

CS3600 — SYSTEMS AND NETWORKS

NORTHEASTERN UNIVERSITY

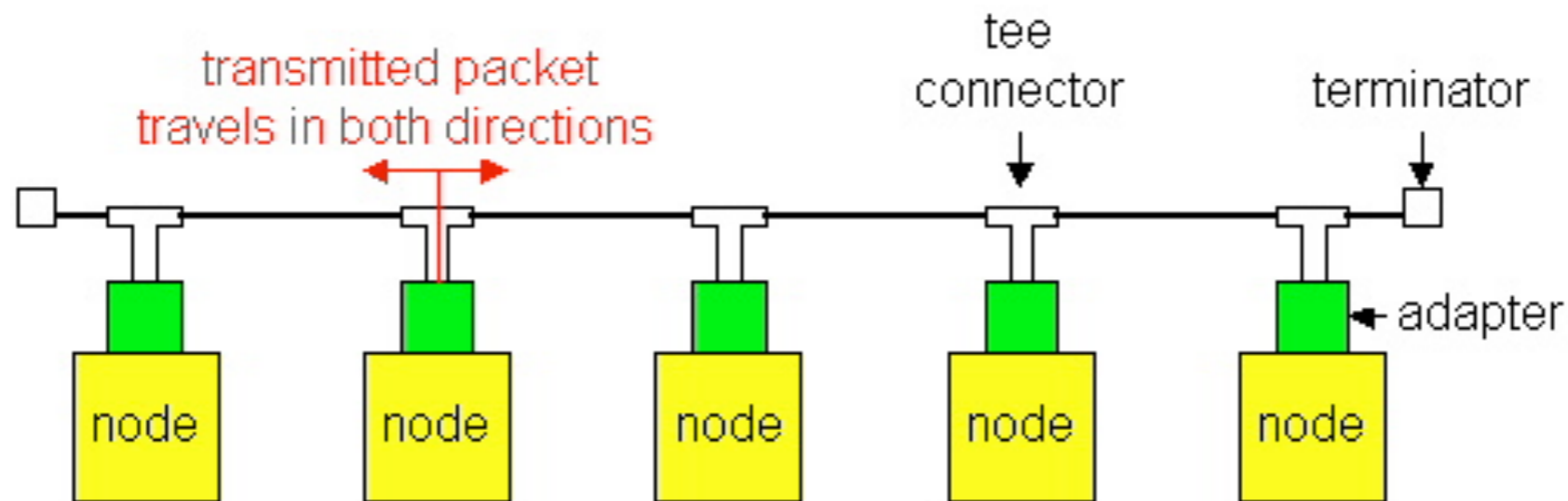
Lecture 19: Ethernet / MAC

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Slides used with permissions from Edward W. Knightly,
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Overview

- Ethernet and Wi-Fi are both “multi-access” technologies
 - Broadcast medium, shared by many hosts
 - Simultaneous transmissions will result in collisions
- Media Access Control (MAC) protocol required
 - Rules on how to share medium



Media Access Control Protocols

- Channel partitioning
 - Divide channel into smaller “pieces” (e.g., time slots, frequency)
 - Allocate a piece to node for exclusive use
 - E.g. Time-Division-Multi-Access (TDMA) cellular network
- Taking-turns
 - Tightly coordinate shared access to avoid collisions
 - E.g. Token ring network
- Contention
 - Allow collisions
 - “recover” from collisions
 - E.g. Ethernet, Wi-Fi

Contention Media Access Control Goals

- Share medium
 - If two users send at the same time, collision results in no packet being received (interference)
 - If no users send, channel goes idle
 - Thus, want to have only one user send at a time
- Want high network utilization
 - TDMA doesn't give high utilization
- Want simple distributed algorithm
 - no fancy token-passing schemes that avoid collisions

802.3 Ethernet

Broadcast technology



- Carrier-sense multiple access with collision detection (CSMA/CD).
 - MA = multiple access
 - CS = carrier sense
 - CD = collision detection
- Base Ethernet standard is 10 Mbps.
 - Original design was ~2 Mbps
 - 100Mbps, 1Gbps, 10Gbps

CSMA/CD Algorithm

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 - Sending would force a collision and waste time
- Send packet and sense for collision.
- If no collision detected, consider packet delivered.
- Otherwise, abort immediately, perform “exponential back off” and send packet again.
 - Start to send at a random time picked from an interval
 - Length of the interval increases with every retransmission

CSMA/CD: Some Details

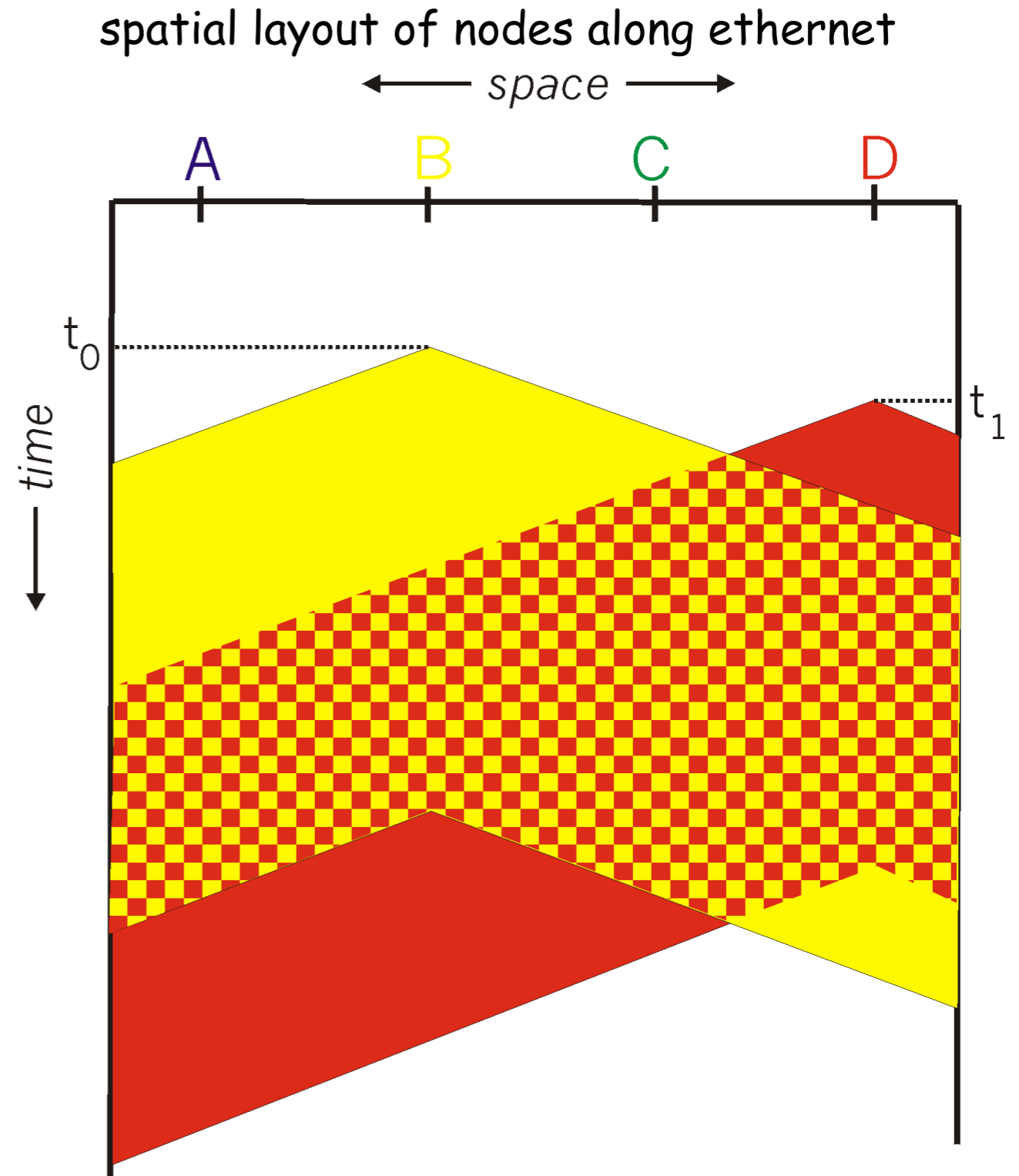
- When a sender detects a collision, it sends a “jam signal”.
 - Make sure that all nodes are aware of the collision
 - Length of the jam signal 48 bits
- Exponential backoff operates in multiples of 512 bit time.

