CS 181AG
Lecture 2

Media Access Control

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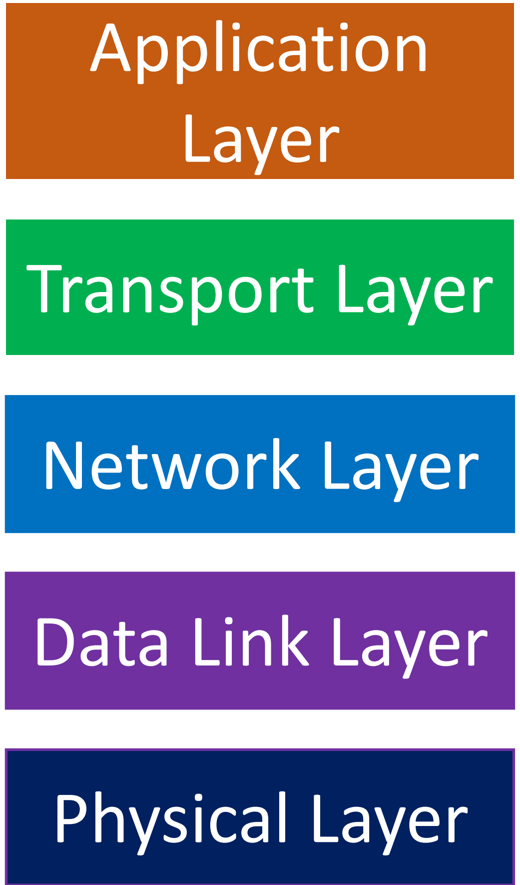
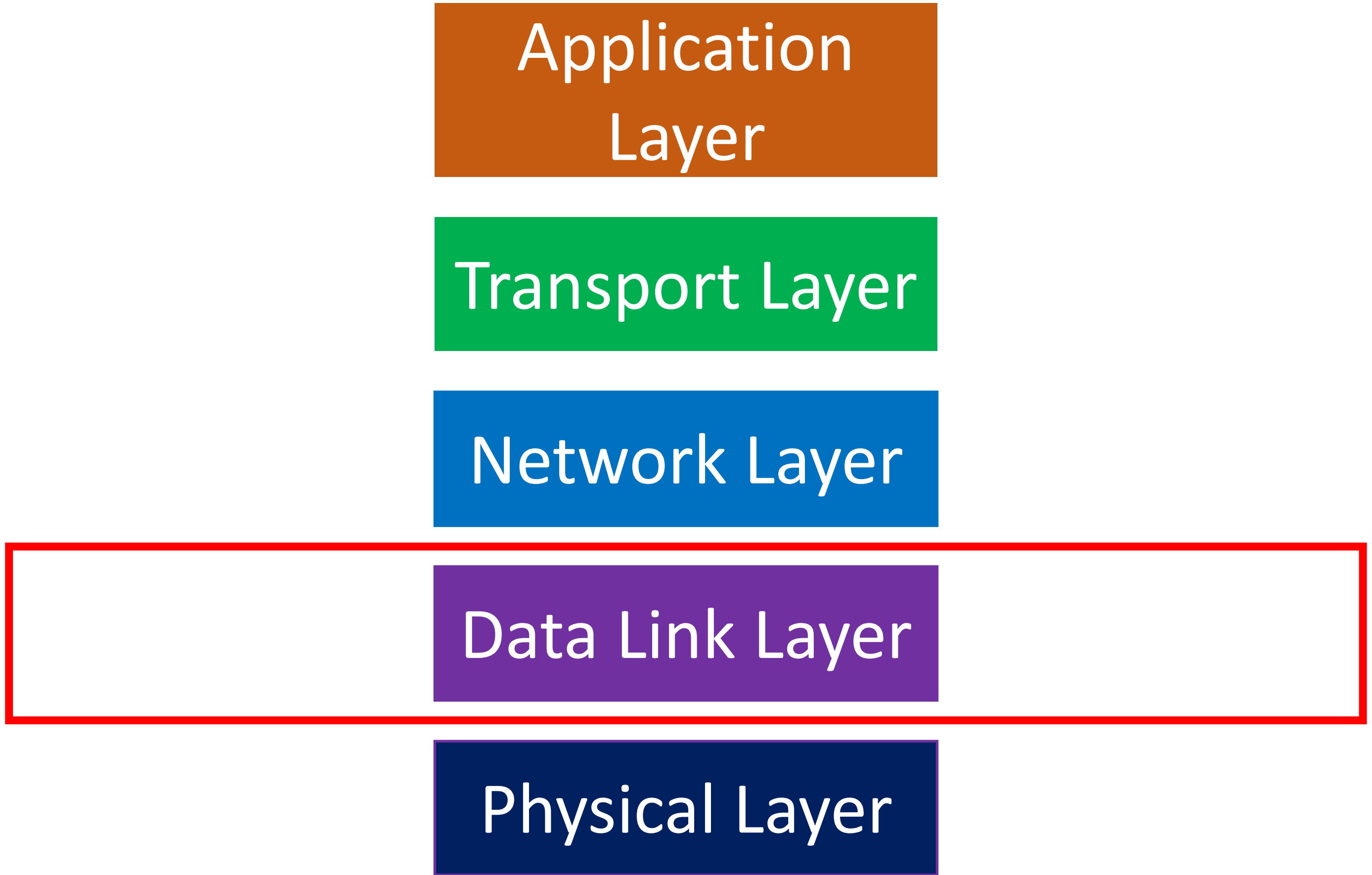
Aug 31, 2022

Last time: Communication Layers



Last time: Communication Layers

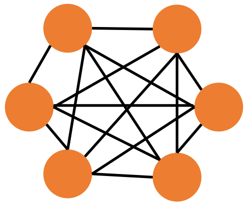
- Today: how do we deliver packets along a single hop in a network? AKA Media Access Control, or MAC



Types of links

- Point to point.

