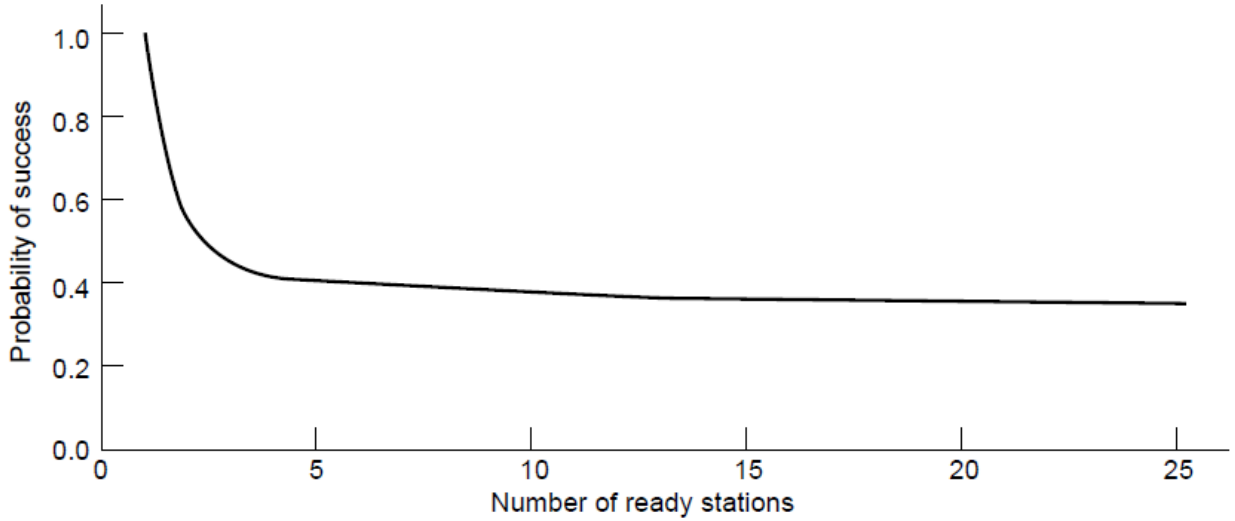
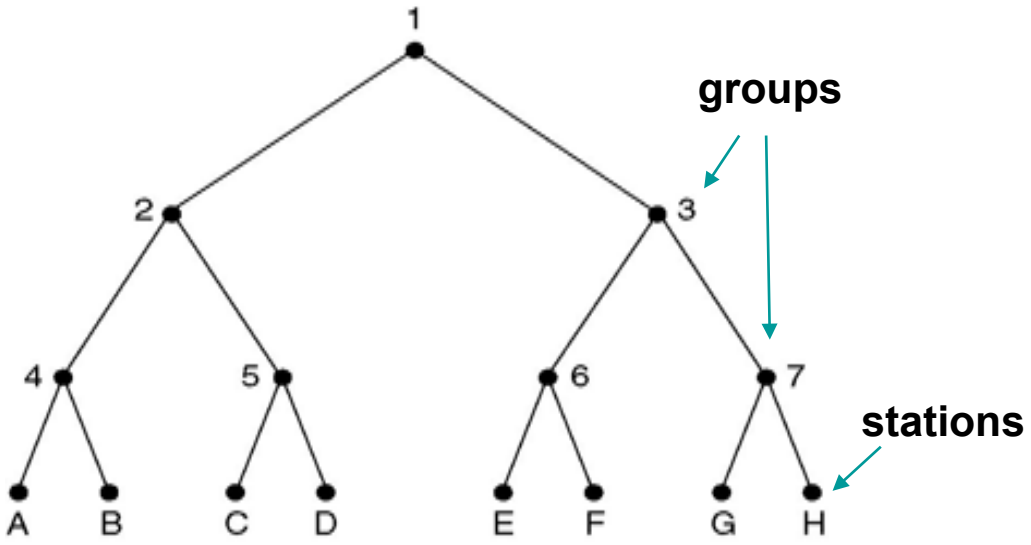
Limited Contention Protocols

- Idea: divide stations into groups, within which only a very small number are likely to transmit data.
- Increase the probability of stations acquiring transmission rights by dividing stations and using a binary algorithm to determine right allocation
- 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