CSMA collisions

Collisions *can* occur:
propagation delay means
two nodes may not
hear each other's
transmission

Collision:
entire packet transmission
time wasted

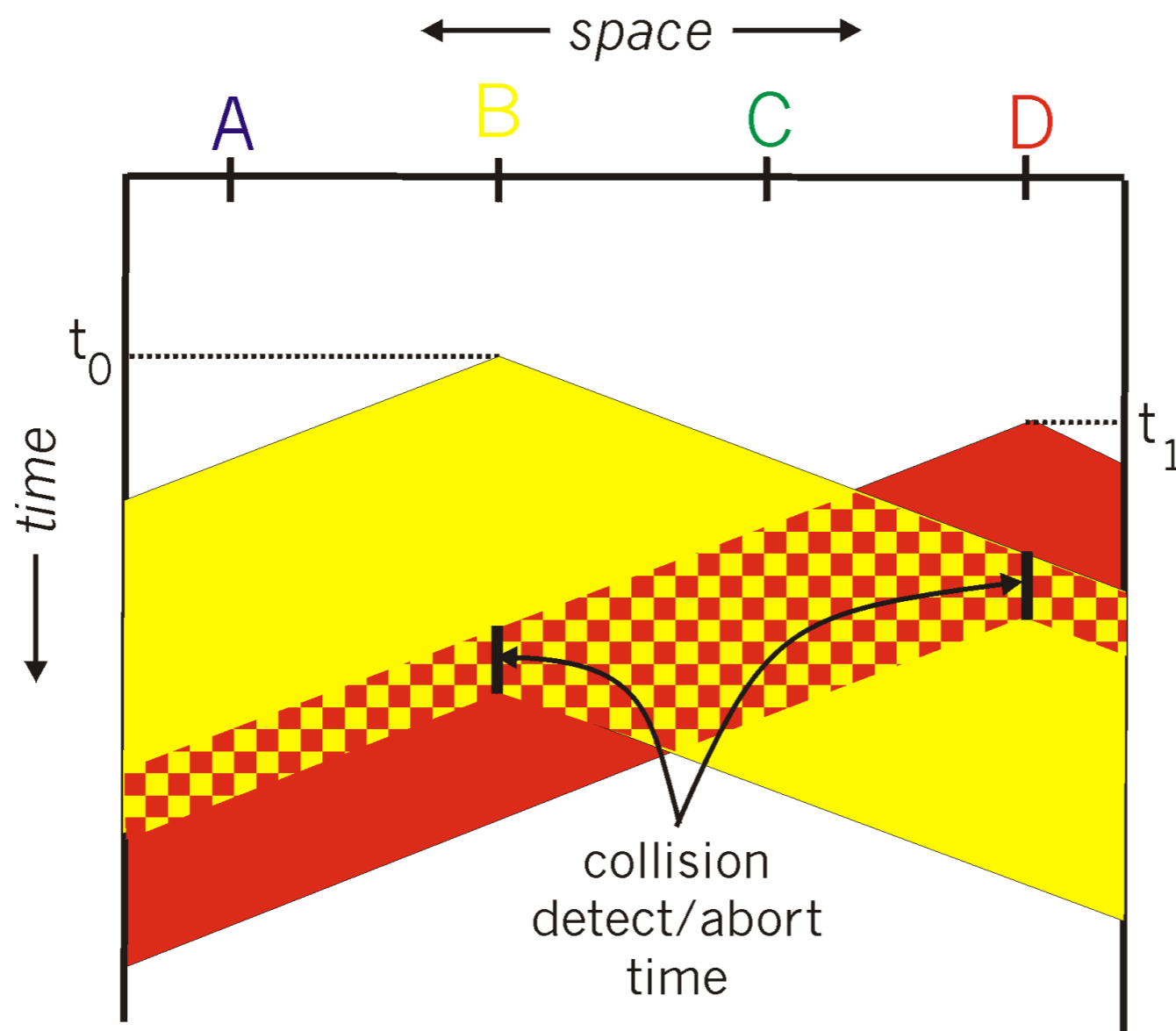
Note:
role of distance and
propagation delay in
determining collision prob.



