ECE 463
Introduction to Computer Networks

Lecture: Ethernet

Sanjay Rao

This class

- Case Study: Ethernet
- Proven most successful LAN technology
- Easy to manage.
- Inexpensive

Ethernet: History and Evolution

- Originally developed in mid 1970's at Xerox PARC.
- DEC and Intel joined Xerox to specify a 10Mbps standard in 1978
- Formed basis of 802.3 standard
- Base Ethernet 802.3 standard is 10 Mbps.
  - Original design was ~2 Mbps
  - More recently: 100Mbps (Fast Ethernet), 1Gbps (Gigabit Ethernet)

Ethernet: Functioning

- Multiple Access Network
  - Set of nodes send and receive frames over a shared link
- Employs carrier-sense multiple access with collision detection (CSMA/CD).
  - MA = multiple access
  - CS = carrier sense
  - CD = collision detection
- Typical usage today has evolved to "switched Ethernets"

Ethernet Frame Format

8	6	6	2			4
Preamble	**Dest**	**Source**	**Type**	**Data**	**Pad**	**CRC**

- Preamble marks the beginning of the frame.
  - Also provides clock synchronization
- Source and destination are 48 bit IEEE MAC addresses.
  - Flat address space
  - Globally unique: 24-bits reserved for vendor
  - Hardwired into the network interface
- Type field is a demultiplexing field.
  - What network layer (layer 3) should receive this packet?
- CRC for error checking.
- Data Field: At least 46 bytes, at most 1500 bytes
- Some changes in 802.3 header format

LAN addresses

- MAC address allocation administered by IEEE
- Manufacturer buys portion of MAC address space (to assure uniqueness)
- Analogy:

  (a) MAC address: like Social Security Number

  (b) IP address: like postal address
- MAC flat address => portability
  - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
  - depends on network to which one attaches

Ethernet Address Recognition

- Each frame contains destination address
- All stations receive a transmission
- Station discards any frame addressed to another station
- Important: interface hardware, not software, checks address

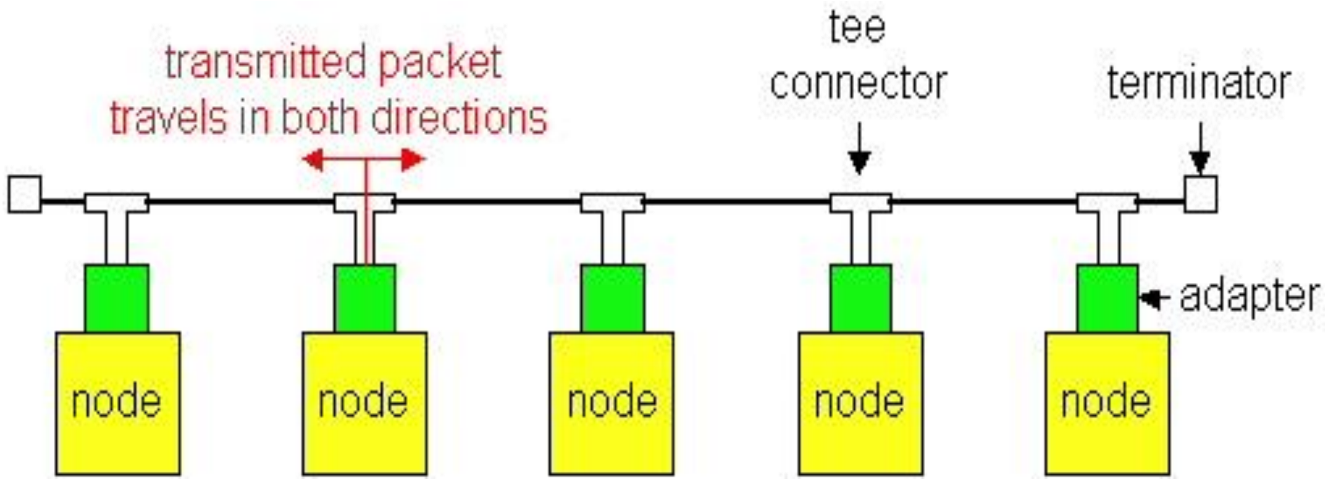
- Packet can be sent to:
  - Single destination (unicast)
  - All stations on network (broadcast)
  - Subset of stations (multicast)