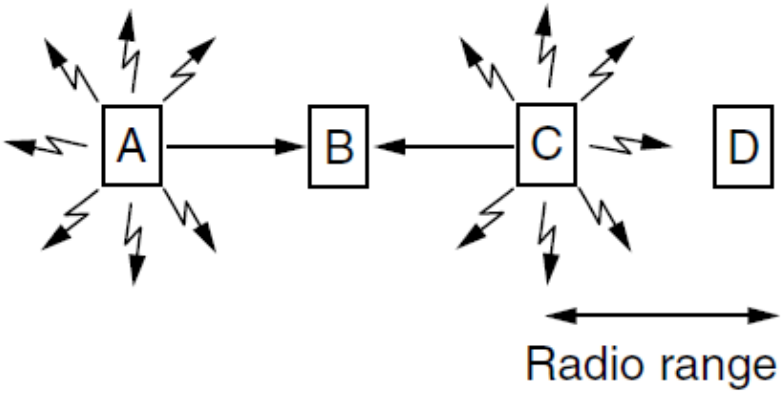
Example 2: B D G
Slot 1 → B, D, G – collision
Slot 2 → B, D - collision
Slot 3 → B
Slot 4 → D
Slot 5 → G

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, interference affects signal reception.
- 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)

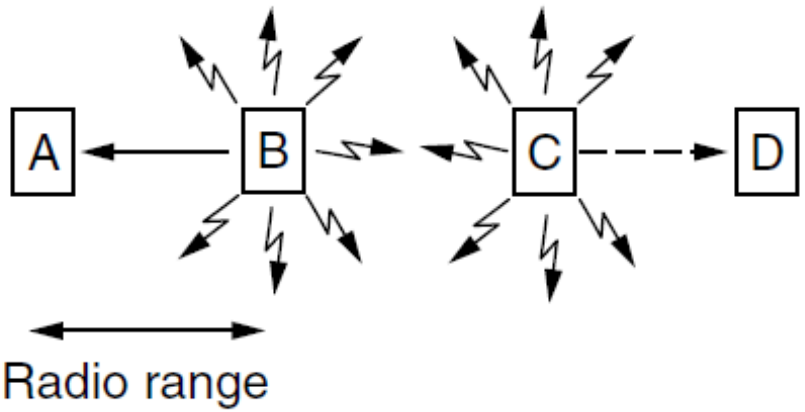
Hidden and Exposed Terminals (1)

- **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 prevent; loss of efficiency



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 concurrency; improves performance



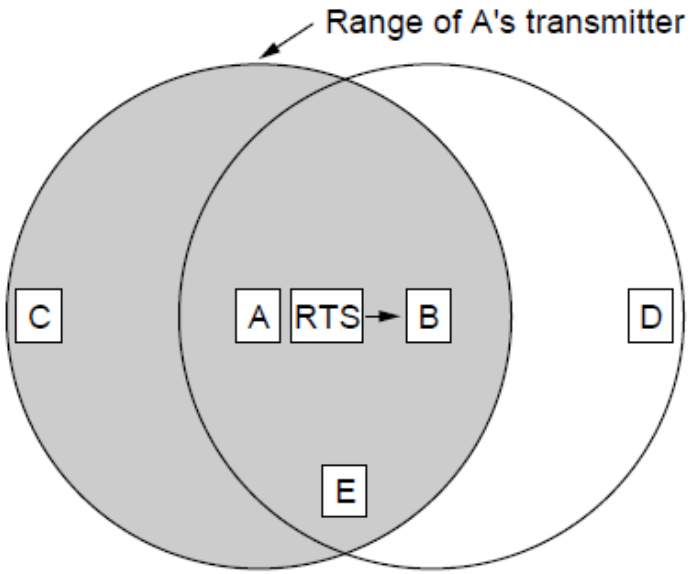
MACA (1)

- MACA: Multiple Access with Collision Avoidance
- Sender asks receiver to transmit short control frame
- Stations near receiver hear control frame
- Sender can then transmit data to receiver

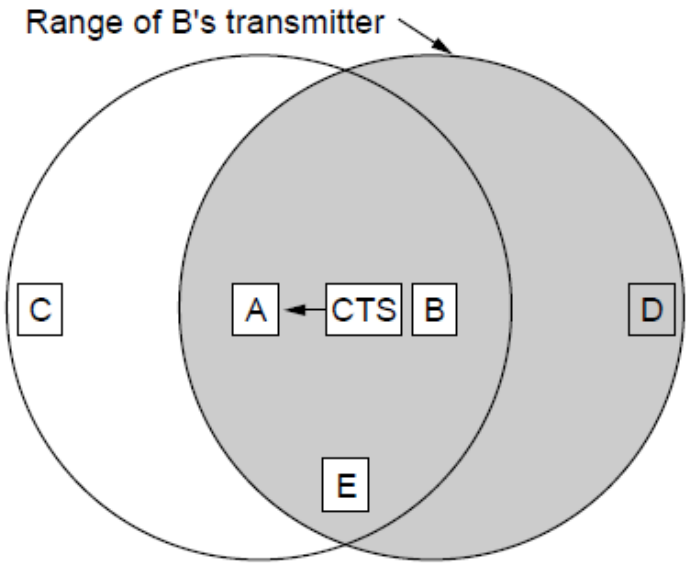
MACA (2)