CSMA/CD (Collision Detection)

- Collisions *detected* within short time
- Colliding transmissions aborted, reducing channel wastage
- Easy in wired LANs:
 - measure signal strengths,
 - compare transmitted, received signals
- Difficult in wireless LANs

CSMA/CD collision detection

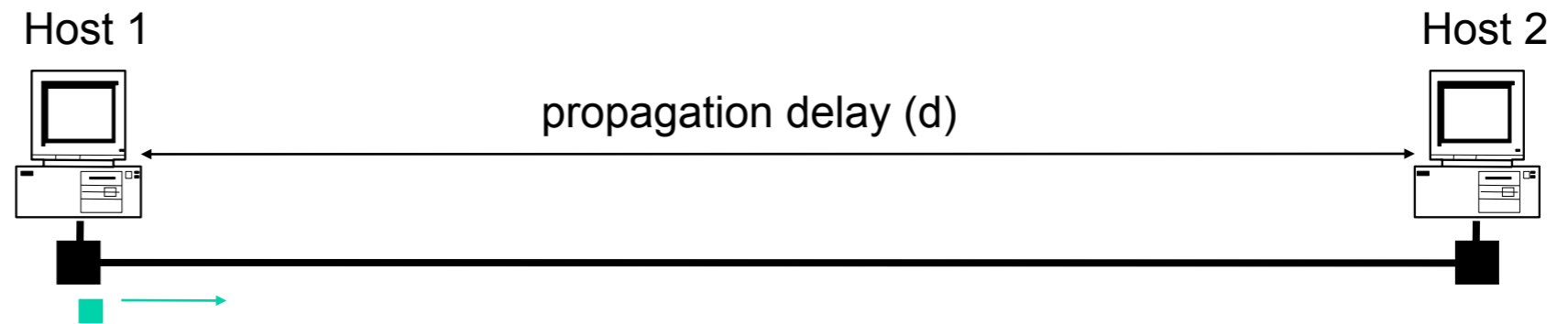


Minimum Packet Size

- Why put a minimum packet size?
- Give a host enough time to detect collisions
- In Ethernet, minimum packet size = 64 bytes (two 6-byte addresses, 2-byte type, 4-byte CRC, and 46 bytes of data)
- If host has less than 46 bytes to send, the adaptor pads (adds) bytes to make it 46 bytes
- What is the relationship between minimum packet size and the length of the LAN?

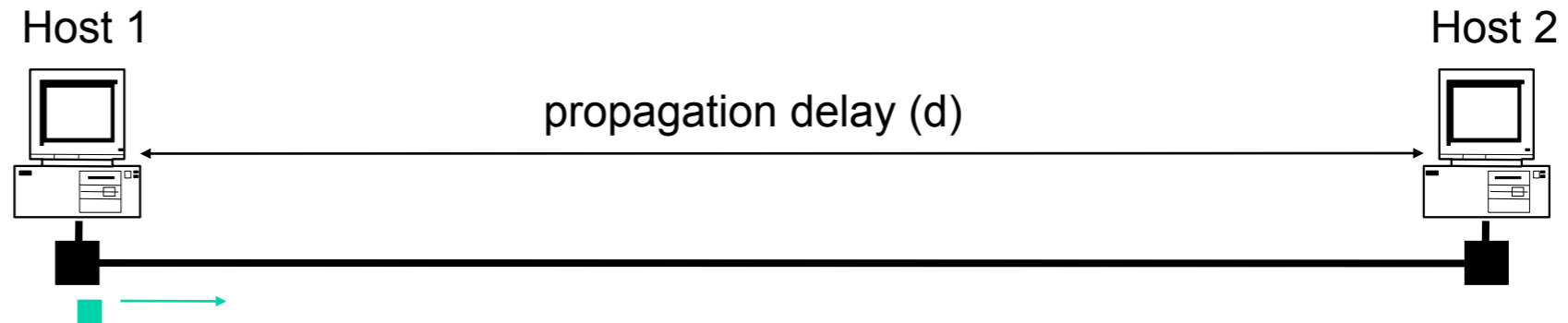
Minimum Packet Size (more)

a) Time = t ; Host 1 starts to send frame

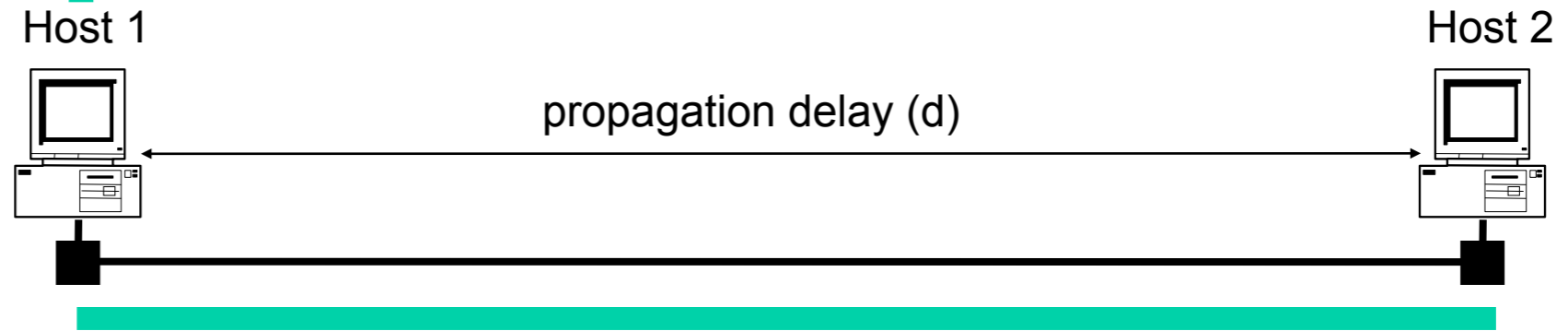


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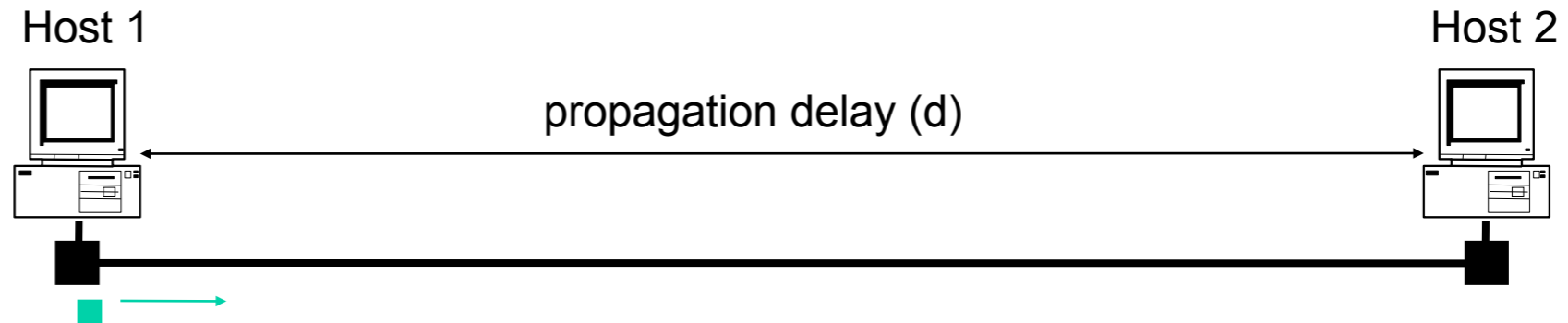


b) Time = $t + d$; Host 2 starts to send a frame just before it hears from host 1's frame

