Application Layer: HTTP (Contd.)

CPSC 433/533, Spring 2021

Anurag Khandelwal

Meeting HTTP Goals

- **Users**
  - Fast downloads (not the same as low-latency communication!)
  - High availability

Improve HTTP to compensate for TCP weak-spots 1

- **Content provider**
  - Happy users (hence, above)
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Caching & Replication 2

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- **Also do some processing**
  - Handle *dynamic* webpages
  - *Transcoding*

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- Requests now sent to CDN's infrastructure…

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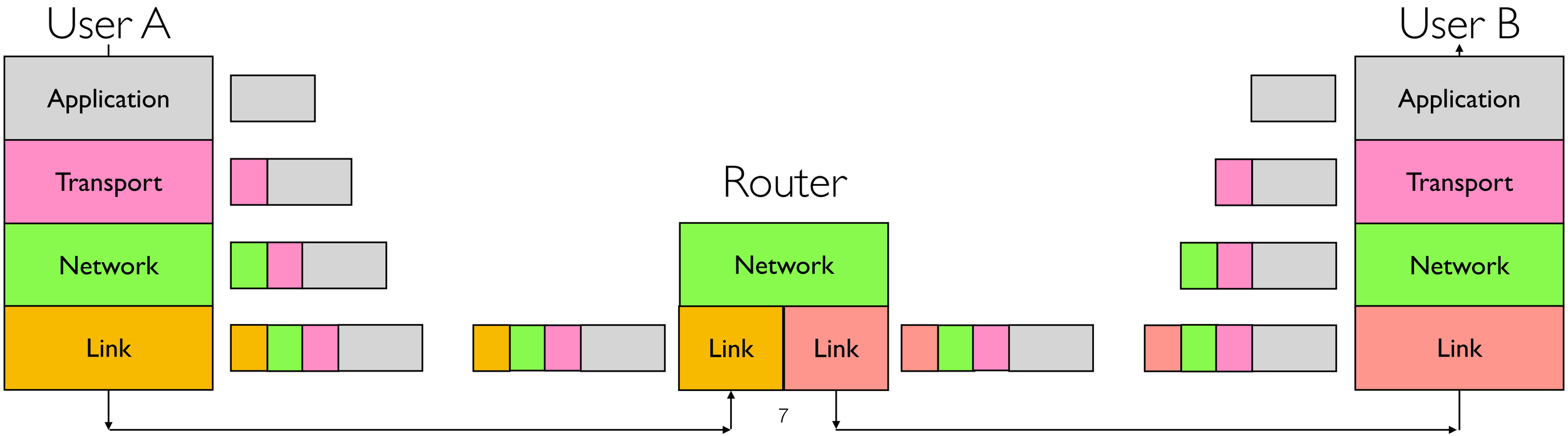
- Examples:
  - Web hosting companies
  - CDNs
  - Cloud infrastructure

Questions?

Taking Stock

Course so far:

- **Concepts, *Overall Architecture***
- **Network Layer,** *Best-effort global delivery of packets*
- **Transport Layer,** *Reliable (or unreliable) delivery of data*
- **Application Layer,** *DNS, HTTP*



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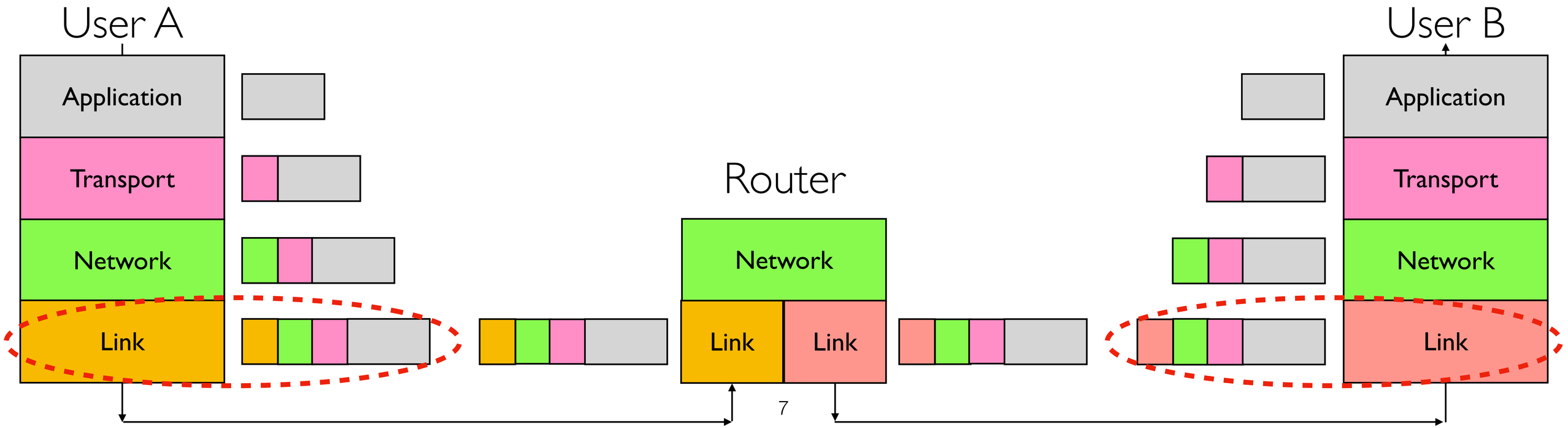
Next:

- **Link Layer,** *Ethernet*



The Link Layer: Ethernet

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Point-to-Point vs. Broadcast Media

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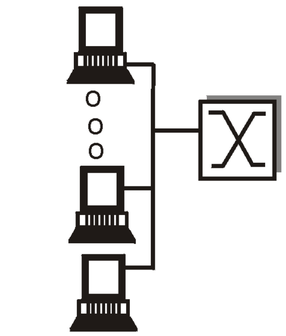
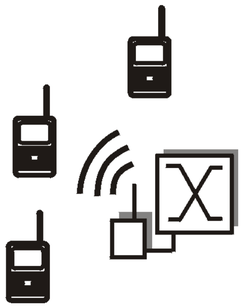


shared wire
(e.g. Ethernet)



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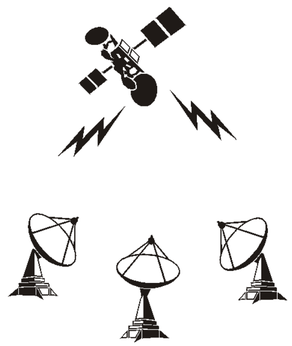

satellite

cocktail party

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- Need distributed algorithm for sharing the channel
- Algorithm determines which node can transmit

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  - Same drawbacks as FDM…
- *Random access:* **allow collisions, and then recover**
  - More in the Internet style!

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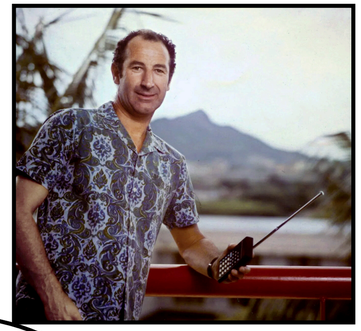
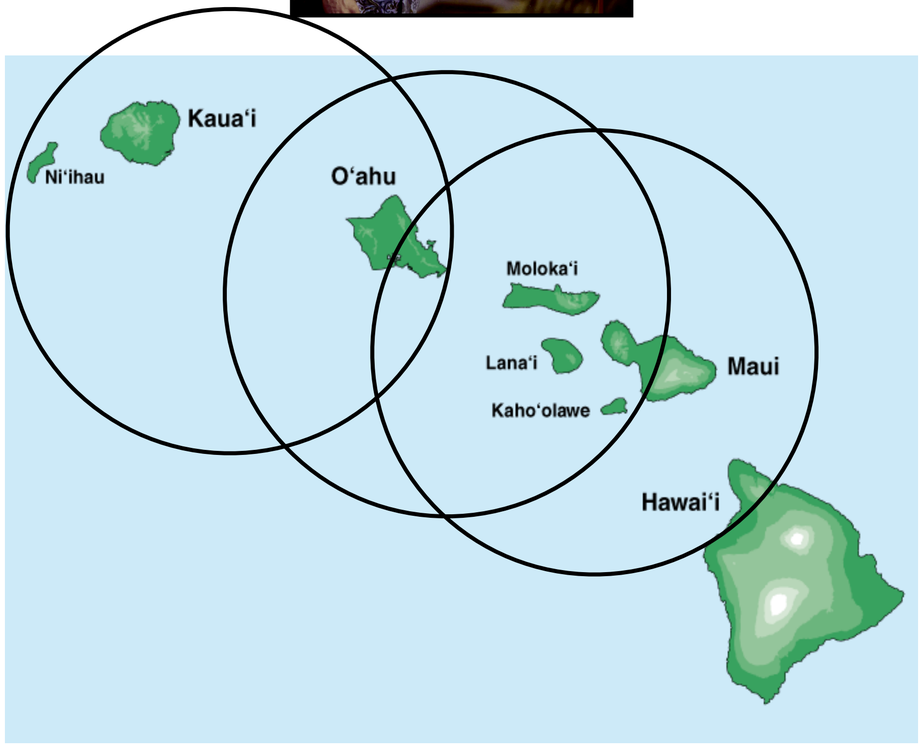
- **Examples**
  - ALOHA and Slotted ALOHA
  - CSMA, CSMA/CD, CSMA/CA (wireless, covered later)