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



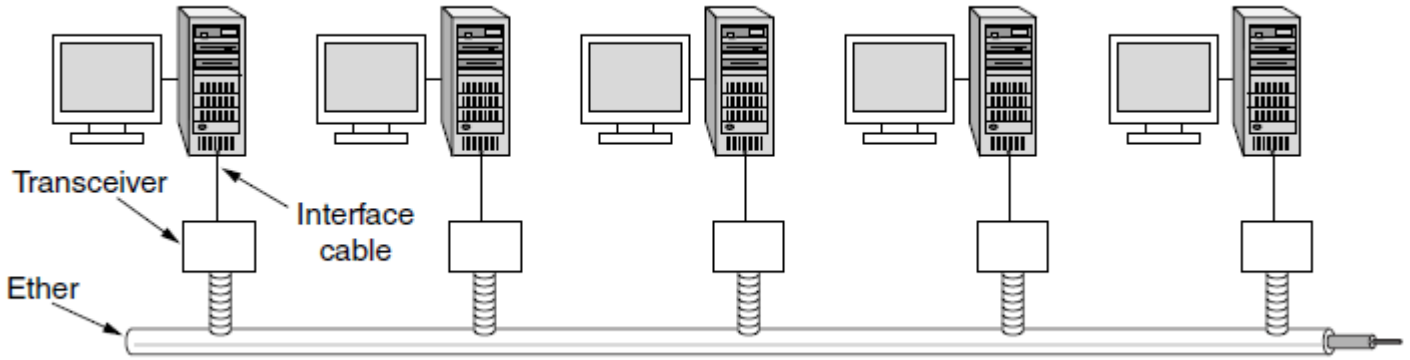
B replies with CTS; D and E hear and defer for data

Ethernet

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

Classic Ethernet

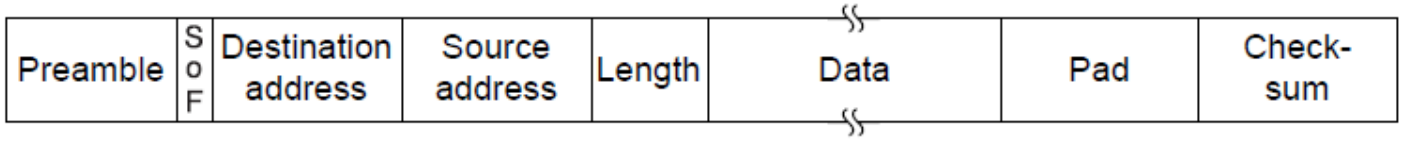
- Each type of Ethernet has a maximum cable length per segment.
- Multiple cable lengths can be connected by repeaters - a physical device which receives, amplifies and retransmits signals in both directions.