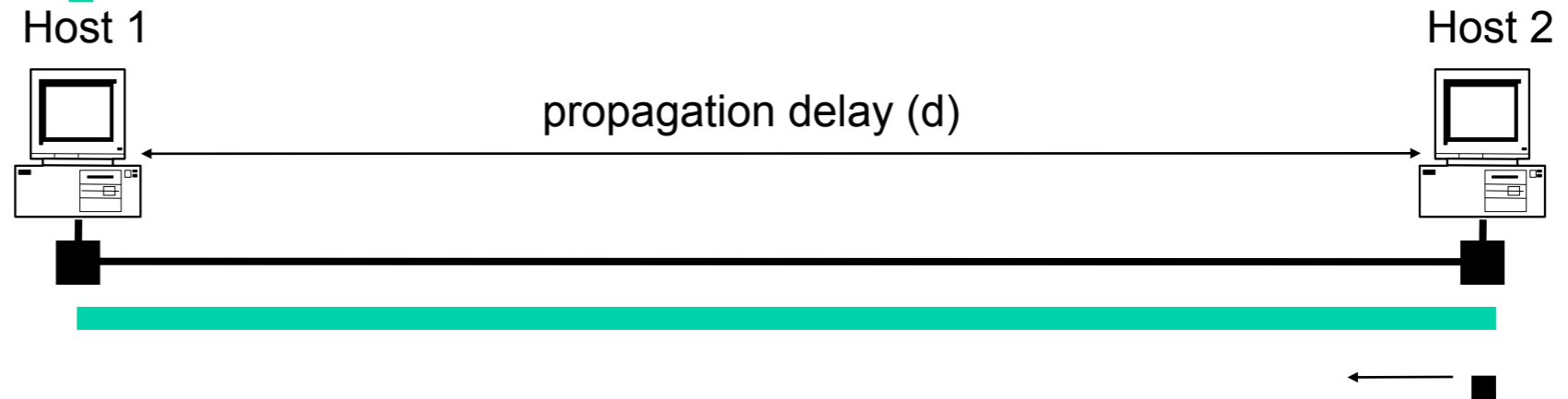


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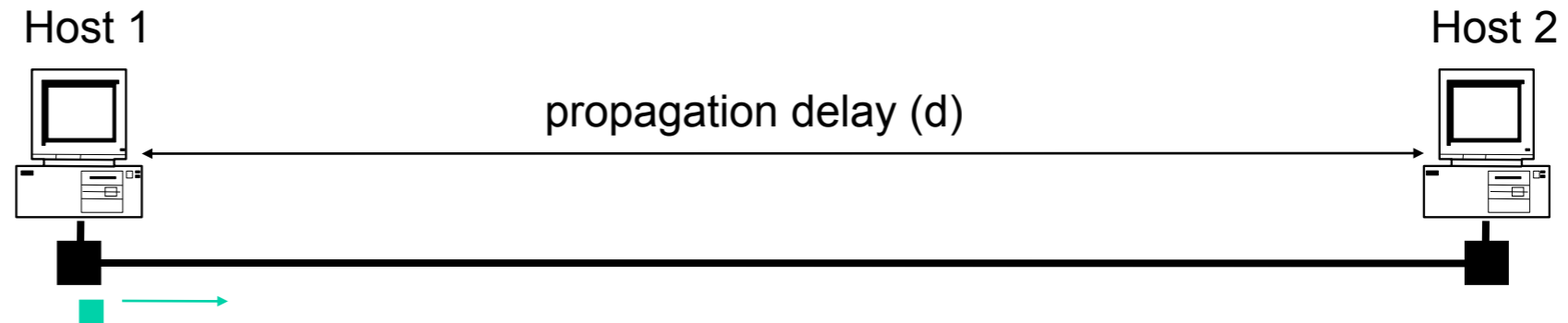


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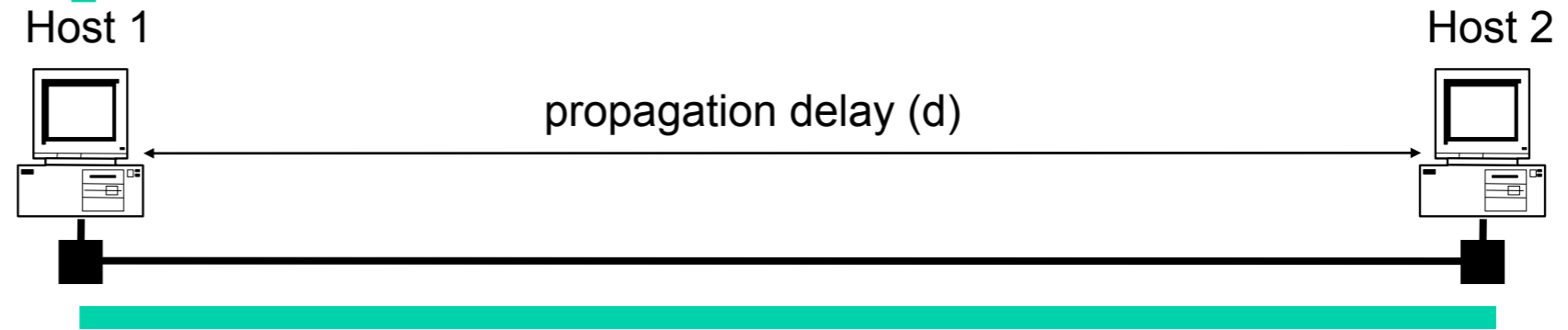