Where it all started: AlohaNet





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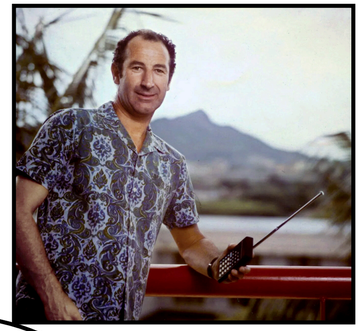

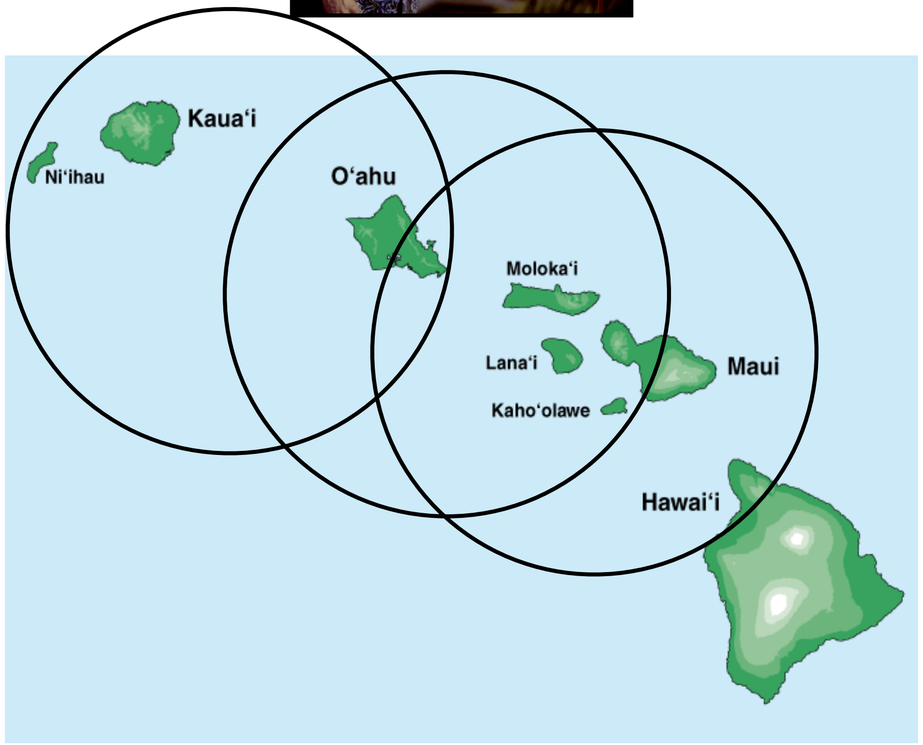

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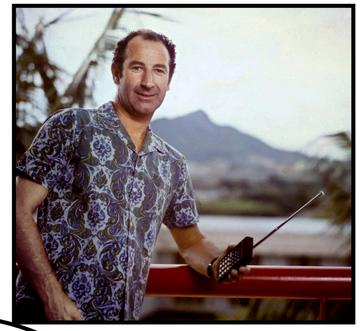

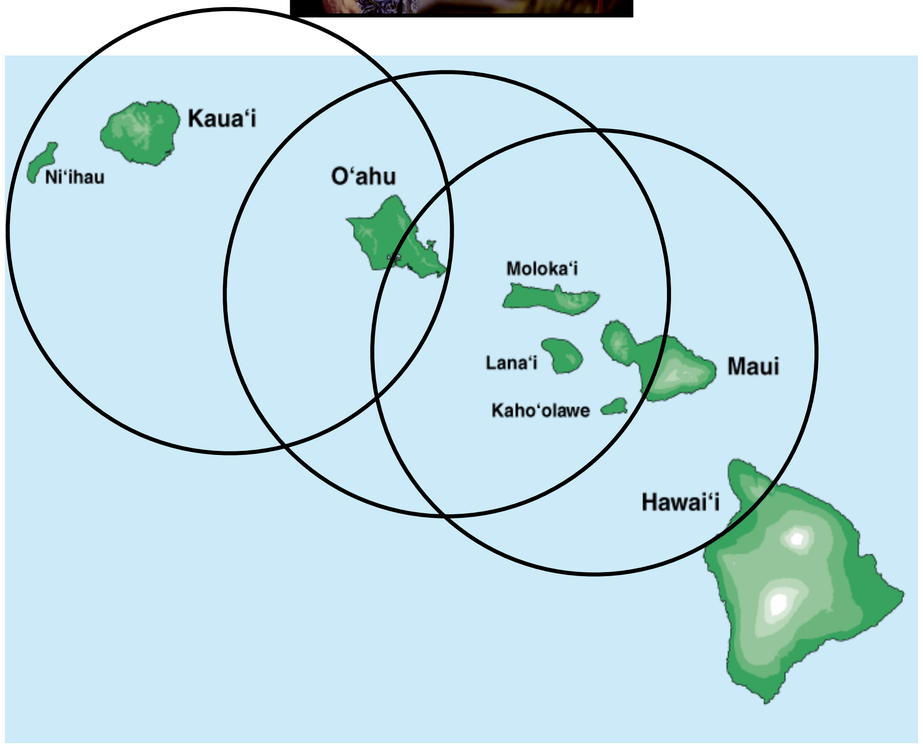

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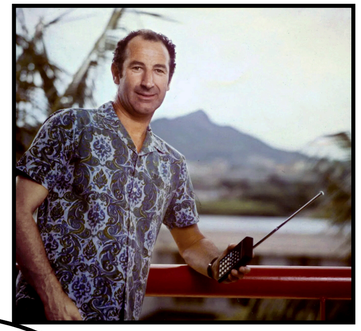