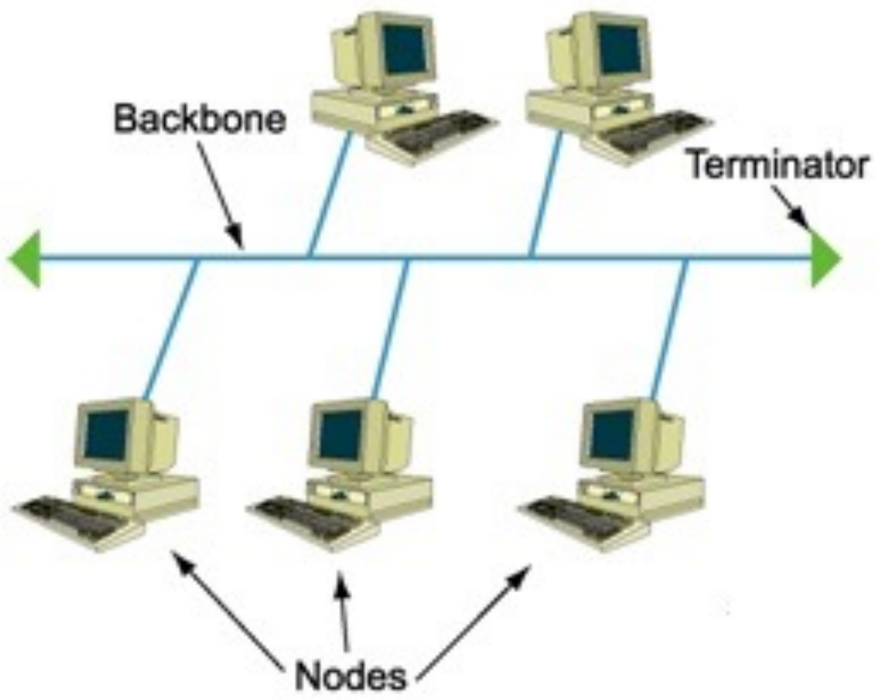
- Broadcast



  - Multiple devices share one medium
  - Why not all point-to-point?

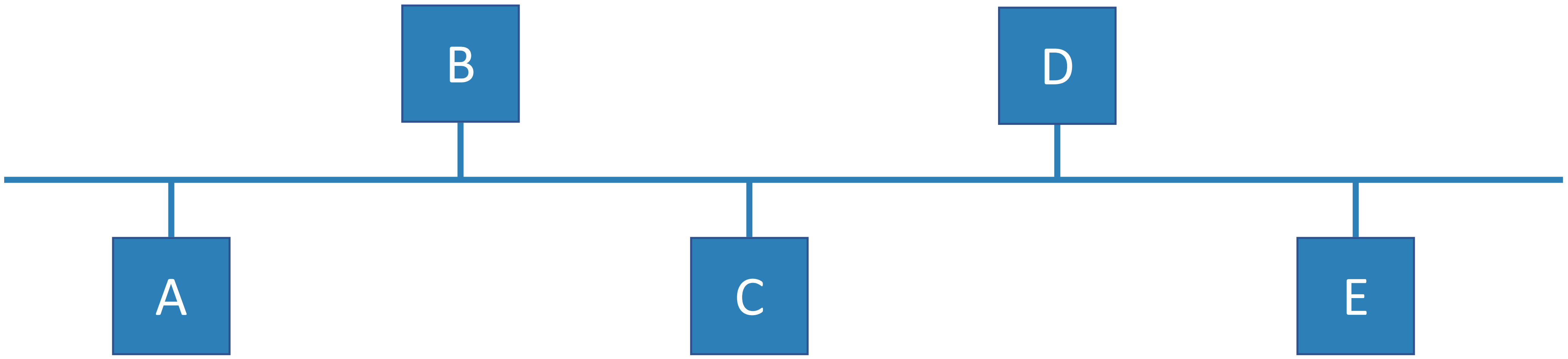
Local Area Networks (LAN)

- Originally, a local network was simply a wire (broadcast) with multiple devices (nodes) connected to it



LAN

- Any message sent using the whole wire is heard by everyone
- Each device is identified by a unique address: MAC address
- “Frame” – unit of transmission across medium (conceptually same as packet)



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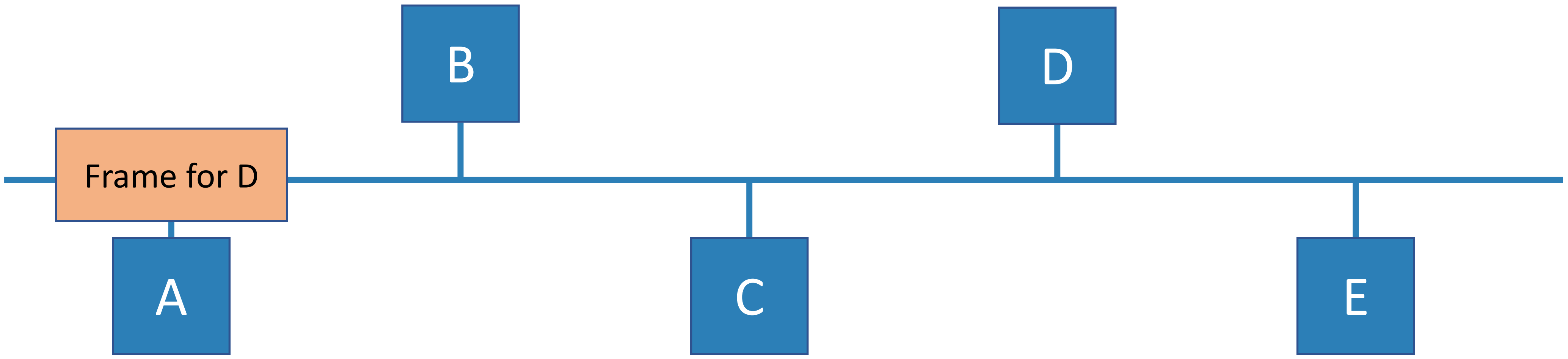

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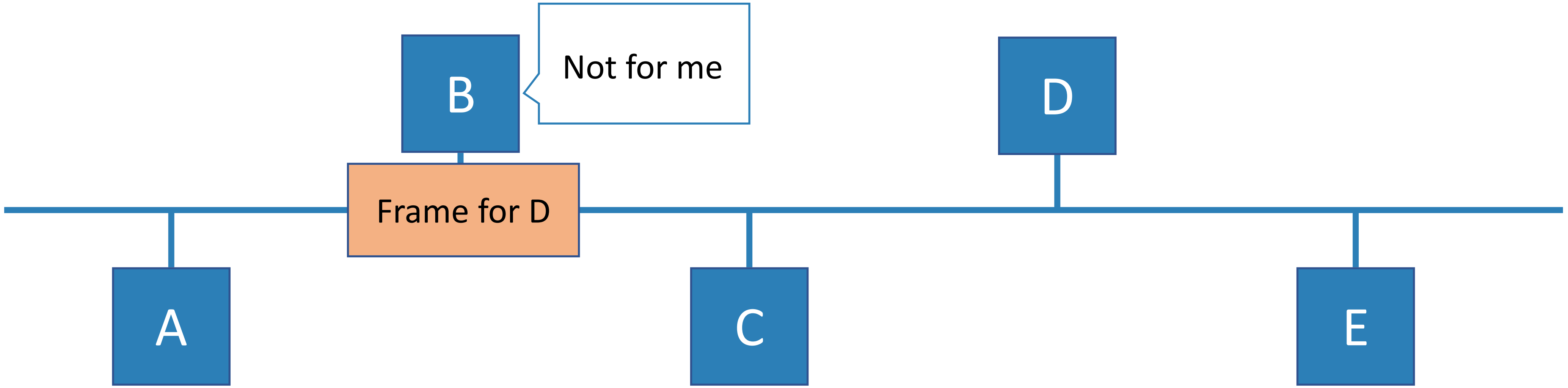