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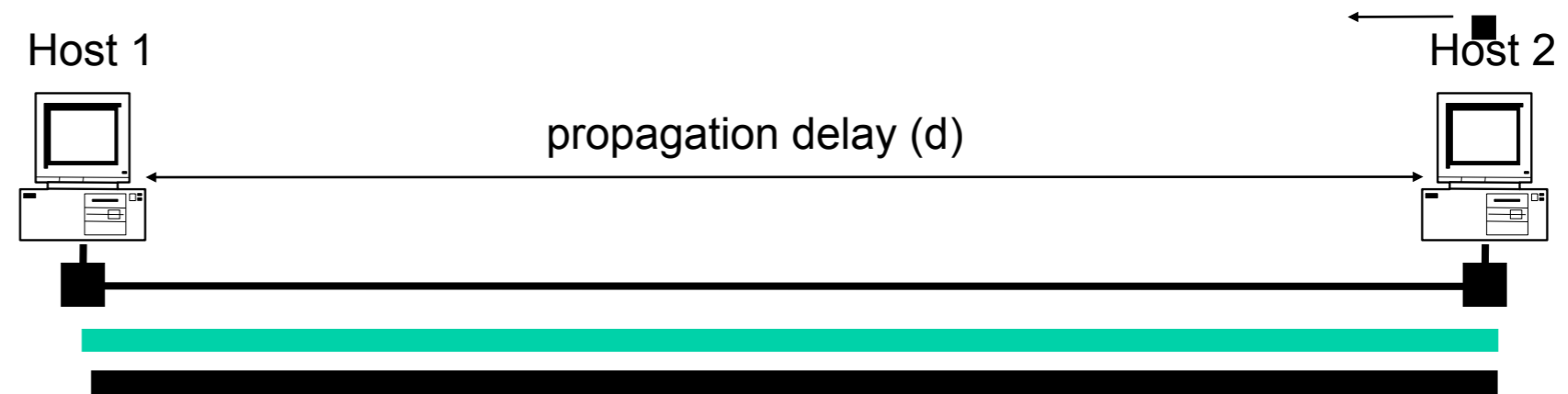
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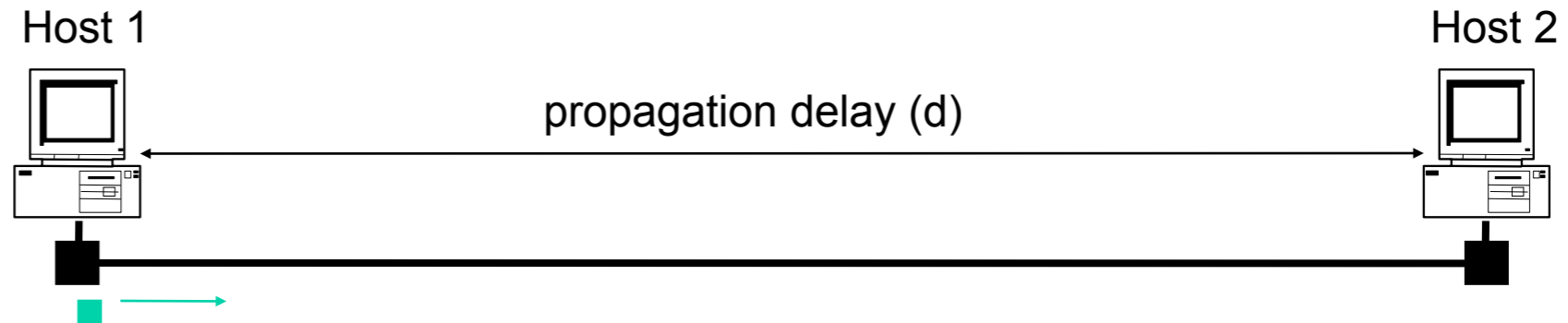