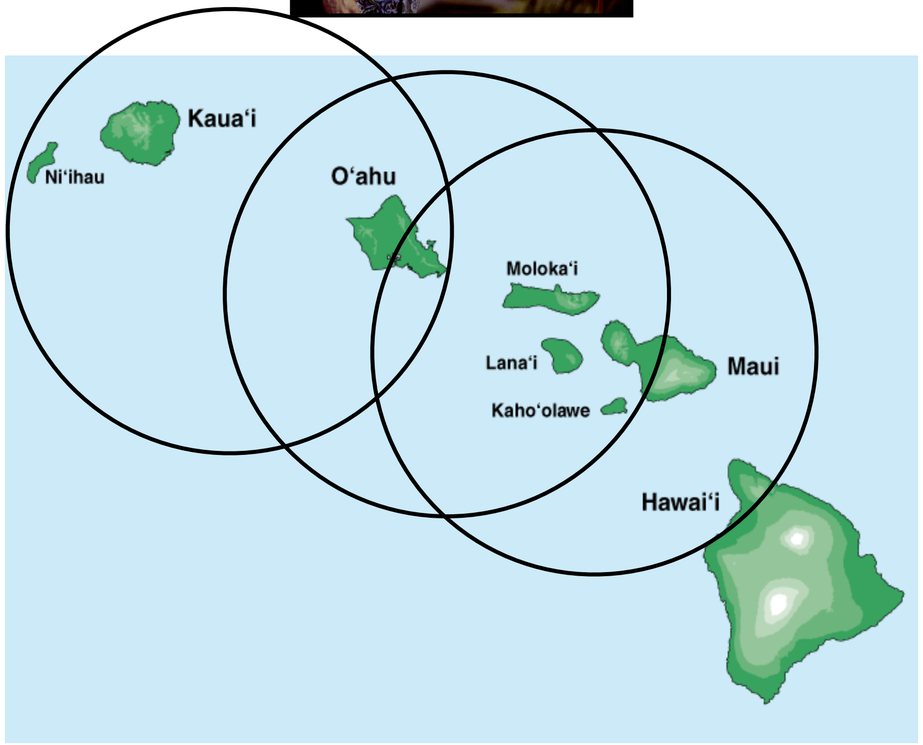

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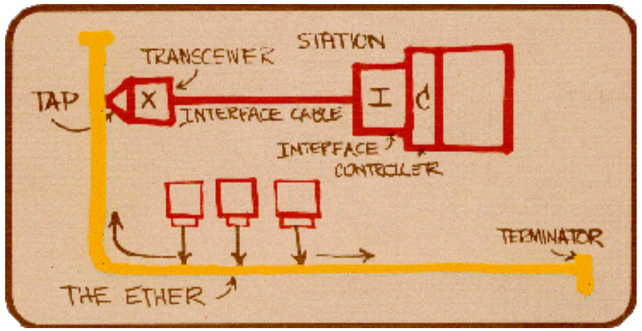
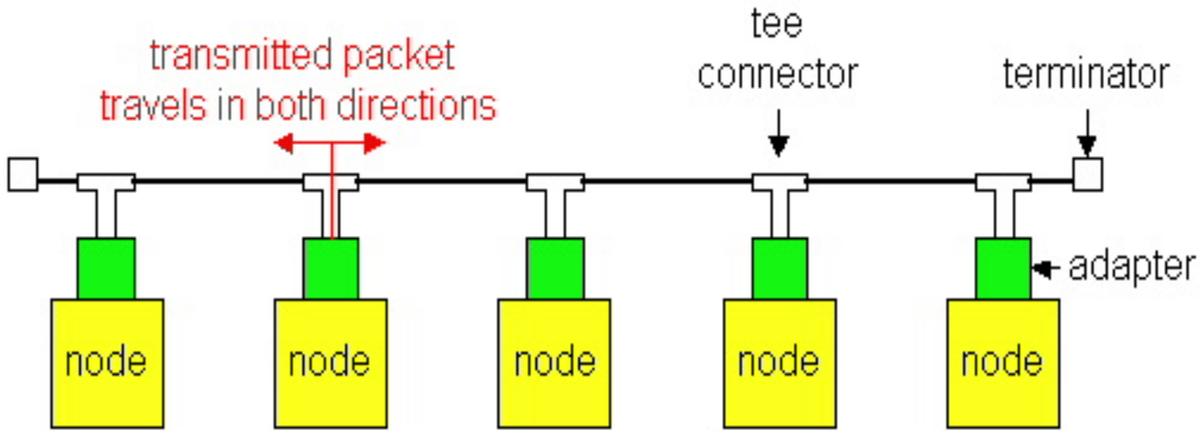
- Hub sends packets to all sites (broadcast channel)
  - Sites can receive even if they are also sending

Ethernet

- **Bob Metcalfe, Xerox PARC, visits Hawaii and gets and idea!**
  - (Maybe we all need to go to Hawaii for good ideas…)
- **Shared wired medium**
  - coax cable





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- **Current Ethernets are "switched" (later)**
  - Point-to-point links between switches; between a host and switch
  - No sharing, no CSMA/CD
  - Uses "self learning" and "spanning tree" algorithms for routing

Questions?

CSMA (Carrier Sense Multiple Access)

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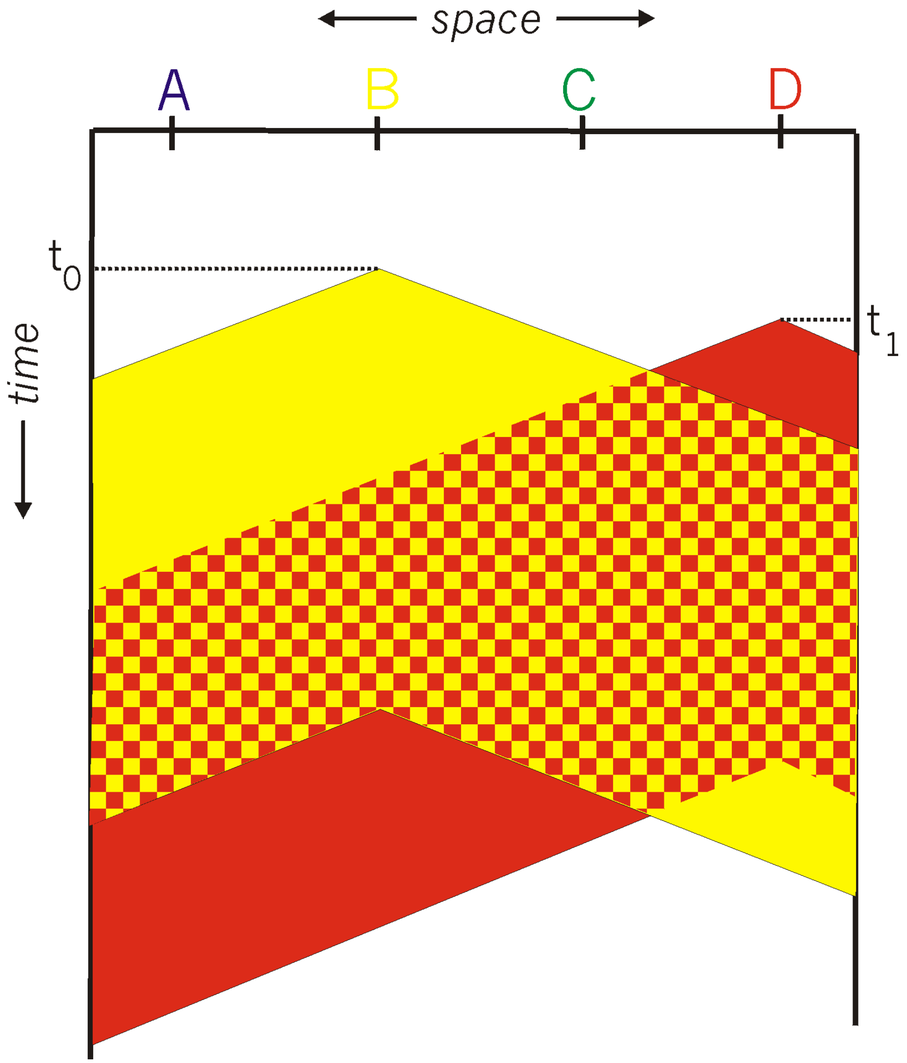
- **Does this eliminate all collisions?**
  - *No*, because of non-zero propagation delay

CSMA Collisions



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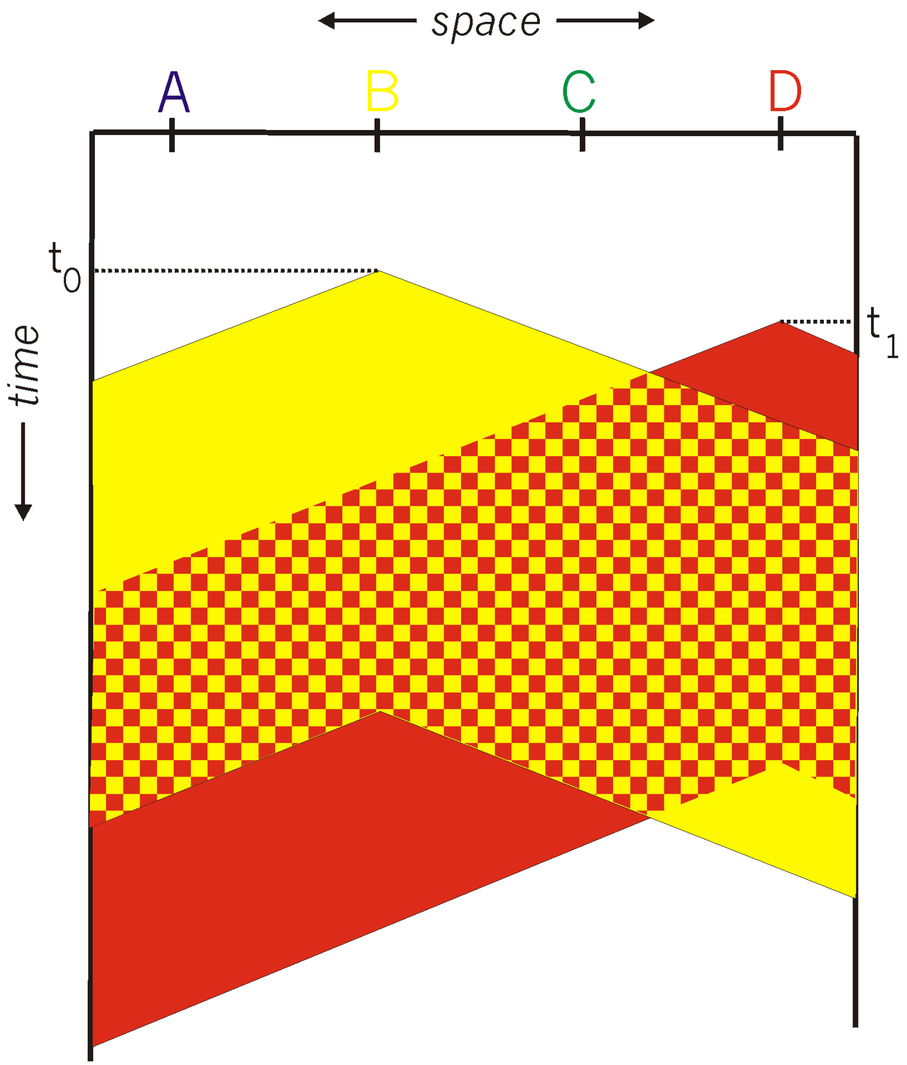