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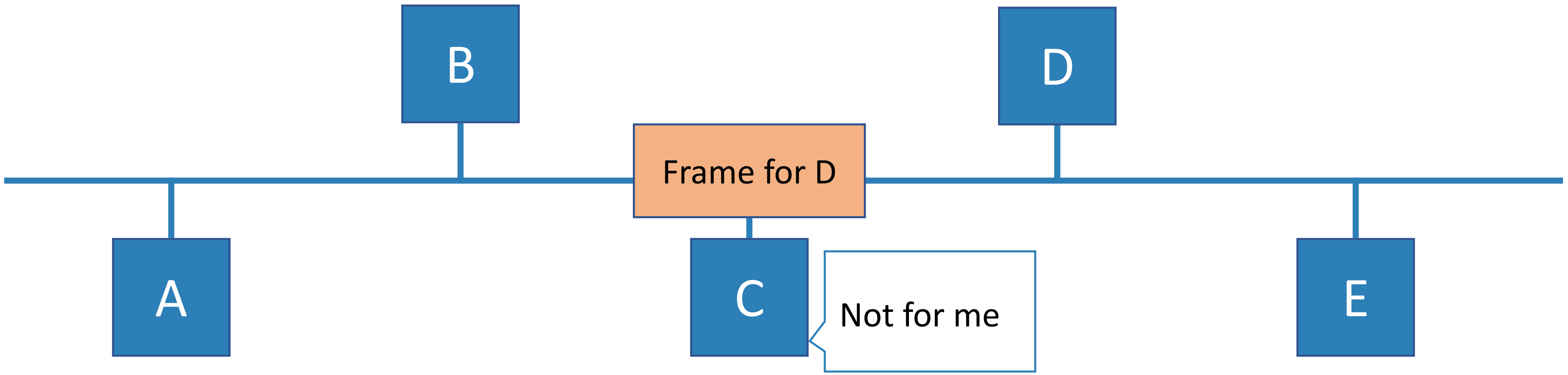

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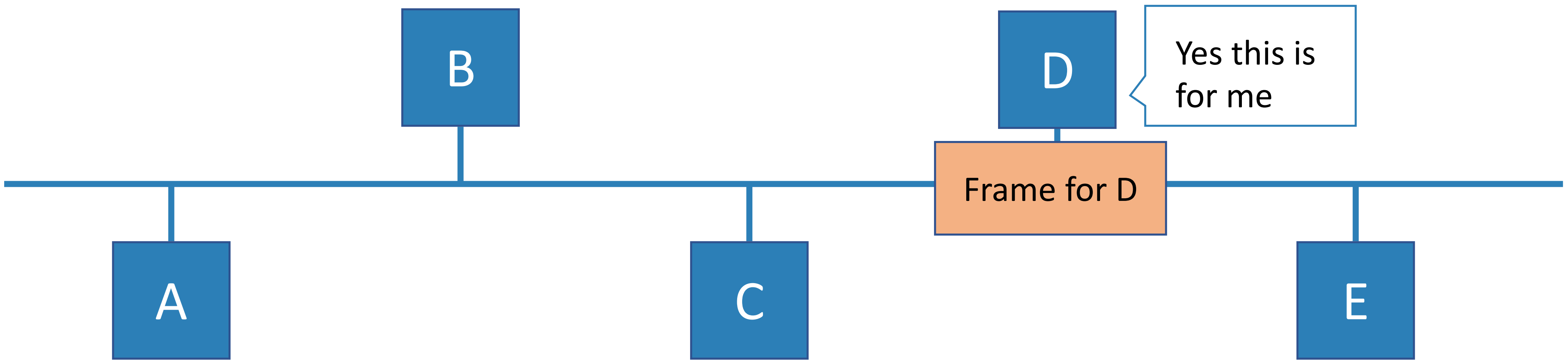

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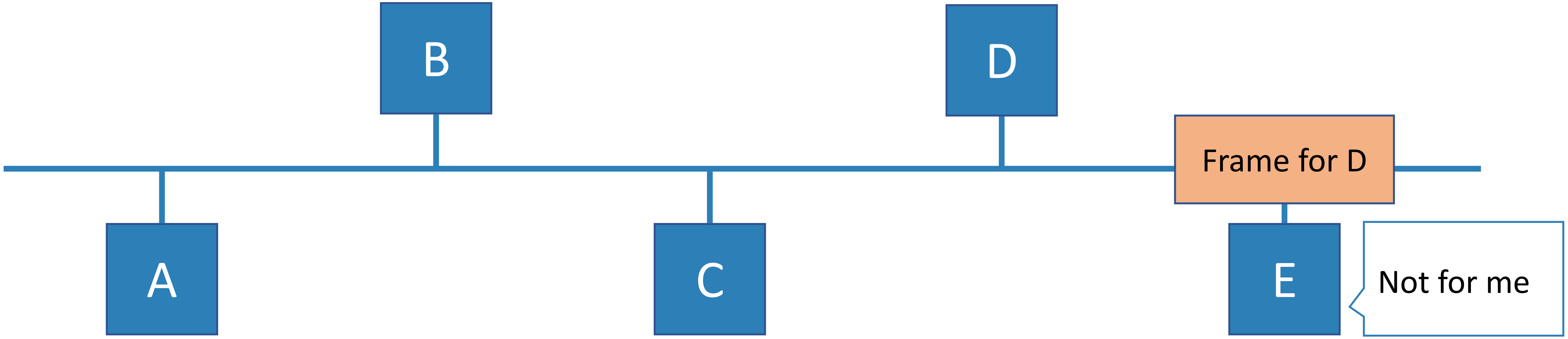
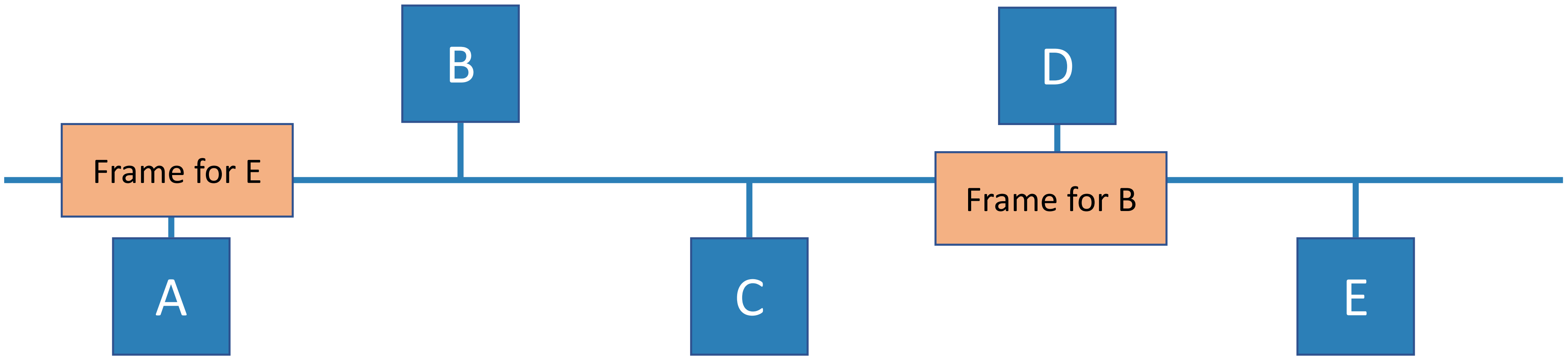