c) Time = $t + 2*d$; Host 1 hears Host 2's frame  detects collision

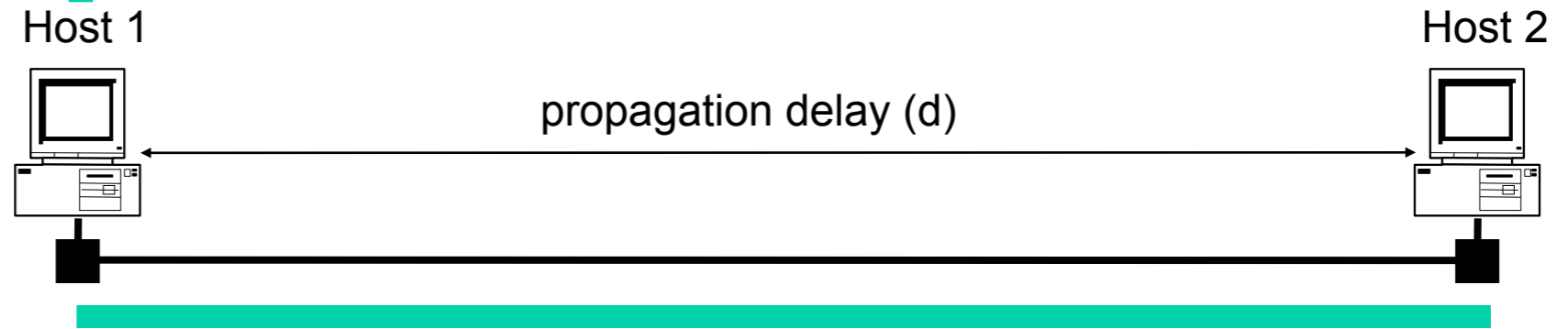



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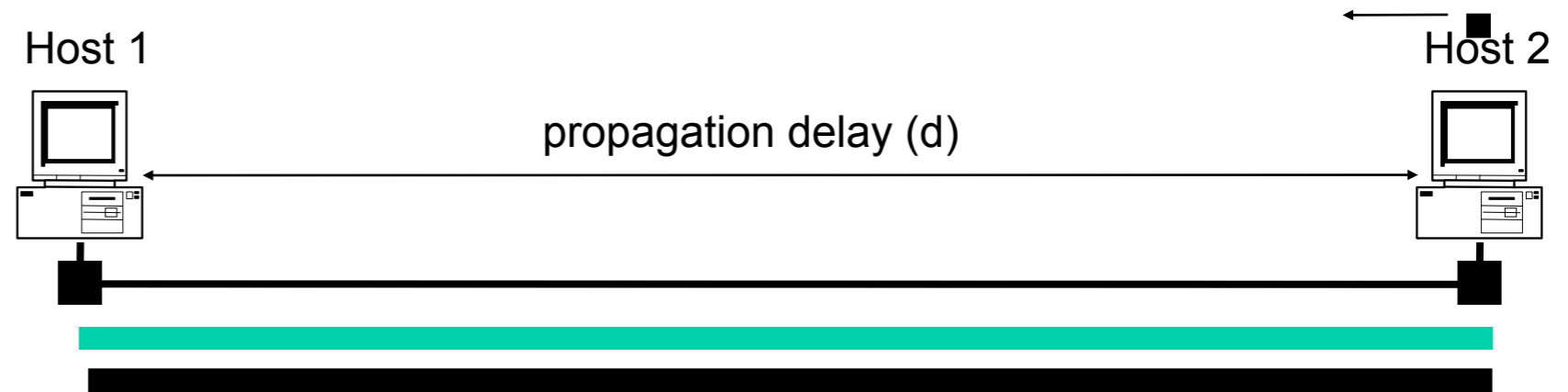
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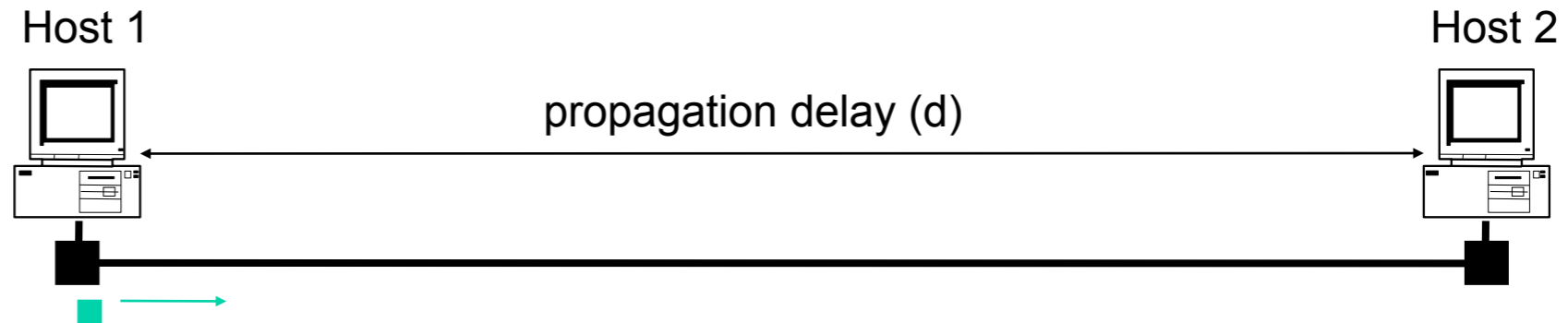
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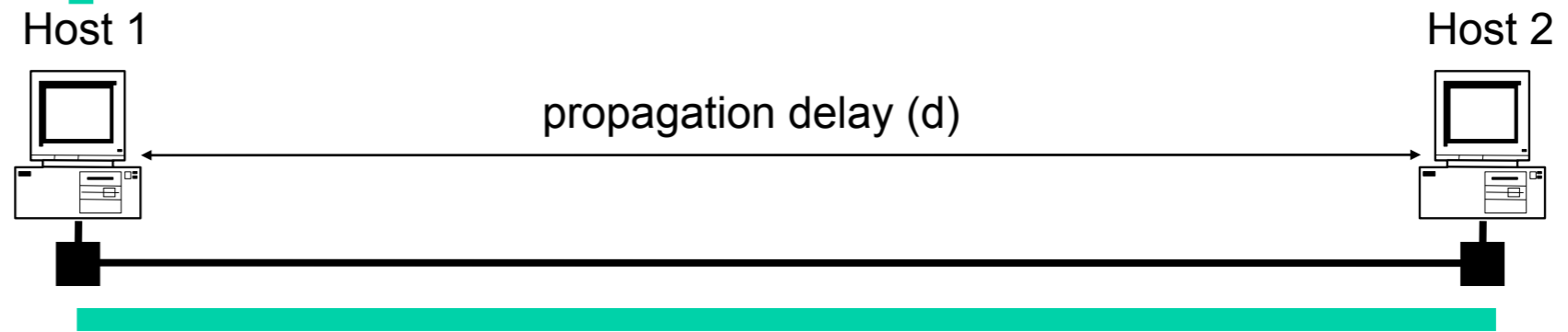
$$(\text{min_frame_size}) / (\text{bandwidth}) > 2 * (\text{LAN_length}) / \text{light_speed}$$


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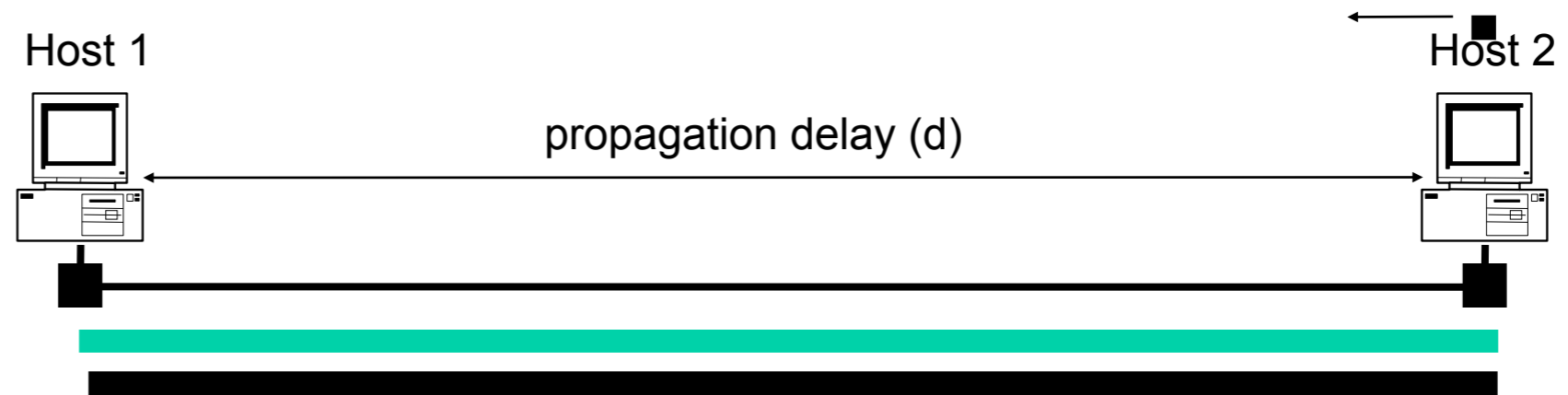
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$$(\text{min_frame_size}) / (\text{bandwidth}) > 2 * (\text{LAN_length}) / \text{light_speed}$$

$$\text{LAN length} < (\text{min_frame_size}) * (\text{light_speed}) / (2 * \text{bandwidth}) =$$

$$< (8 * 64\text{b}) * (2.5 * 10^8 \text{mps}) / (2 * 10^7 \text{bps}) = 6400\text{m approx}$$