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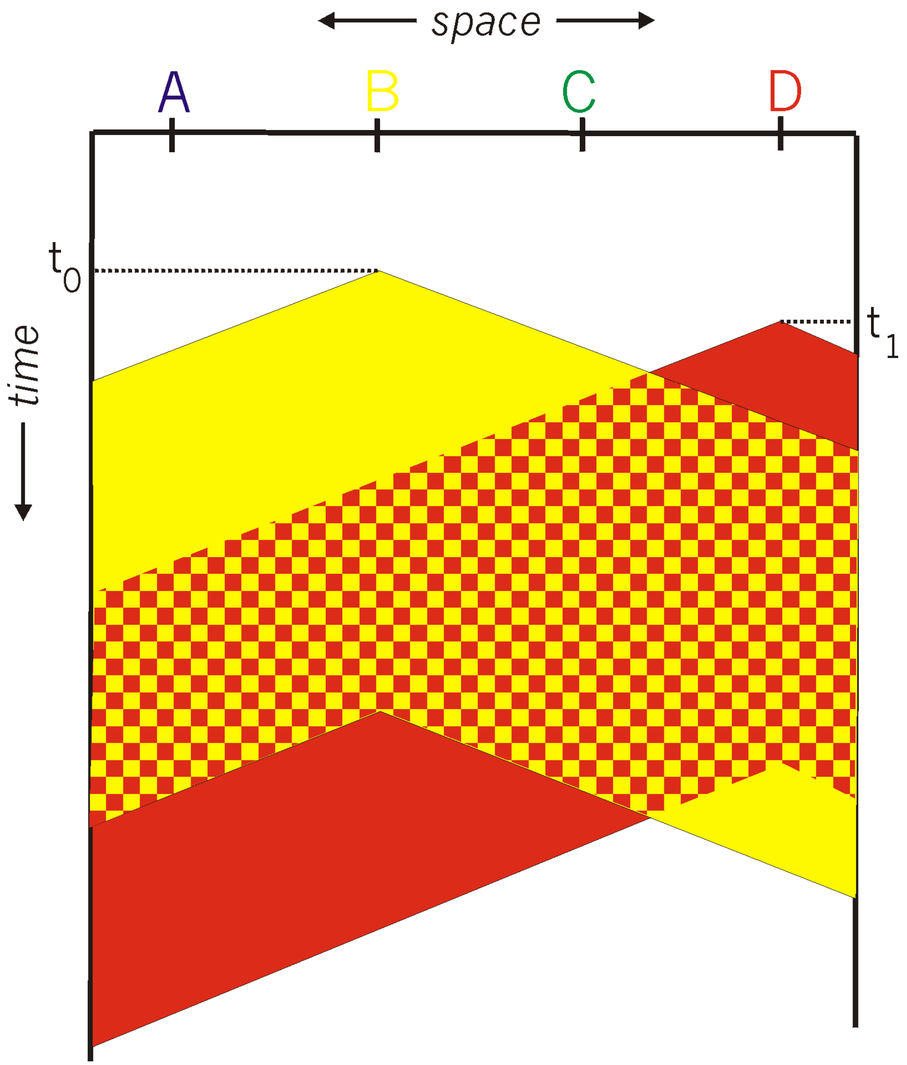

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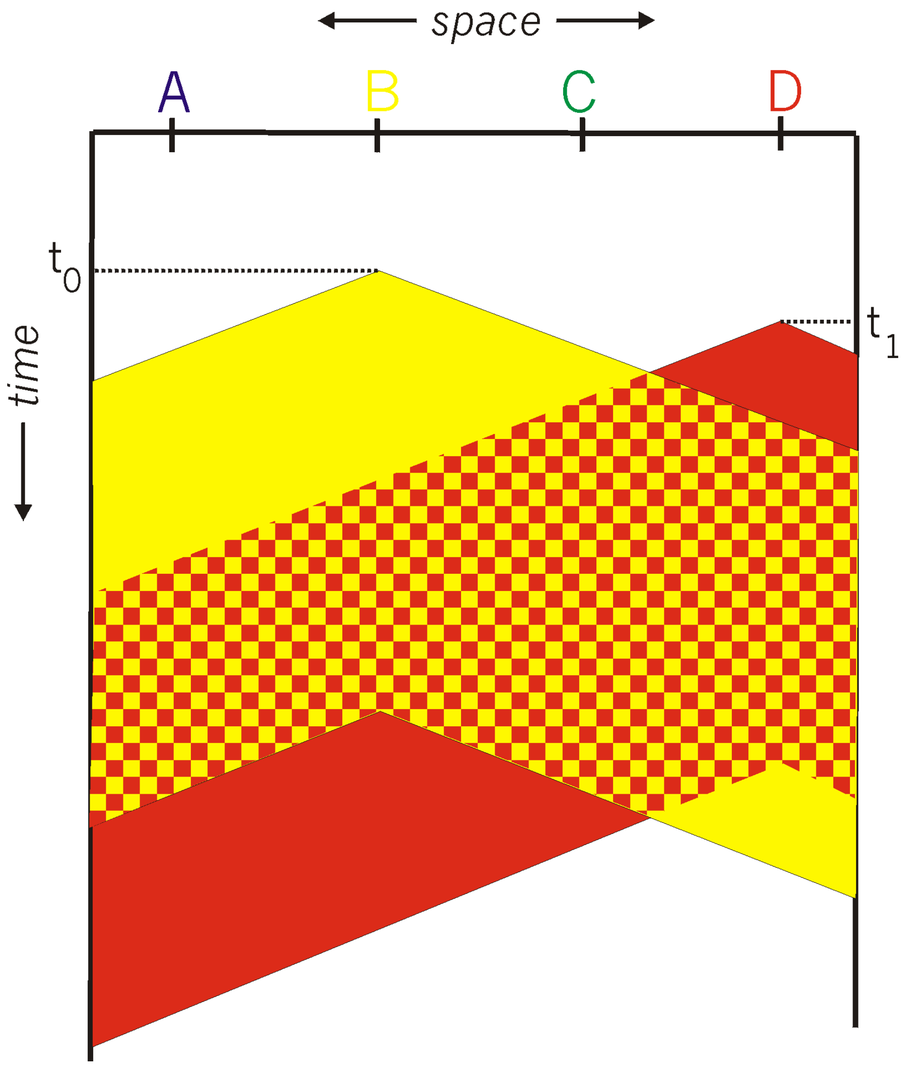