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

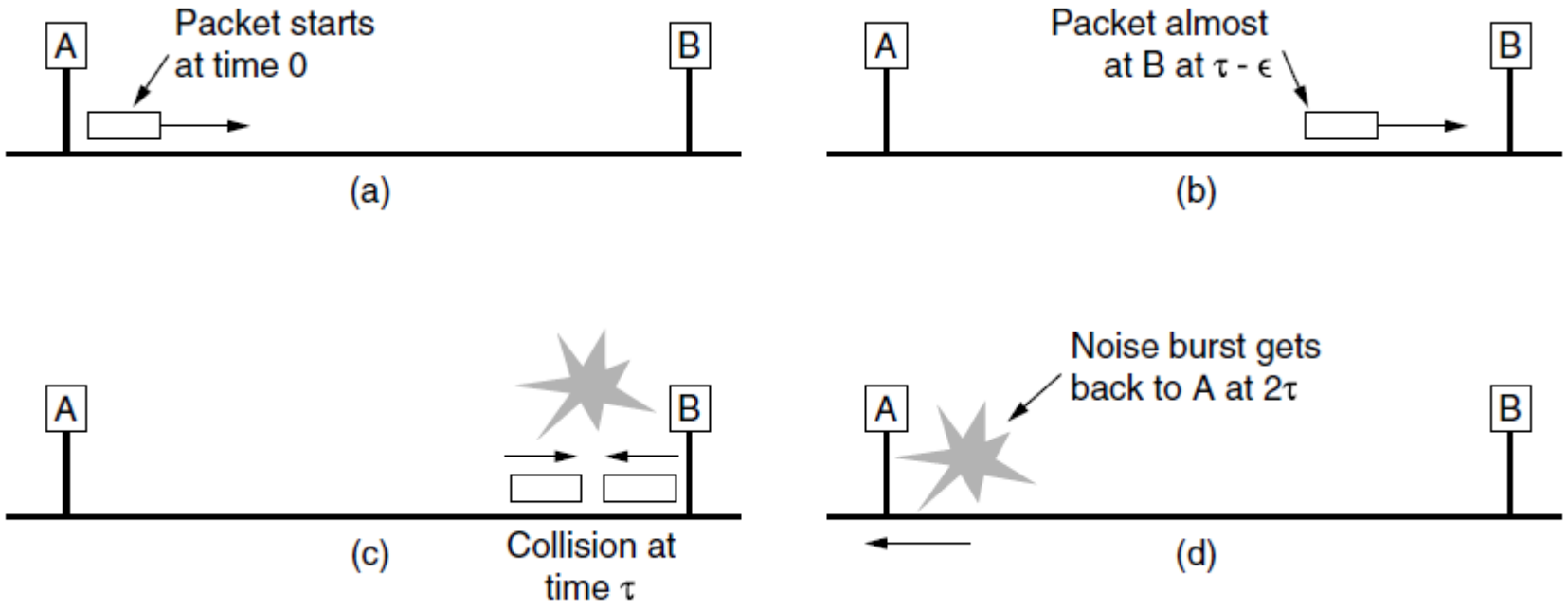
IEEE 802.3



Preamble (7B) – synchronisation between sender and receiver
Start of Frame (1B) – FLAG bytes
Dest. & Source addresses (6B + 6B) – to identify sender and receiver
Type or Length (2B) – specifies which process to give the frame to (0x0800 means data contains IPv4)
Data (0~1500B)
Pad(0~46B) – minimum size of the message of the Ethernet is 64 Bytes
CRC (4B) – 32 bits checksum

Classic Ethernet Minimum Packet 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 minimum packet size for reliable detection



MAC Addressing

- Source and Destination Addressing can be done at a local or global levels
- The **MAC Address** provides the unique identifier for a physical interface
- MAC Address is a 48-bit number encoded in the frame, written in hexadecimal notation

  e.g. 00:02:2D:66:7C:2C

Ethernet Performance

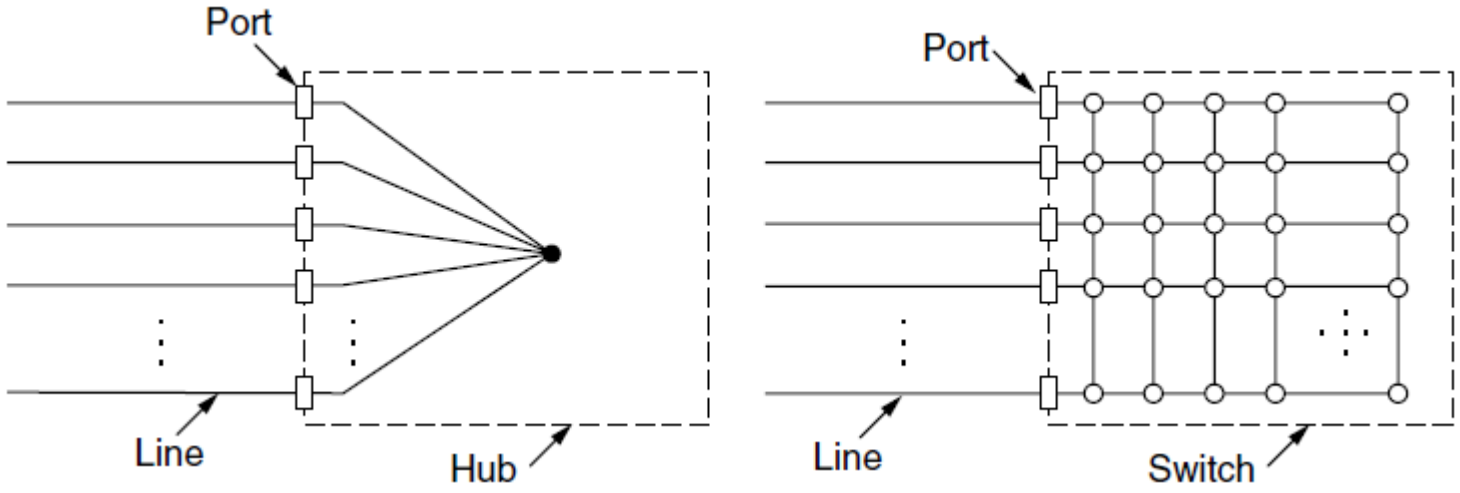
$$\textbf{Channel Efficiency} = \frac{1}{1+(2BLe)/(cF)}$$

- F: frame length
- B: bandwidth
- L: cable length
- c: speed of signal propagation; e: constant ≈ 2.71828
- Optimal case: e contention slots per frame

- 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 CSMA/CD with full-duplex lines



Summary of Multiple Access Protocols

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