- All 1's: Broadcast address
- First bit 1, but not broadcast address: multicast address

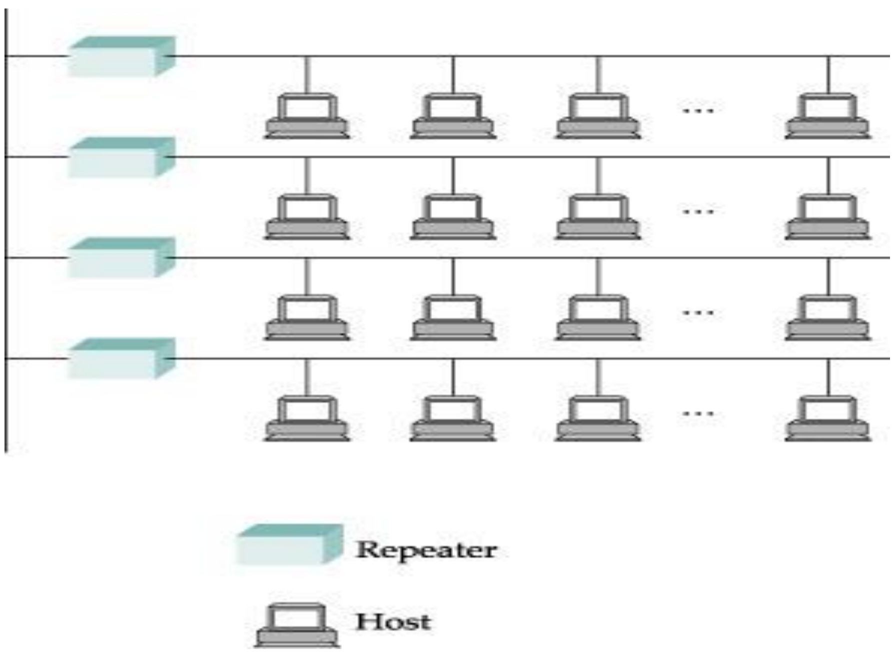
- Promiscuous mode: Host can choose to accept all packets even if not destined to it

Physical Properties

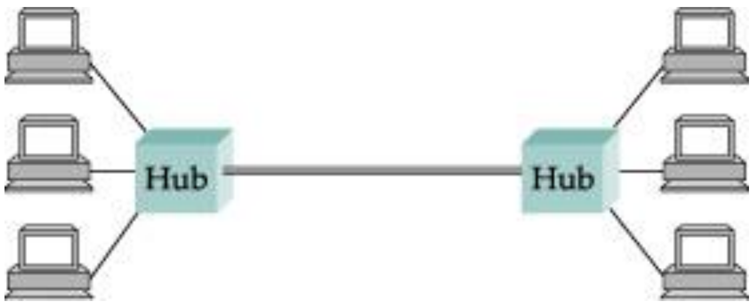
- Various types of Ethernet cables:
  - 10Base5, 10Base2, 10BaseT etc.
  - Differ in their thickness levels, different limits on maximum length between segments (e.g. 10Base5: 500m, 10Base2: 200m etc.)
  - Uses Manchester encoding scheme.
- Repeaters/Hubs
  - Multiple Ethernet segments can be joined together by repeaters.
  - Dumb physical layer device that forwards digital signals
  - Devices on either side in the same collision domain
  - Standards specify limits on number of repeaters between hosts.
- Repeaters/Hubs are different from Bridges/Switches:
  - Bridges/Switches are more intelligent devices that forward data only to hosts needing them (discuss later in course)



transmitted packet
travels in both directions
tee
connector
terminator
adapter
node
node
node
node
node



...
...
...
...
Repeater
Host



Hub
Hub

Collision Domains

- Collision Domain:
  - Data transmitted by host reaches all other hosts.
  - All hosts compete for access to same link, and only one can transmit at any given time.
- Hosts on a single Ethernet segment are in the same collision domain.
  - Also true if seperated by repeaters/hubs (but not switches/bridges)