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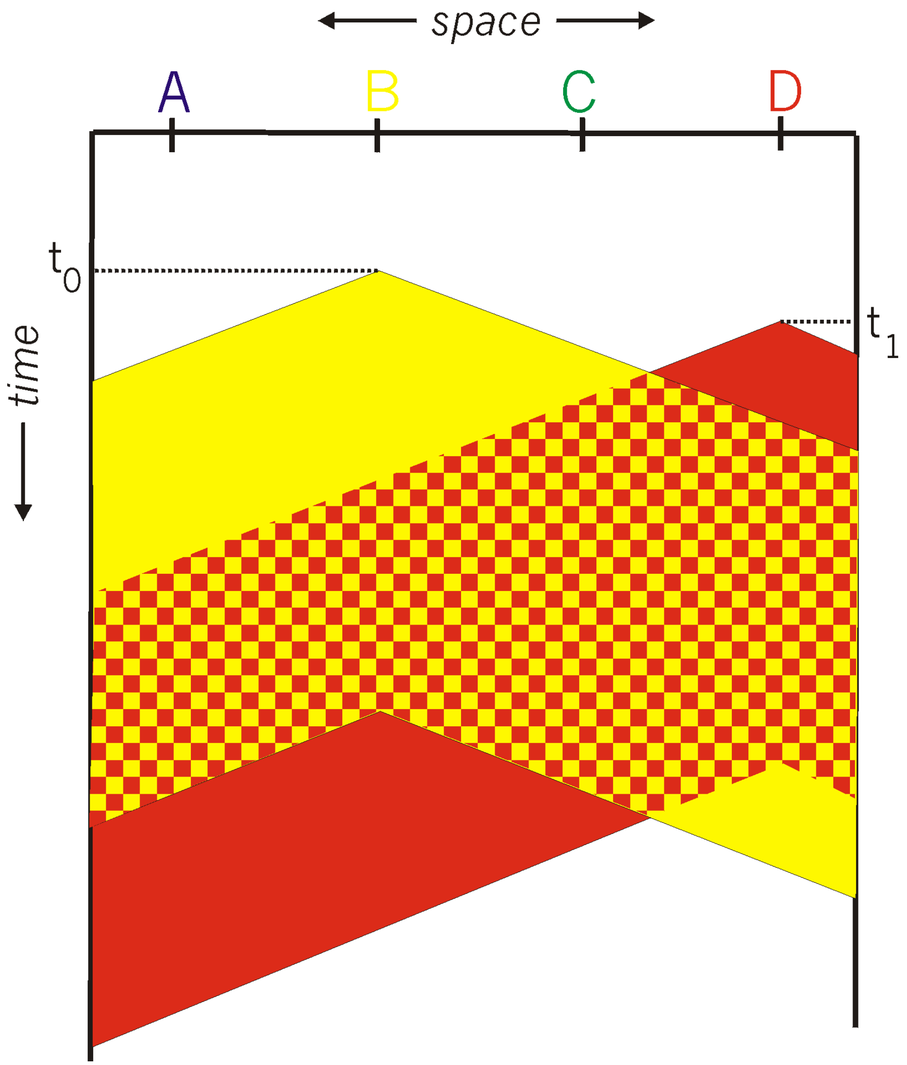

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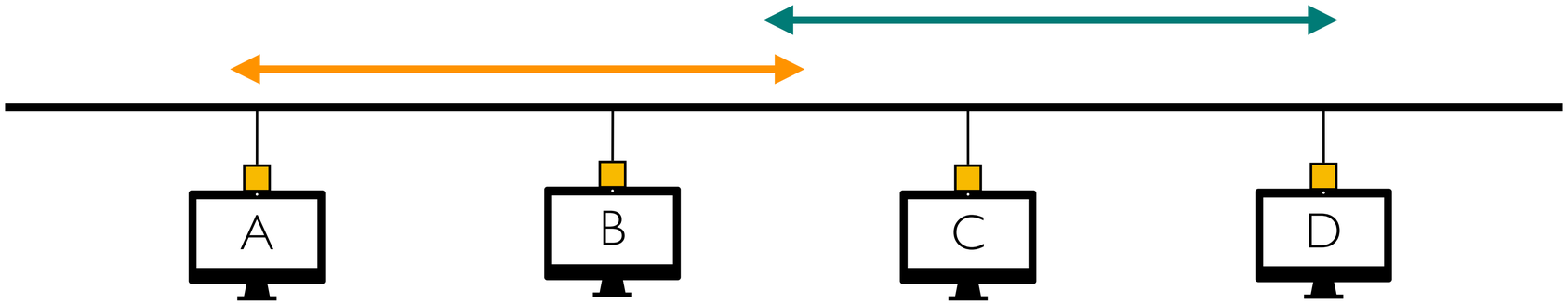

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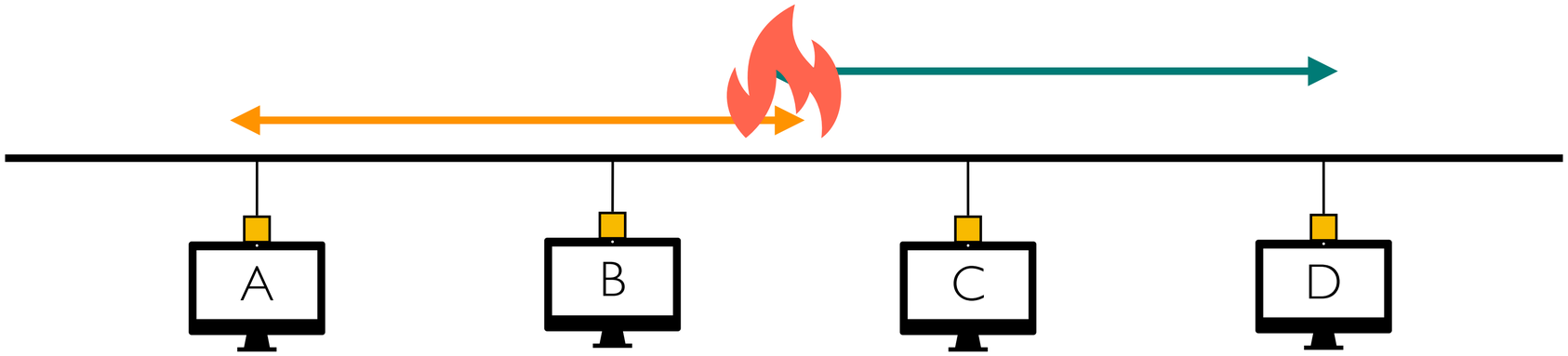

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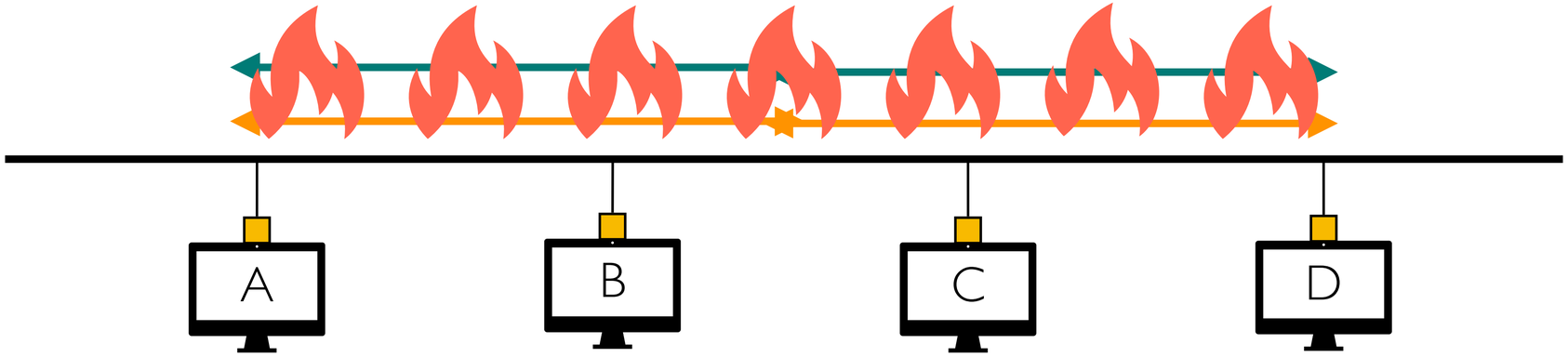

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- **Collision detection difficult in wireless LANs**
  - *Will learn more in Lecture on Wireless*