Ethernet Collisions

- Collisions occur when multiple nodes transmit at the same (or similar) times so their transmission overlap on the wire



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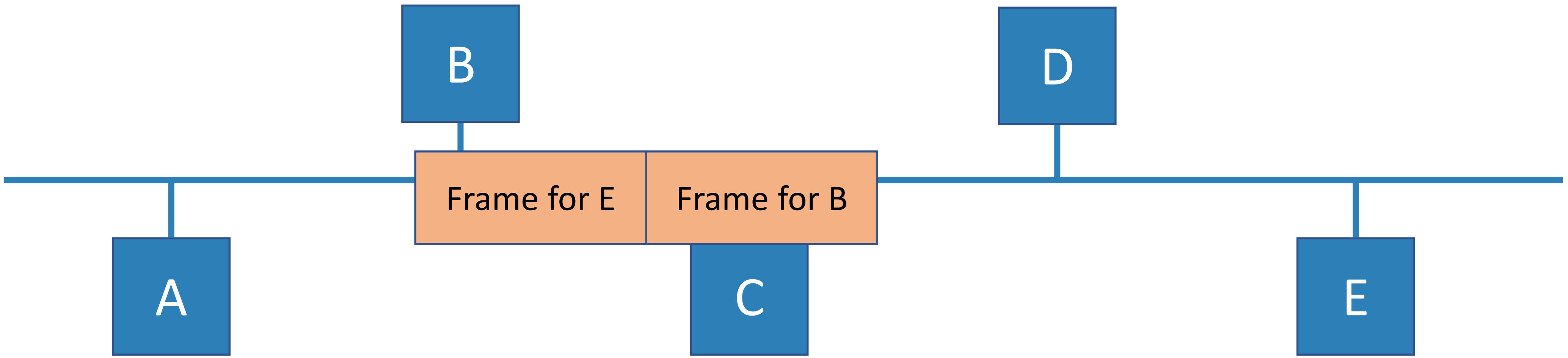
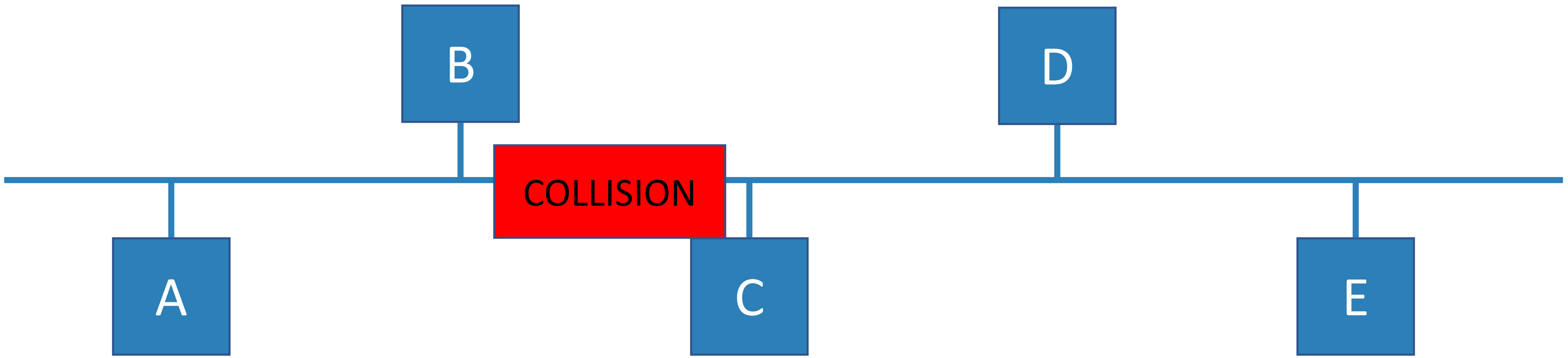


Ethernet Collisions

- Collisions occur when multiple nodes transmit at the same (or similar) times so their transmission overlap on the wire
- Result: both messages fail to be sent



Multiple people talking in a room

- Come up with 2 ways to differentiate conversations

Media Access Control Goals

- Mediate access to medium among nodes
- Properties of ideal MAC protocol (given channel of rate R bps):
  - When only one node wants to send, it can send at R bps
  - When M nodes want to transmit, they can send at R/M bps
  - Fully decentralized
  - Simple