Multiple Access Protocols

- Distributed algorithm that determines how stations share channel, i.e., determine when station can transmit

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- Key Objectives:
  - High resource utilization : Efficiency
  - Avoid starvation : Fairness
  - Simplicity

Ethernet: Random Access protocols

- When node has packet to send
  - transmit at full channel data rate R b/s.
  - no *a priori* coordination among nodes
- Two or more transmitting nodes -> “collision”,
- Random access MAC protocol specifies:
  - when to transmit
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)

Evolution of Contention Protocols

Aloha

Developed in the 1970s for a packet radio network

Slotted Aloha

Improvement: Start transmission only at fixed times (slots)

CSMA

CSMA = Carrier Sense Multiple Access
Improvement: Start transmission only if no transmission is ongoing

CSMA/CD

CD = Collision Detection

Improvement: Stop ongoing transmission if a collision is detected (e.g. Ethernet)

CSMA/CD Algorithm (used in Ethernet)

- Sense for carrier.
- If carrier present, wait until carrier ends.
  - 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

Exponential Backoff Algorithm

- Ethernet uses the exponential backoff algorithms to determine when a station can retransmit after a collision
- Helps adjust dynamically to the load on the system. Repeated collision => system highly loaded => less aggressive in retransmitting

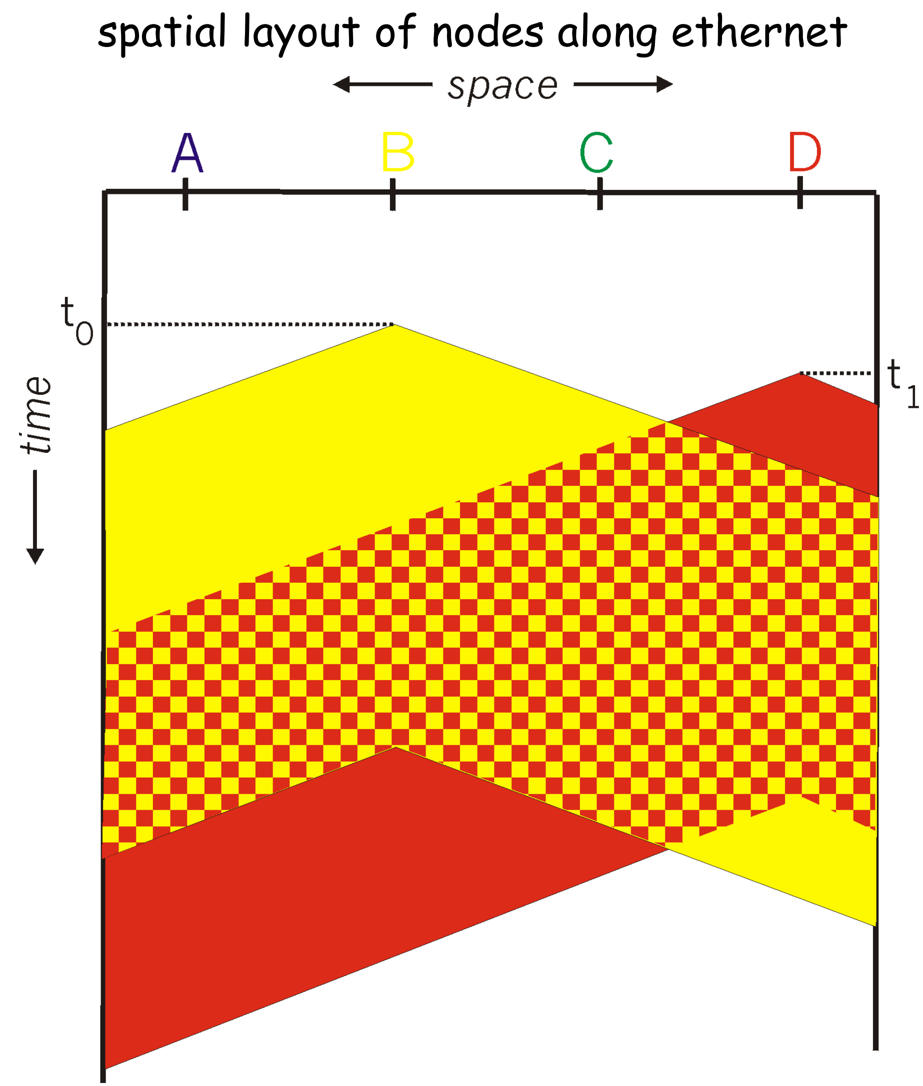
Algorithm:

- After first collision wait 0 or 1 time units

  •Time unit => standard specified, 51.2 microseconds for 10Mbps Ethernet.