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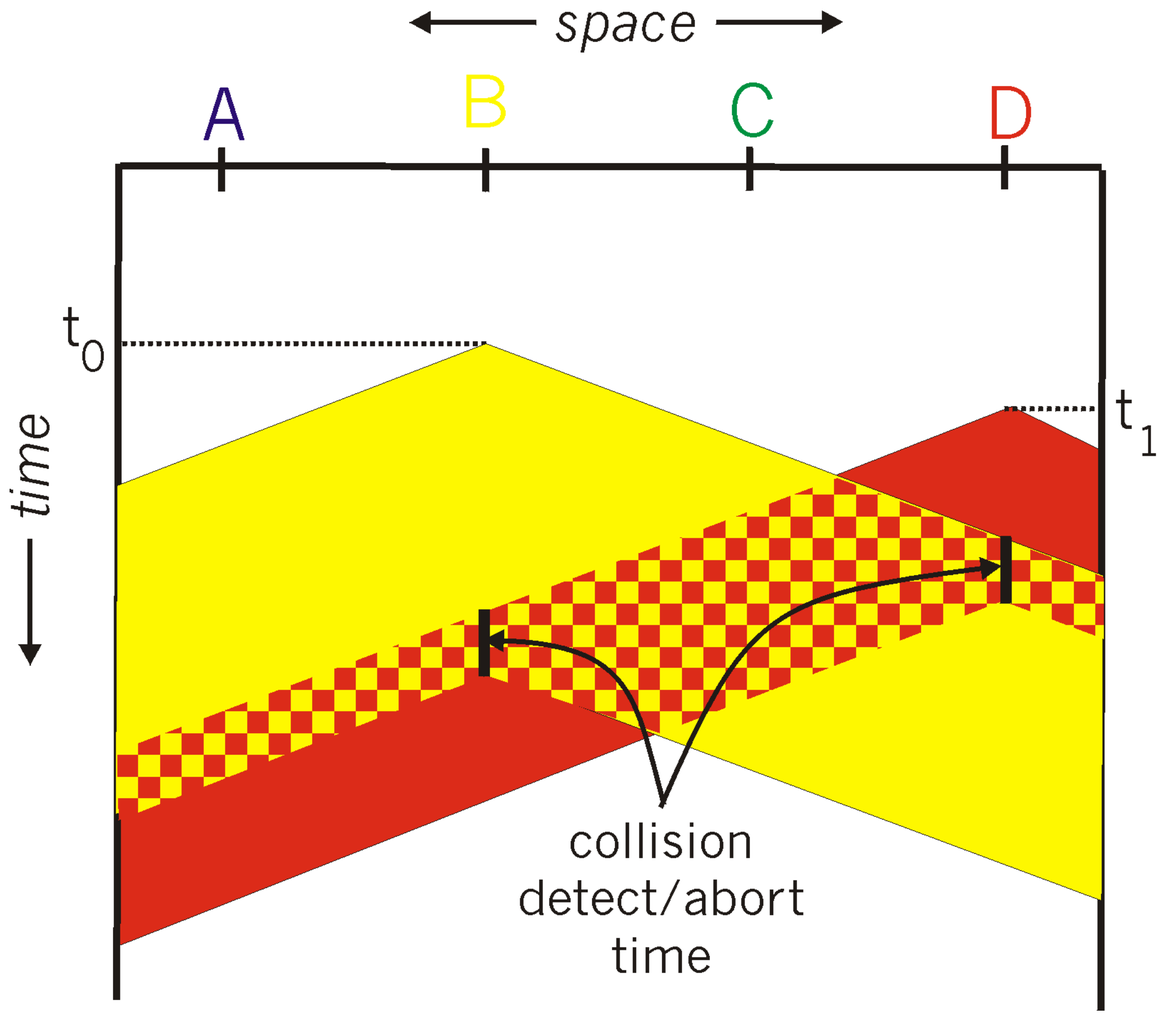

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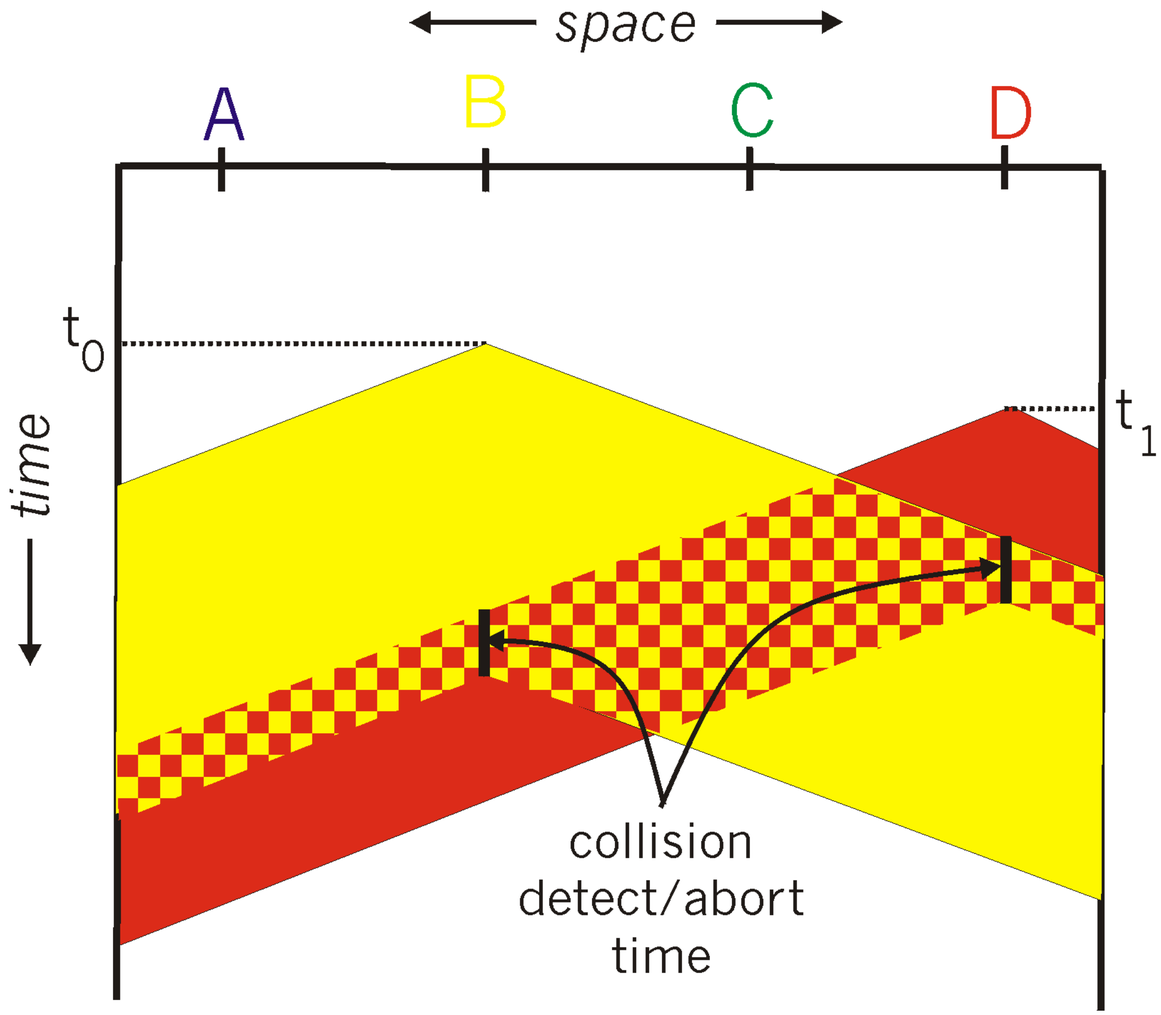
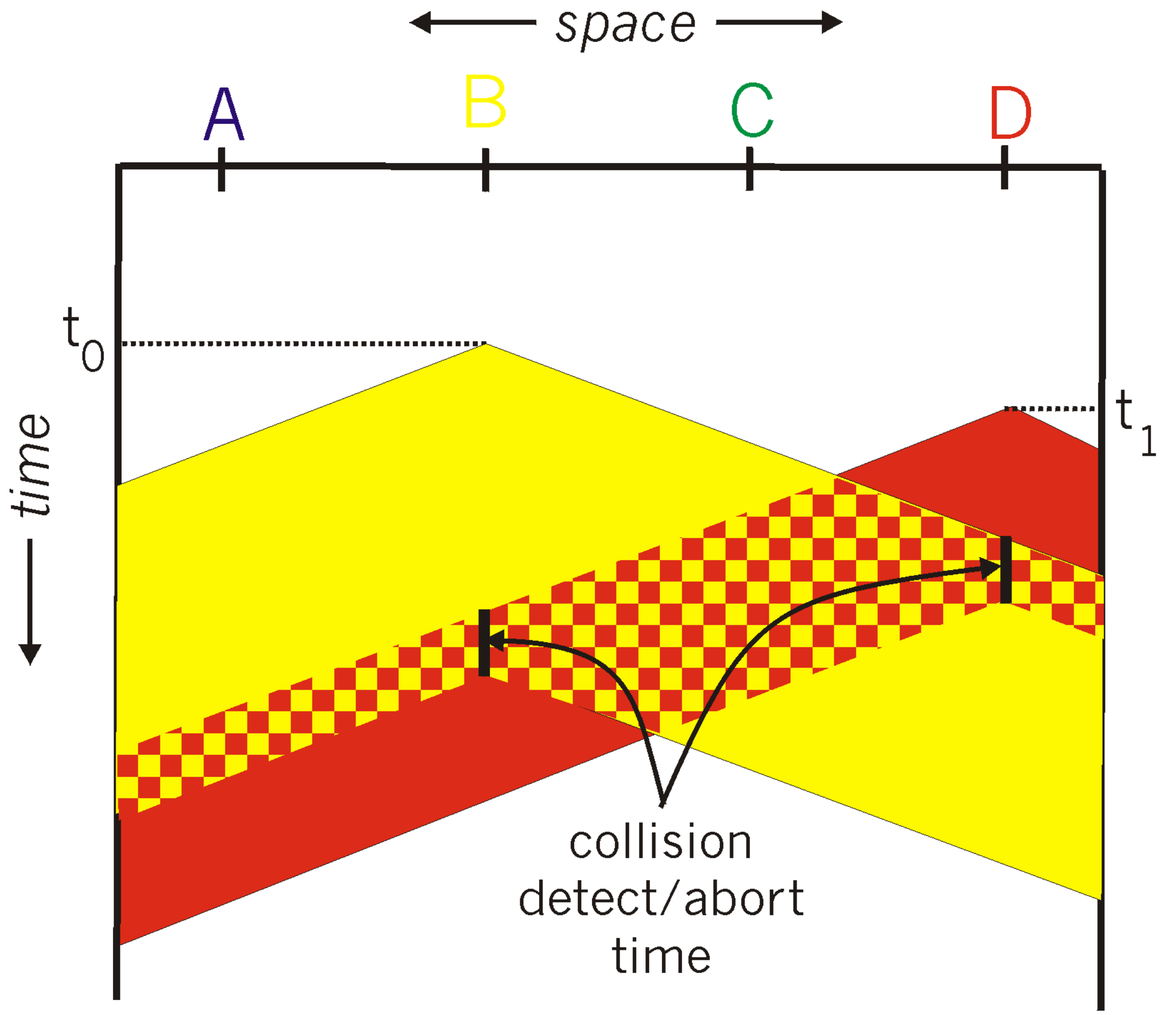