MAC Protocols Summary

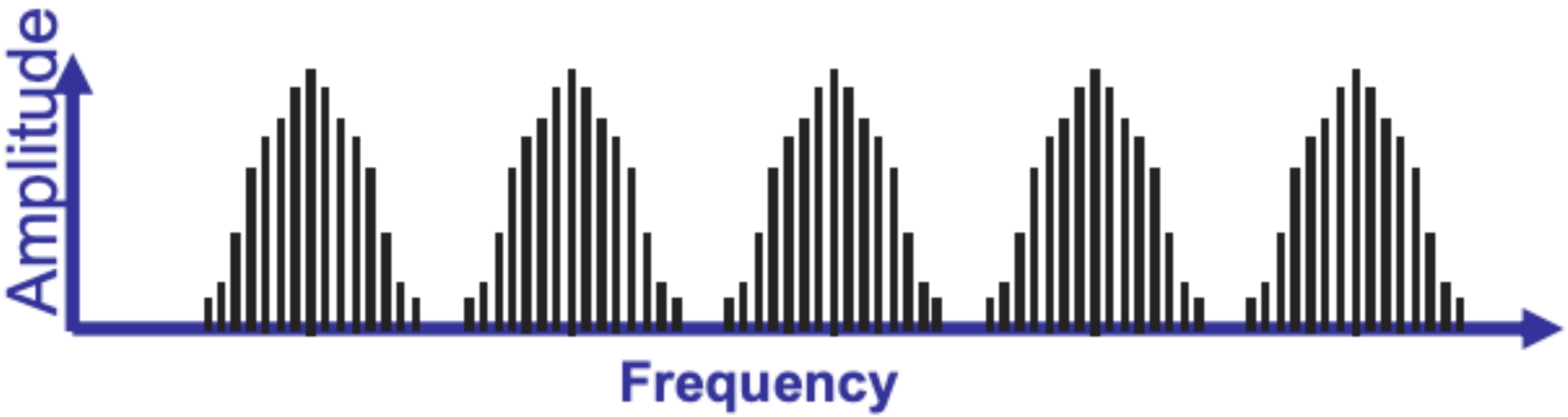
Channel Partitioning Protocols

Random Access Protocols

Controlled-Access Protocols

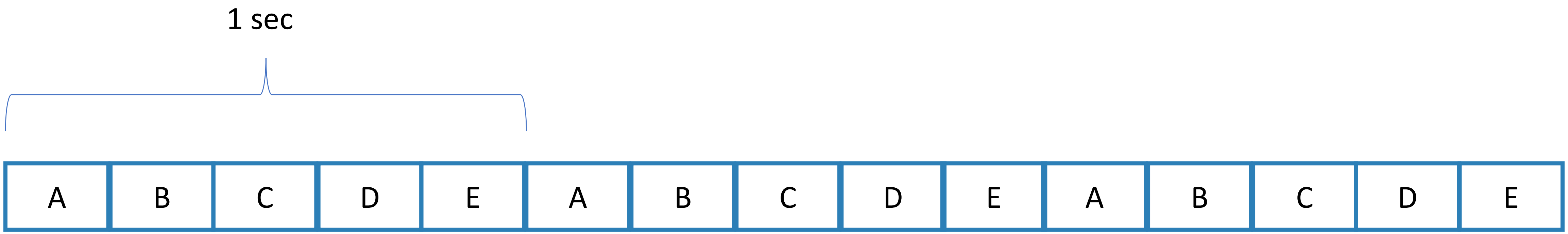
Channel Partitioning

- Frequency **(FDMA)**: divide channel bandwidth between M nodes
  - Used by radio, TV
  - Disadvantage?



Channel Partitioning

- Time **(TDMA)**: Divide channel into rounds of n time slots, assign different nodes to different time slots
  - Example: 5 slots (200 ms each)

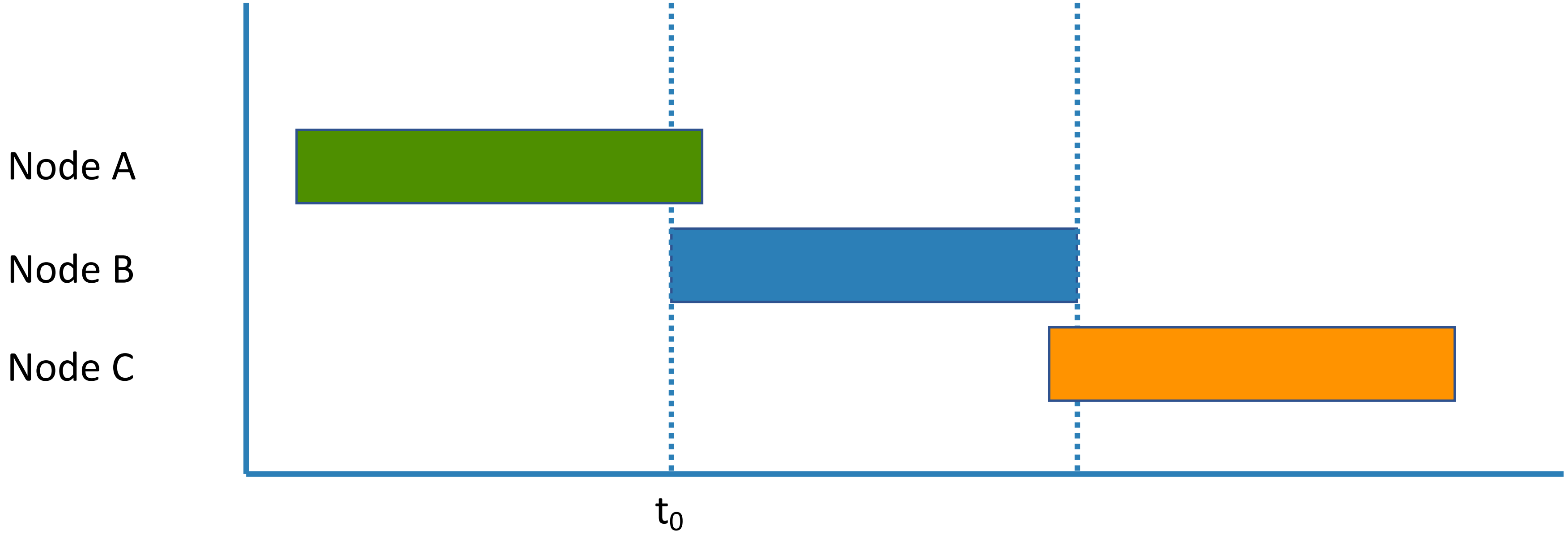


Channel Partitioning

- Channel partitioning is not well suited for low loads and hard to coordinate
- Instead, what if we let collisions occur and dealt with them?
  - Random Access Protocols!