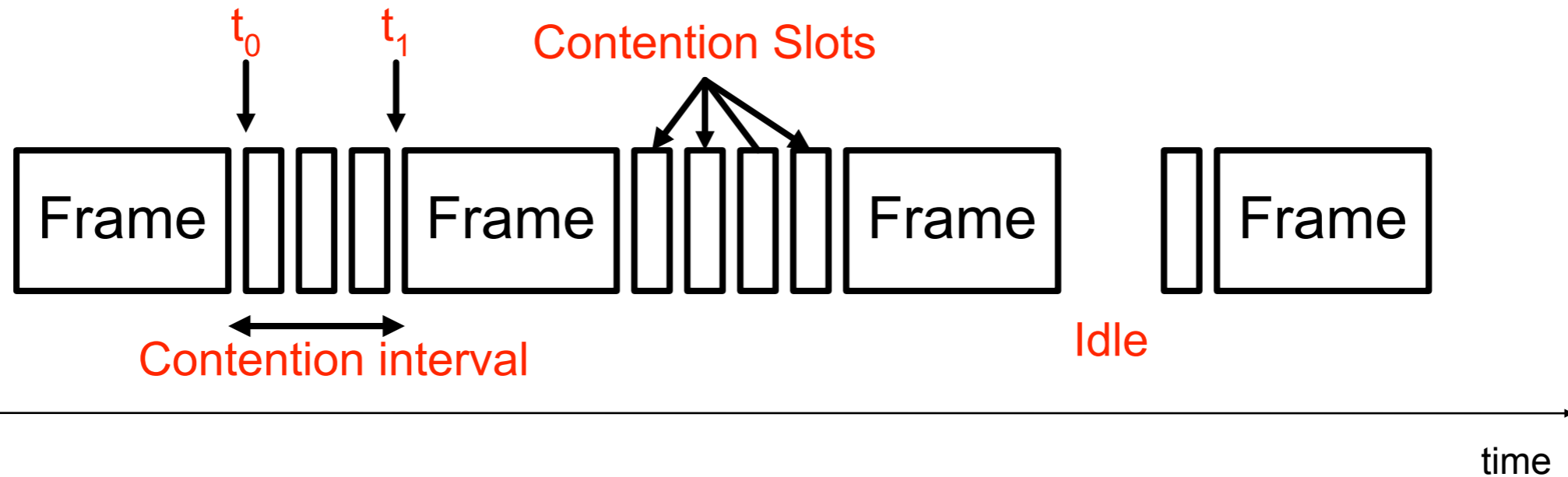
Exponential Backoff Algorithm

- Ethernet uses the **exponential backoff algorithms** to determine when a station can retransmit after a collision

Algorithm:

- Set “slot time” equal to 512bit time
- After first collision wait 0 or 1 slot times
- After i -th collision, wait a random number between 0 and $2^i - 1$ time slots
- Do not increase random number range, if $i = 10$
- Give up after 16 collisions

CSMA/CD Contention Interval



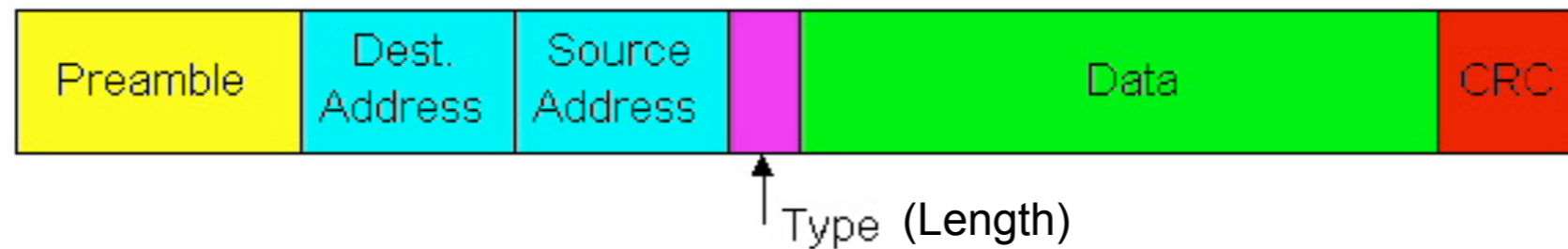
- Contention slots end in a collision
- Contention interval is a sequence of contention slots
- Length of a slot in contention interval is 512 bit time

Min packet size & slot time

- Min packet size is 512 bits
- Slot time is the transmission of 512 bits
- Coincident?
- If slot time is the transmission of 256 bits, then two stations picking 0 and 1 slot to wait respectively can still collide

Ethernet Frame Structure

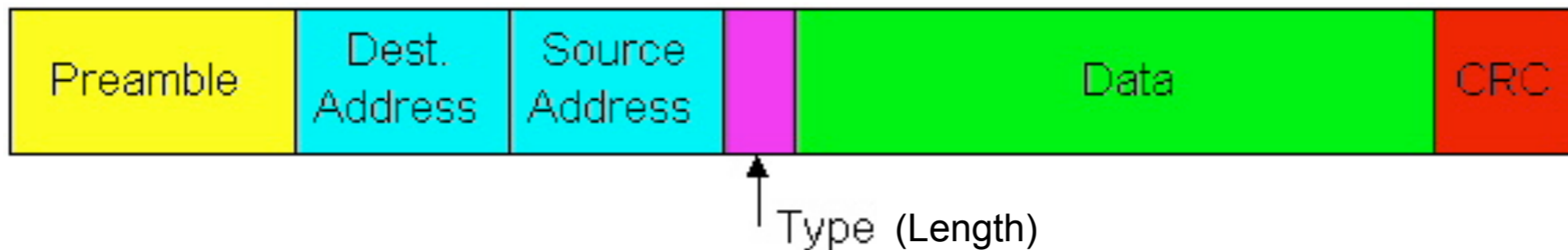
- Sending adapter encapsulates IP datagram



- Preamble:
 - 7 bytes with pattern 10101010 followed by one byte with pattern 10101011
 - Used to synchronize receiver, sender clock rates; establish baseband

Ethernet Frame Structure (more)

- Addresses: 6 bytes, frame is received by all adapters on a LAN and dropped if address does not match
- Type: 2 bytes, is actually a length field in 802.3
- CRC: 4 bytes, checked at receiver, if error is detected, the frame is simply dropped
- Data payload: maximum 1500 bytes, minimum 46 bytes
 - If data is less than 46 bytes, pad with zeros to 46 bytes