CSMA Collisions

- B and D can tell the collision occurred
- They will try again…
  - *When?*



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- Should it be a random number with a fixed distribution?

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- **Collision Detection: listen while transmitting**
  - No collision: transmission is complete
  - Collision: abort transmission & send *jam* signal
- **Random access: binary exponential backoff**
  - After collision, wait a random time before trying again
  - After m^{th} collision, chose K randomly from $\{0, \ldots, 2^{m-1}\}$
  - …and wait for K units of time before trying again
    - If transmission occurring when ready to send, wait until end of transmission (CSMA)

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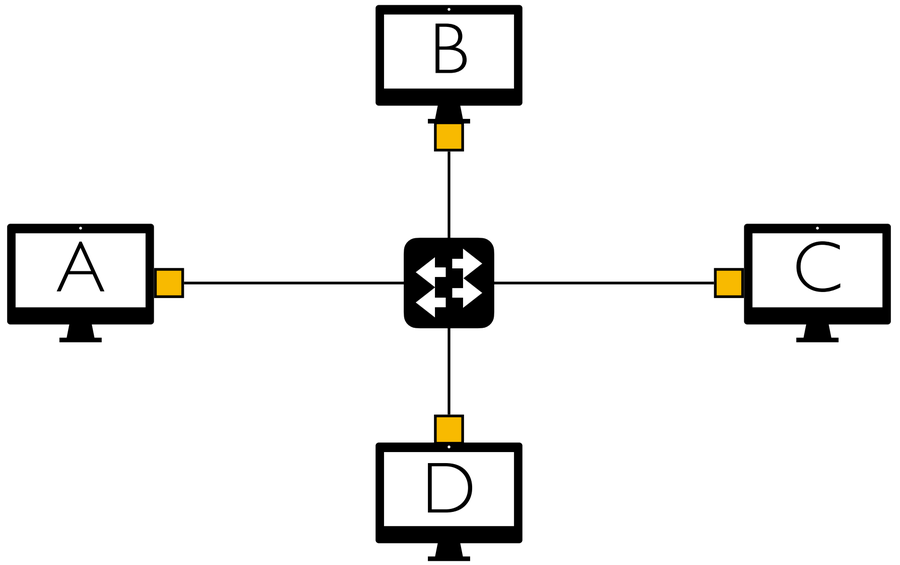
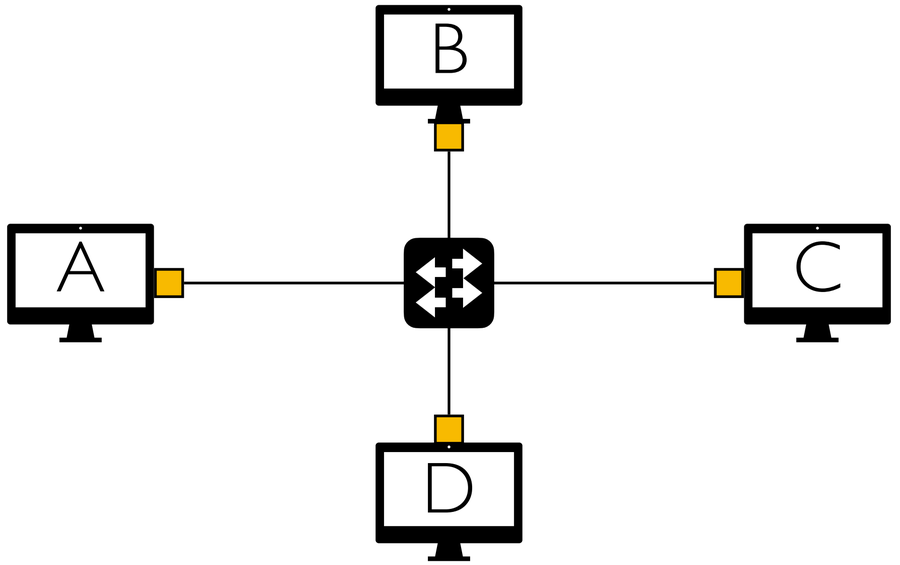


Why Switched Ethernet?



- Enables concurrent communication
  - **Host A can talk to C, while B talks to D**
  - No collisions → no need for CSMA, CD
  - No constraints on link lengths, *etc.*

The evolution of Ethernet

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- From the shared media coax cables to dedicated links

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The evolution of Ethernet

- From the shared media coax cables to dedicated links
- From 3 Mbit/s experimental ethernet to 100 Gbit/s
- From electrical signaling to optical
- **Changed almost everything except the frame format**
- Lesson: the **right interface** can accommodate many changes
  - Evolve the implementation while maintaining the interface (backward compatibility)

Topics

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- Frames and framing

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- Addressing

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- Routing

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- Discovery: Bootstrapping end-to-end communication

Ethernet “Frames”

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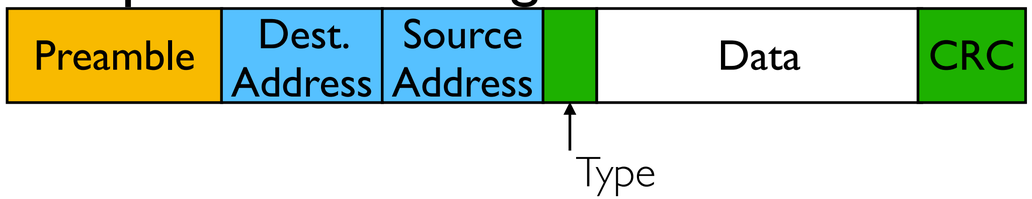
- Encapsulates IP datagram



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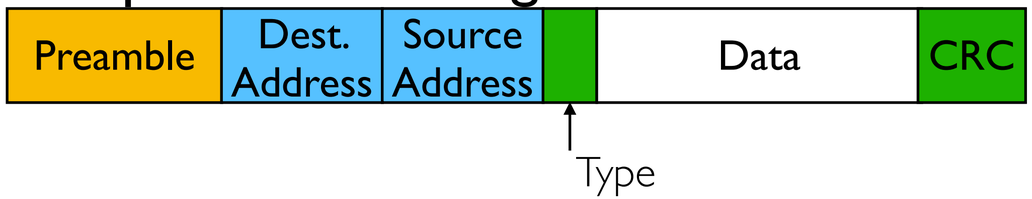

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  - 7 bytes for clock synchronization
  - 1 byte to indicate start of frame