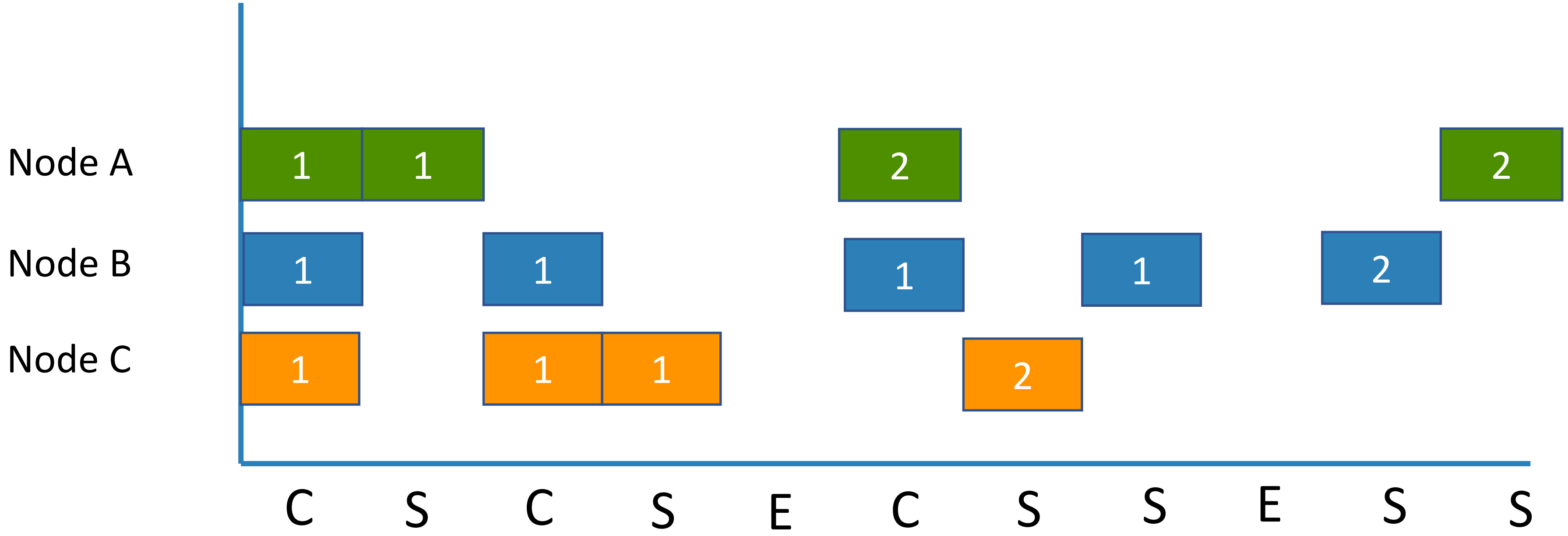
Random Access: Aloha

- When you have data, go ahead and **send it**
- If data doesn't get through (no acknowledgement), retransmit after some **random delay**
- Frames sent at t_0 will overlap with frames sent in $[t_0 - 1, t_0 + 1]$



Random Access: Slotted Aloha

- Time is divided in equal size slots
- When you have data, **wait until next slot to send it**
- If no acknowledgment, retransmit after a random delay
- Requires time synchronization between nodes

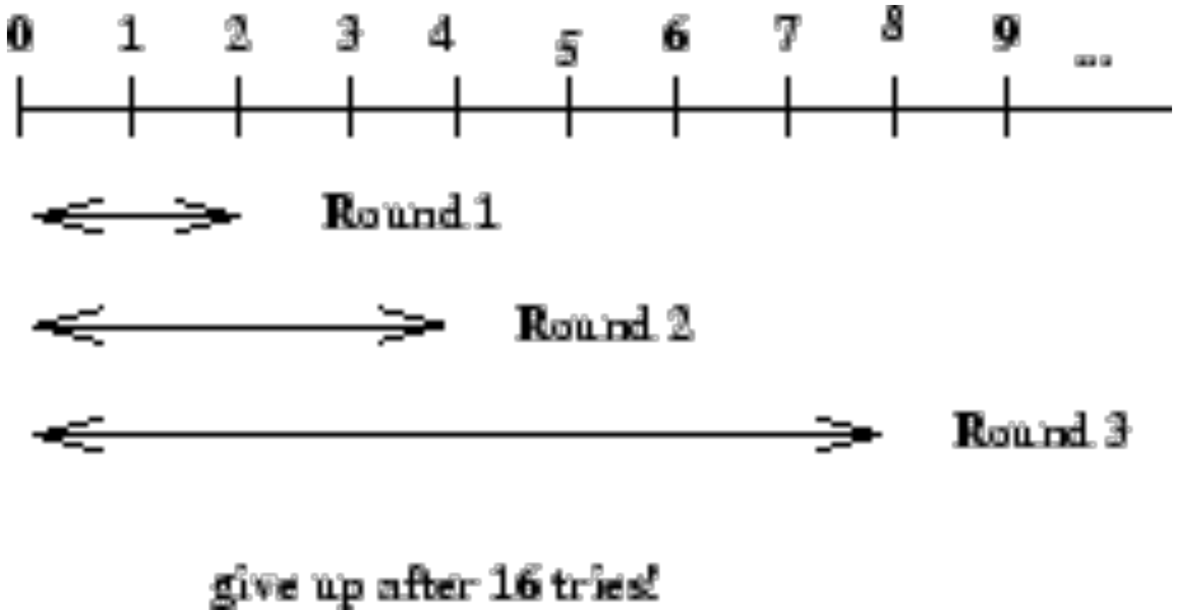


Carrier Sense (CSMA)

- Listen to the wire first. If another node is transmitting, wait
- If you hear someone else talking, don't talk
- Retransmission options:
  - Non-persistent: try listening again later
  - 1-persistent: keep listening and send when channel is idle
    - Problem?
  - p-persistent: keep listening and send with probability p when channel is idle (only if slotted)
- Better backoff scheme than completely random?

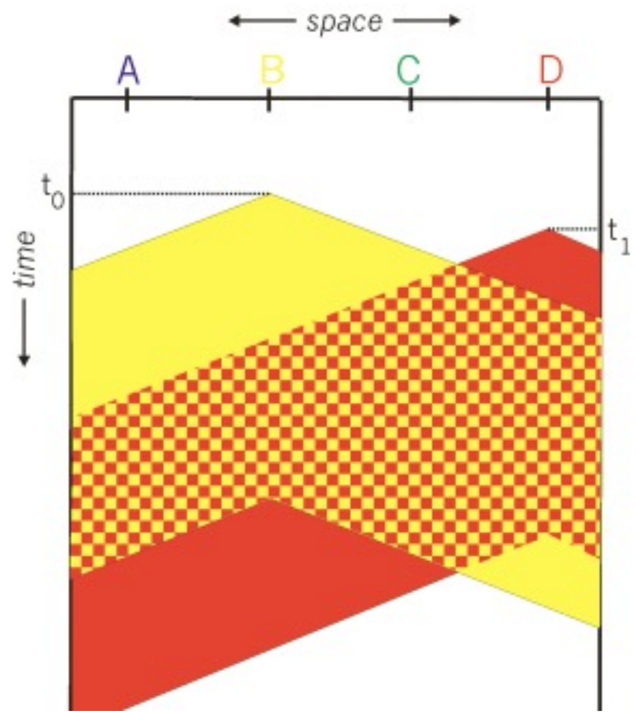
Exponential Backoff

- First collision: choose K from {0, 1} and wait K*512 bit times
- Next collision: choose K from {0, 1, 2, 3} and wait K*512 bit times
- Next: choose K from {0, 1, 2, 3, 4, 5, 6, 7} etc.