- After i-th collision, wait a random number between 0 and 2^i-1 time units
- Do not increase random number range, if i=10
- Give up after 16 collisions

CSMA collisions



Collisions *can* occur:

propagation delay means two nodes may not hear each other's transmission

Collision:

entire packet transmission time wasted

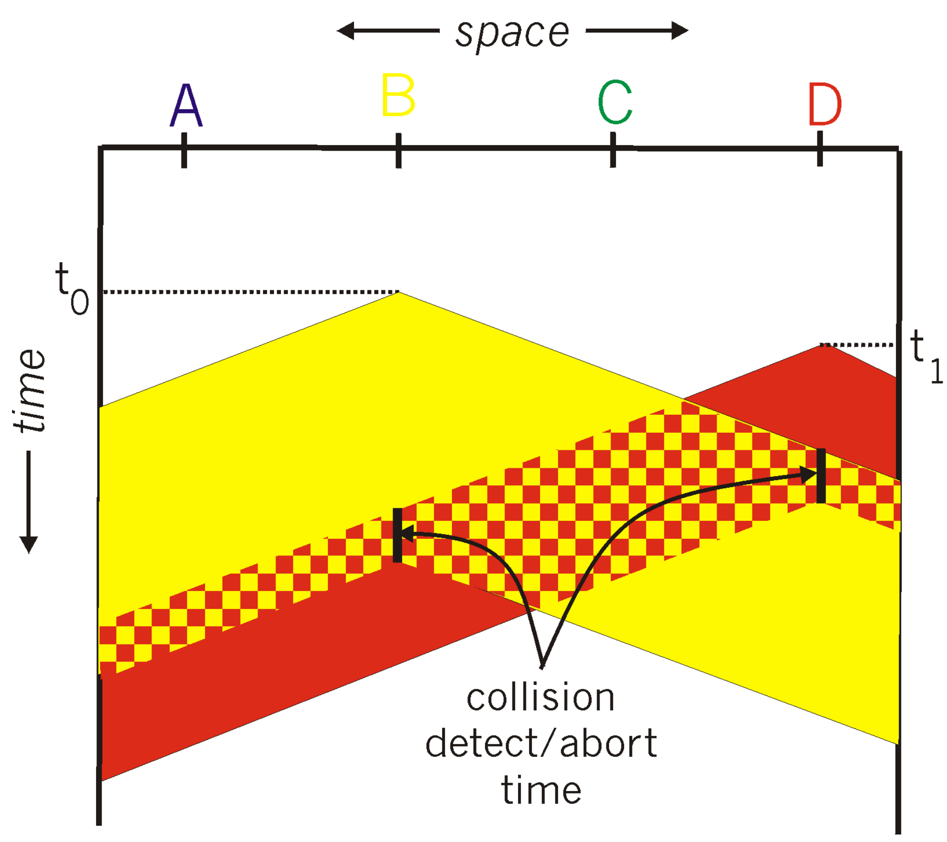
Note:

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

CSMA/CD collision detection

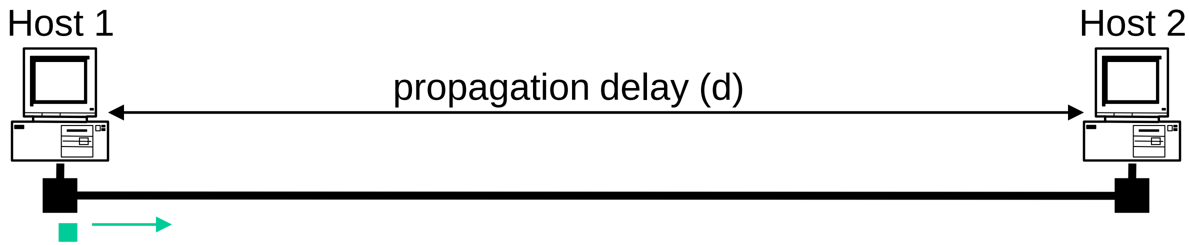


Minimum frame Size

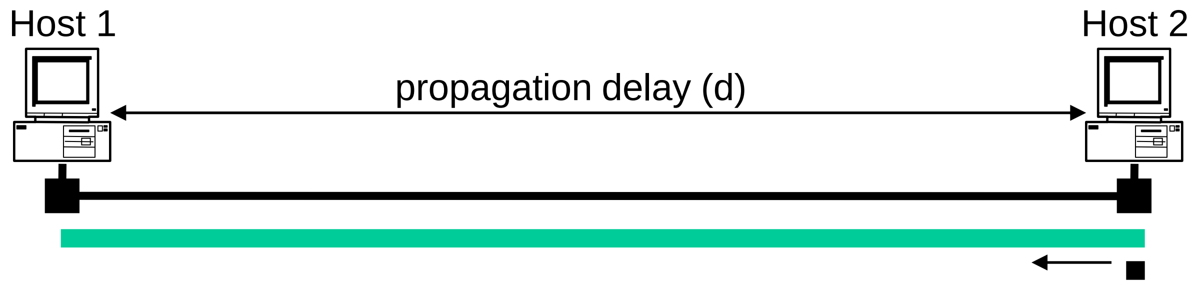
- Why put a minimum frame size?
- Give a host enough time to detect collisions
- In Ethernet, minimum frame size = 64 bytes (two 6-byte addresses, 2-byte type, 4-byte CRC, and 46 bytes of data)
- If host has less than 46 bytes to send, the adaptor pads (adds) bytes to make it 46 bytes
- What is the relationship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

Minimum Frame Size (more)

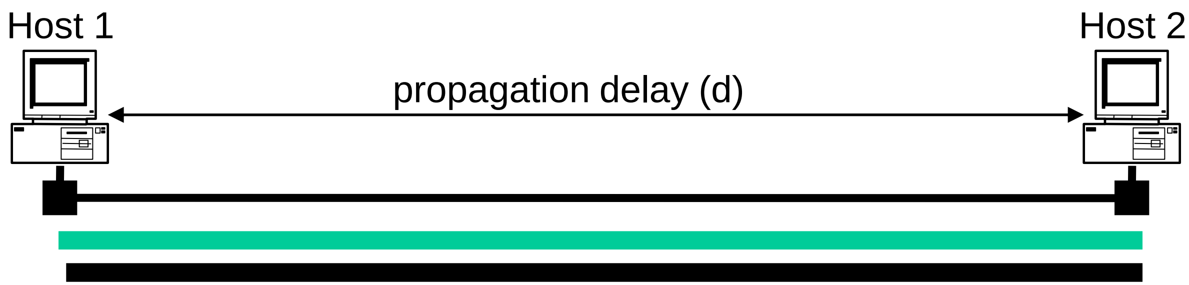
a) Time = t; Host 1 starts to send frame



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



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



Host 1 must not finish transmission before Host2’s signal seen

MinFrameSize/bandwidth > 2 * d

Minimum Frame Size (contd).

MinFrameSize/bandwidth > 2 * d

MinFrameSize/bandwidth > 2 * (LAN-length)/(light-speed)

LAN length < (MinFrameSize)*(light-speed)/(2*bandwidth)

= (8*64b)*(2*10^8mps)/(2*10^7 bps)

= 5.12 km

Homework Hints

- You may be asked to compute "efficiency" of channel.
  - That would be the fraction of time "useful work" is done (packet is transmitted successfully)
  - If asked in terms of slots, that's the same as fraction of slots in which successful transmission occurs (as opposed to collision, or "empty")
- You might be asked what's the "goodput" or "available bandwidth" or "effective bandwidth" of the link.
  - This would be (Link bandwidth) * efficiency.
  - E.g. 10Mbps Ethernet, 30% efficiency, goodput => 3Mbps.