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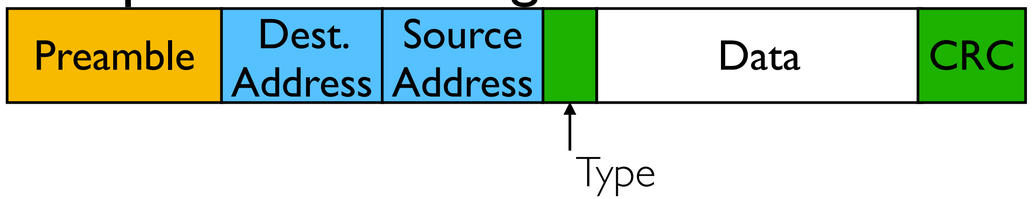

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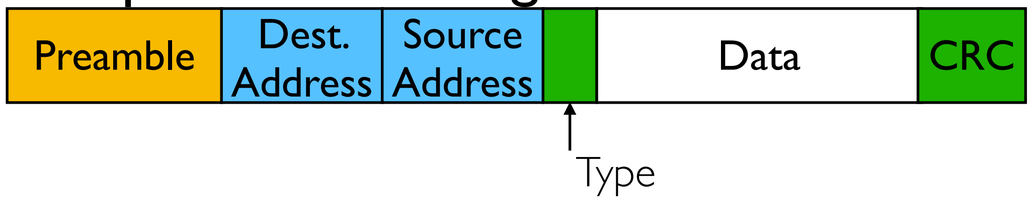

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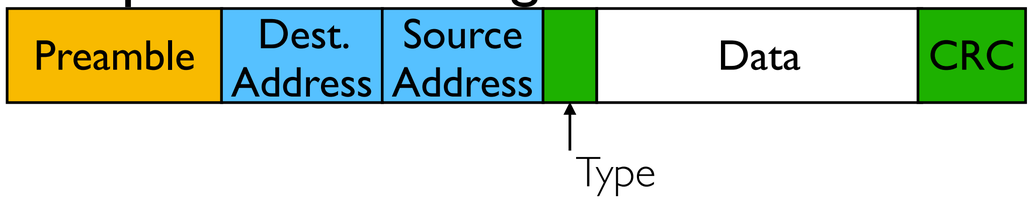

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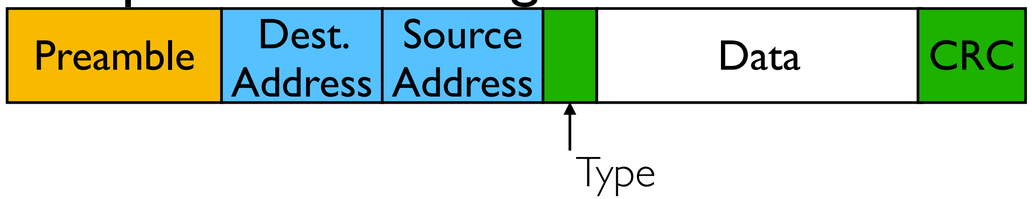

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- **CRC:** 4 bytes for error correction

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  - Service provided by the link layer
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- But, two hosts connected on the same physical medium need to be able to exchange *frames*
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- Framing problem: how does the link layer determine where each frame begins and ends?

Simple approach: count bytes

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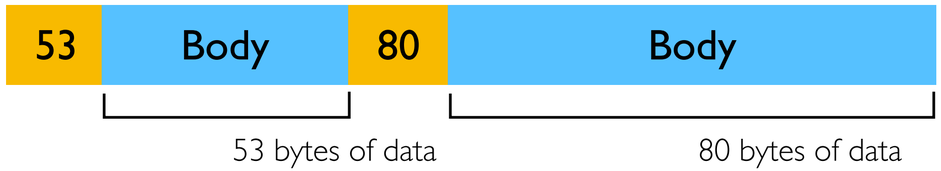
- Sender includes number of bytes in header



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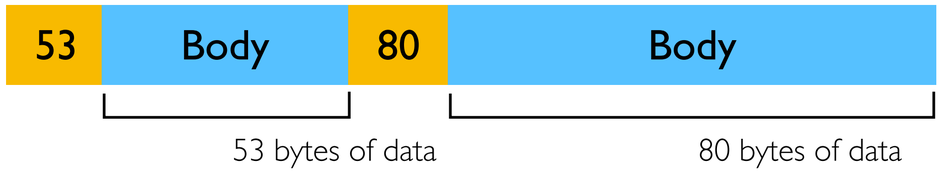

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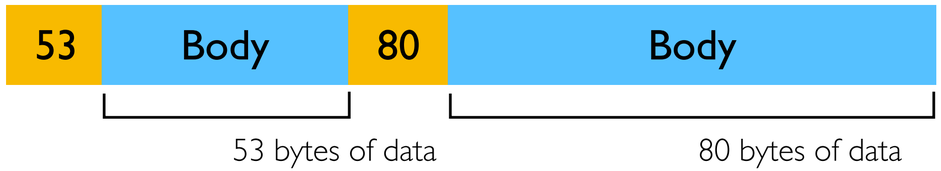

- Receiver extracts this number of bytes of body
- But what if the count field is corrupted?

- L2 will frame the wrong bytes → a framing error
- CRC tells you to discard this frame, but what about the next one?

Desynchronization

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Desynchronization

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- Need a method to *resynchronize*

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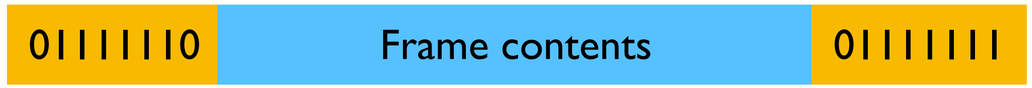
- Delineate frame with special “sentinel” bit pattern
  - E.g., 01111110 → start, 01111111 → end



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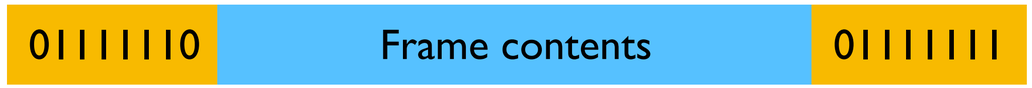

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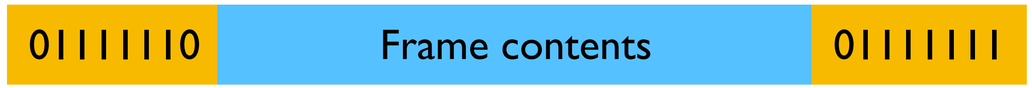

- **Problem: what if the sentinel bits occurs in the frame?**
- **Solution:** bit stuffing
  - Sender always inserts a 0 after five 1s in the frame contents
  - Receiver always removes a 0 appearing after five 1s

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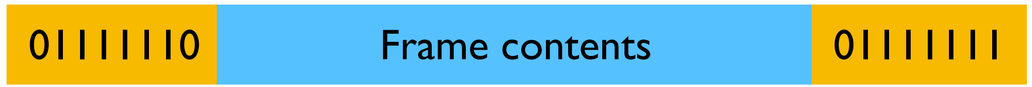

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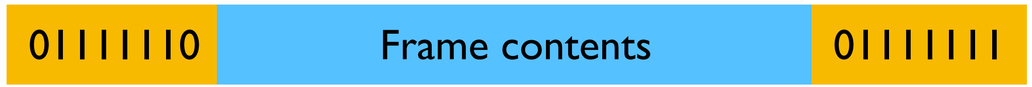

- **If next bit 0, remove it, and begin counting again**
  - Because this must be a stuffed bit; we can't be at beginning/end of frame (those had six or seven 1s)

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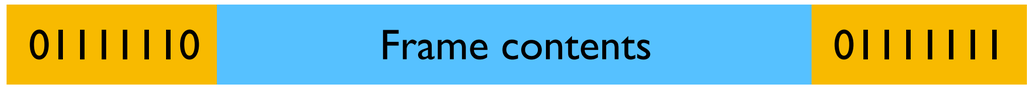

- **If next bit 0, remove it, and begin counting again**
  - Because this must be a stuffed bit; we can't be at beginning/end of frame (those had six or seven 1s)
- **If next bit 1 (i.e., we have seen six 1s) then:**
  - If following bit is 0, this is start of frame
    - Because the receiver has seen 01111110
  - If following bit is 1, this is end of frame
    - Because the receiver has seen 01111111

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- **Sender rule: five 1s → insert a 0**
  - After bit stuffing at the sender:
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- **Receiver rule: five 1s and next bit 0 → remove 0**
  - After bit de-stuffing at the receiver:
  - 01111110011111101111101111100101111111

Questions?