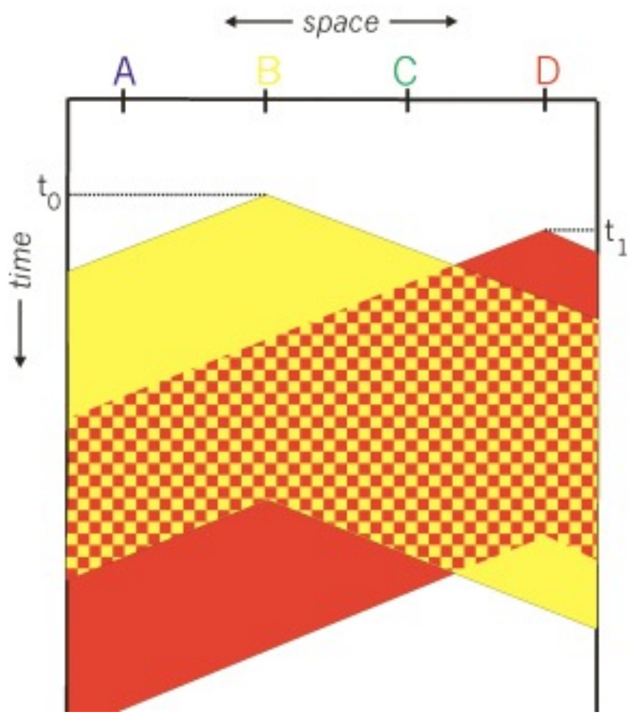
Collisions

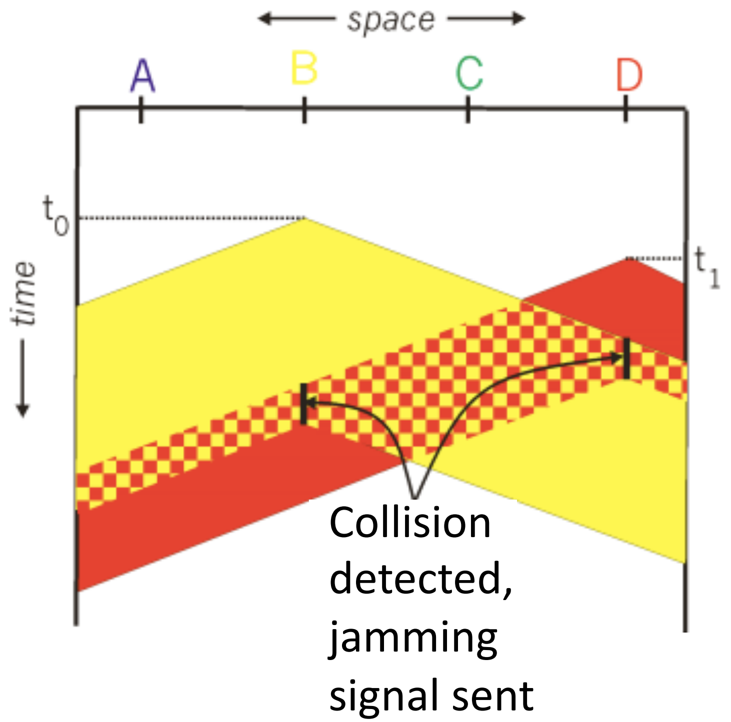
- CSMA lowers the chance of collisions but does not eliminate them
- Collisions waste a lot of time. Can we do better?



Collision Detection

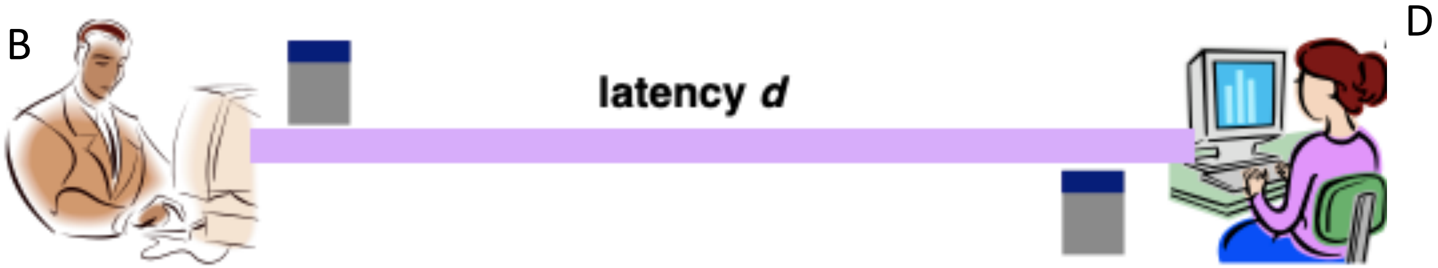
- Each node monitors the medium to listen for collisions
- Listen while you're talking. If you hear someone else's talking as well: collision





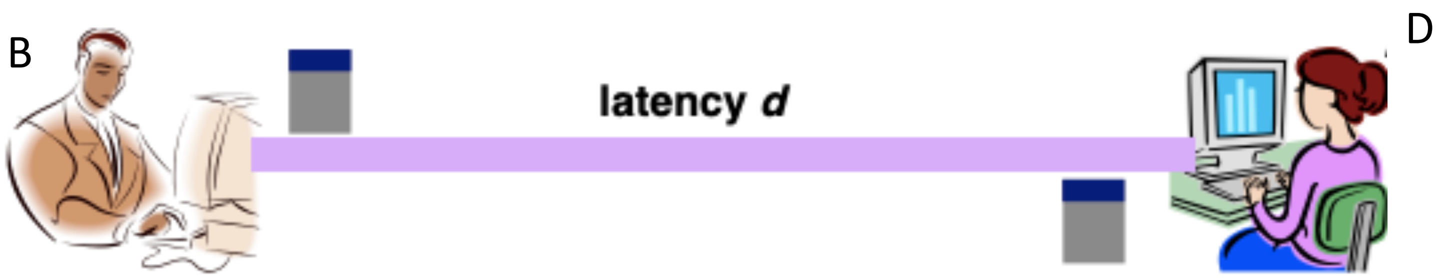
Collision Detection

- If *d* = time to reach D, and B sends at *t*=0, what is the max time at which B detects collision?