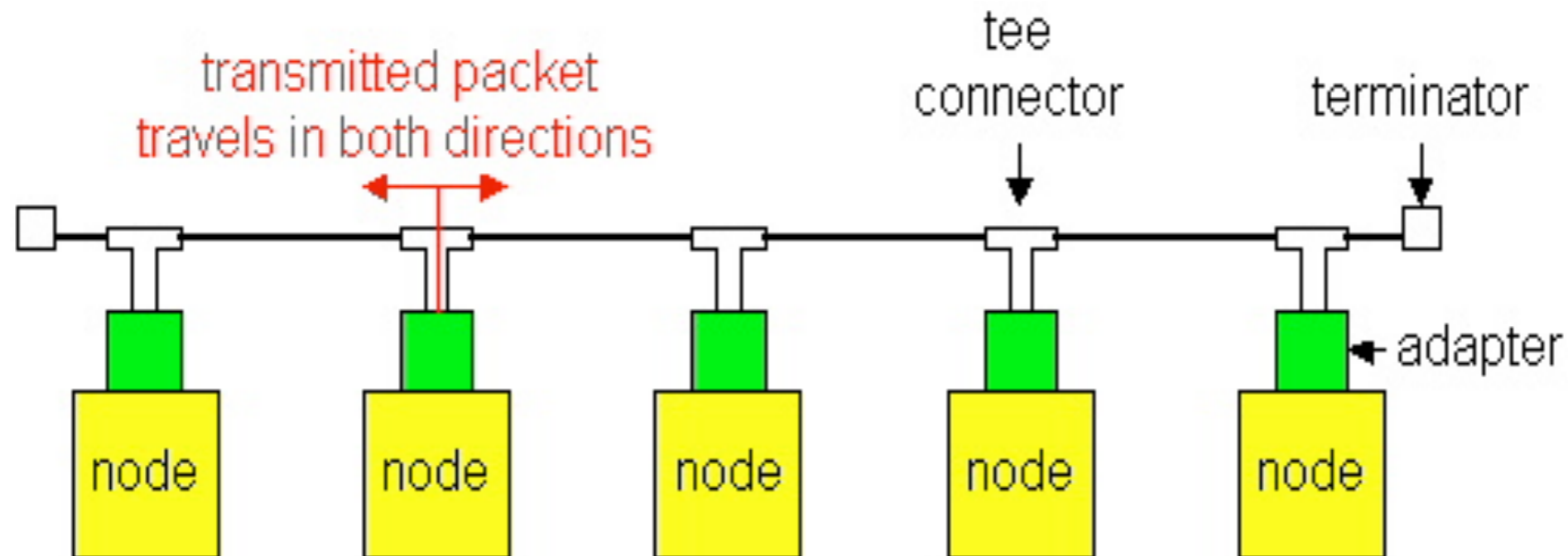


Ethernet Addresses

- 48 bits long
- Globally unique
 - Burned into ROM of network cards
- Usually represented in hex: 00:a0:38:22:fe:33
 - First three bytes are manufacturer
 - Last three bytes are unique to device
- Also, one *broadcast* address ff:ff:ff:ff:ff:ff
 - All hosts receive packets sent to broadcast address

Ethernet Technologies: 10Base2

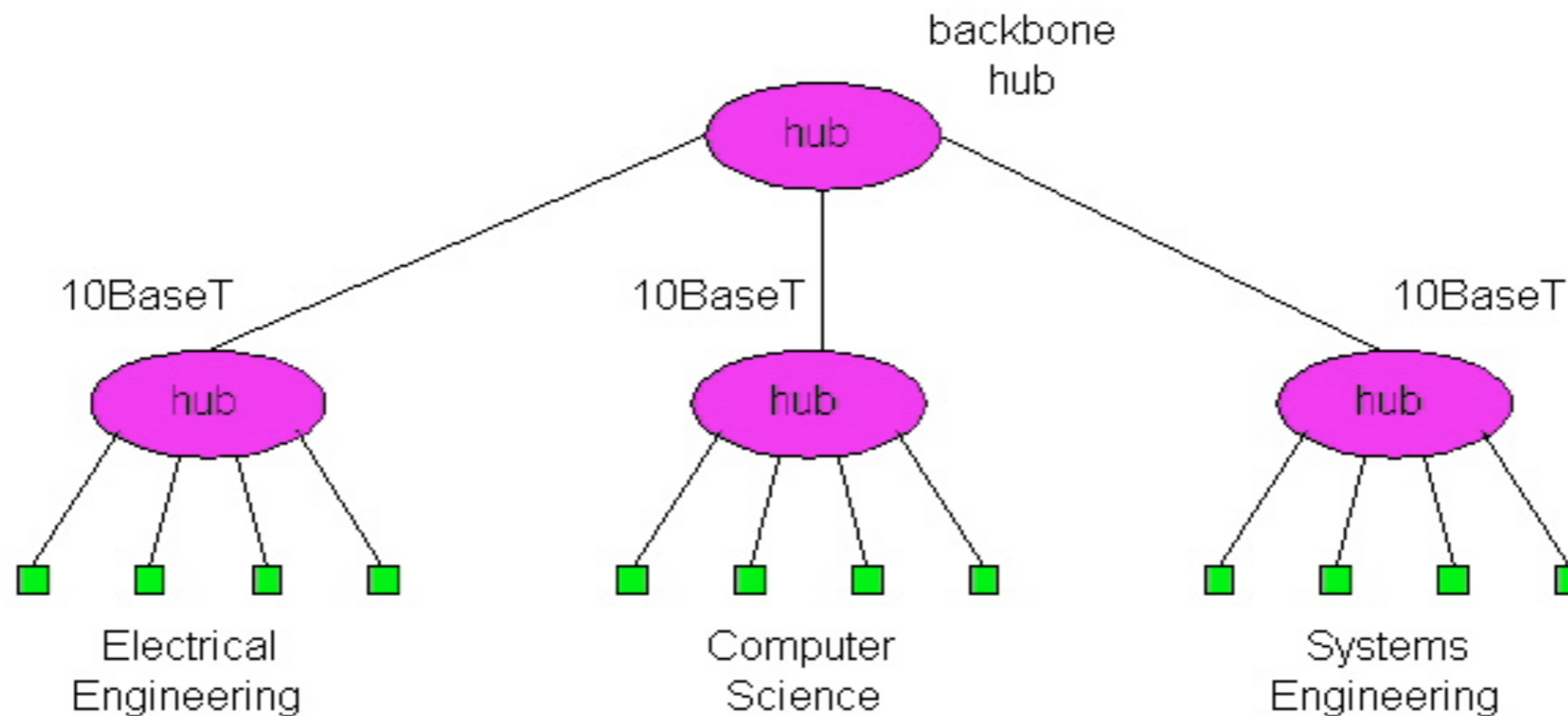
- 10: 10Mbps; 2: under 200 meters max cable length
- Thin coaxial cable in a bus topology



- Repeaters used to connect up to multiple segments
- Repeater repeats bits it hears on one interface to its other interfaces: physical layer device only!

10BaseT and 100BaseT

- 10/100 Mbps rate; latter called “fast ethernet”
- T stands for Twisted Pair
- Hub to which nodes are connected by twisted pair, thus “star topology”



10BaseT and 100BaseT (more)

- Max distance from node to Hub is 100 meters
- Hub can gather monitoring information, statistics for display to LAN administrators
- Hubs still preserve one collision domain
 - Every packet is forwarded to all hosts
- Use bridges to address this problem
 - Bridges forward a packet only to the destination leading to the destination
 - Next lecture

Gbit Ethernet

- Use standard Ethernet frame format
- Allows for point-to-point links and shared broadcast channels
- In shared mode, CSMA/CD is used; short distances between nodes to be efficient
- Full-Duplex at 1 Gbps for point-to-point links