- B might not know about a collision until $t + 2d$
- What if B is done sending by then?

Minimum Packet Size



- B might not detect the collision if its packet is too short
- B must keep transmitting during this period
- Min packet size = size needed for B to still be talking when signal makes it to the end of wire and back

Ethernet Specifications

- Ethernet specifies max value of 2d to be 51.2 μs
- This means max distance of 2500 m between nodes (at 10 Mbps)
- So, Ethernet frames must be at least 512 bits (64 bytes) long – pad if not

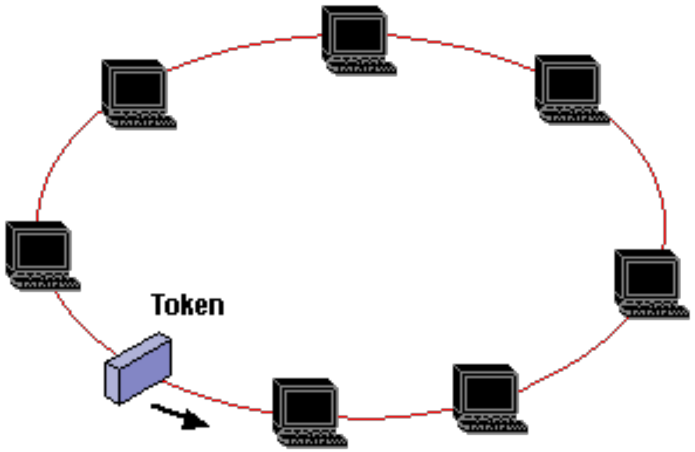
Classic Ethernet (802.3)

- Modified 1-persistent CSMA/CD
- Max length 2500 m
- Exponential backoff
- Hugely successful

Contention-Free Protocols

- Take turns based on who needs to send

Token Ring: token (control) is passed between nodes; if token is free, node can seize control of it



Polling: Master node is chosen. Master collects request to send messages (RTS) from other nodes and chooses who will send (gives clear to send, or CTS messages)

MAC Protocols Summary

Channel Partitioning Protocols

- FDMA
- TDMA
- CDMA

Random Access Protocols

- Aloha
- Slotted Aloha
- CSMA/CD
- CSMA/CA

Controlled-Access Protocols

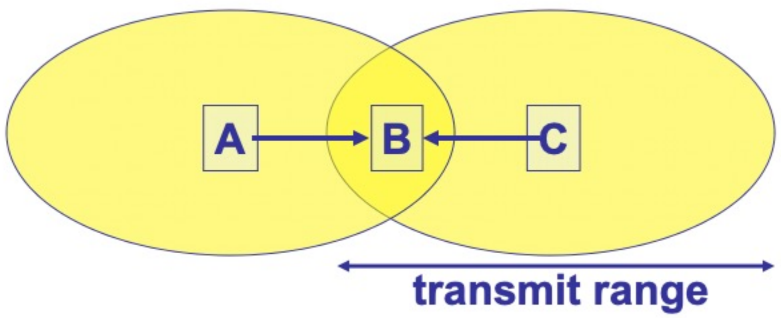
- Token Ring
- Polling

Why Did Ethernet (CSMA/CD) Win?

- More fault tolerant (no single point of failure)
- Good performance in the common case
- Completely distributed – easy to maintain/add/remove

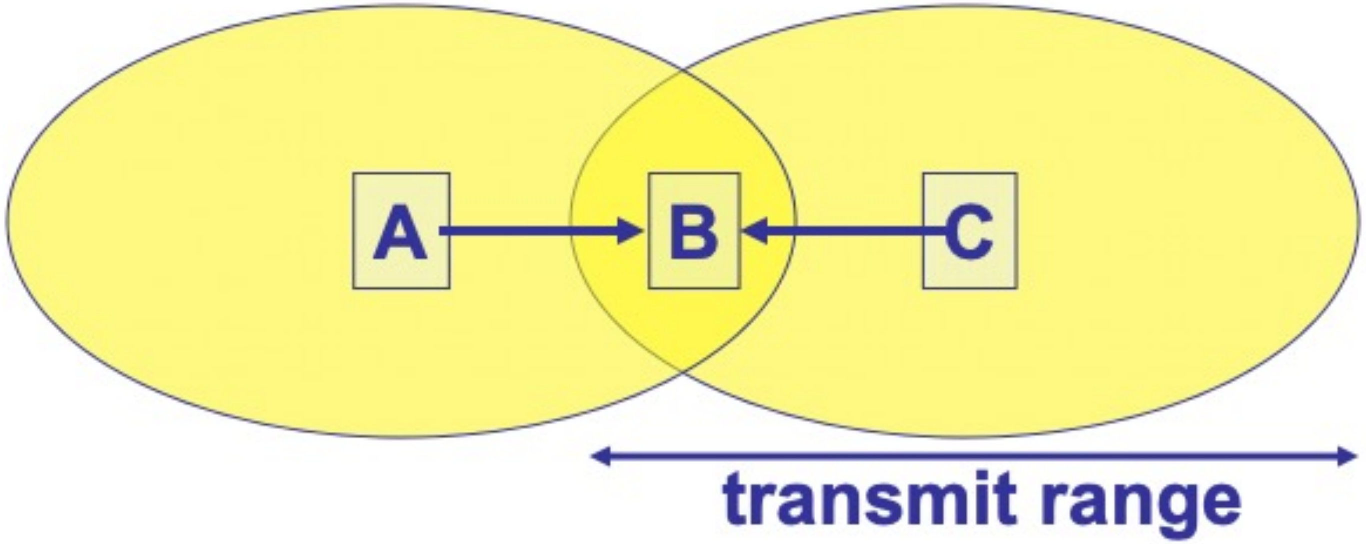
Wireless Protocols

- Different transmitters have different coverage areas



Hidden Terminals Problem

- A and C can both send to B but can’t hear each other
  - A is a hidden terminal for C and vice versa
  - CSMA will be ineffective



Solution

- Collision *avoidance* rather than detection
- Polling: A and C both first send a RTS (request to send). B sends CTS (clear to send) to only one of them

Next Time

- Now we know to to connect multiple devices in a local network. But this is limited in length and number of devices
- Next time: How do we extend these local networks to make them reach more devices?