CPE348: Introduction to Computer Networks

Lecture #6: Chapter 2.4

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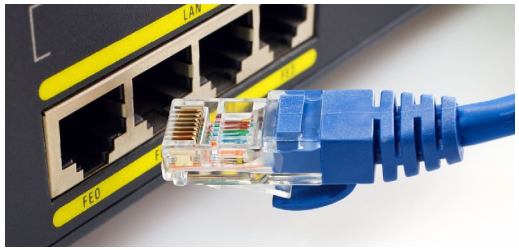
Ethernet – history

- Most successful networking technology of last 20 years.
- Developed in the mid-1970s by Palo Alto Research Centers (PARC), 10-Mbps Ethernet standard in 1978.
- Now, it has been extended to 100-Mbps version called Fast Ethernet, 1000-Mbps version called Gigabit Ethernet, 10 Gbps,100Gbps and more.



Ethernet – key technology

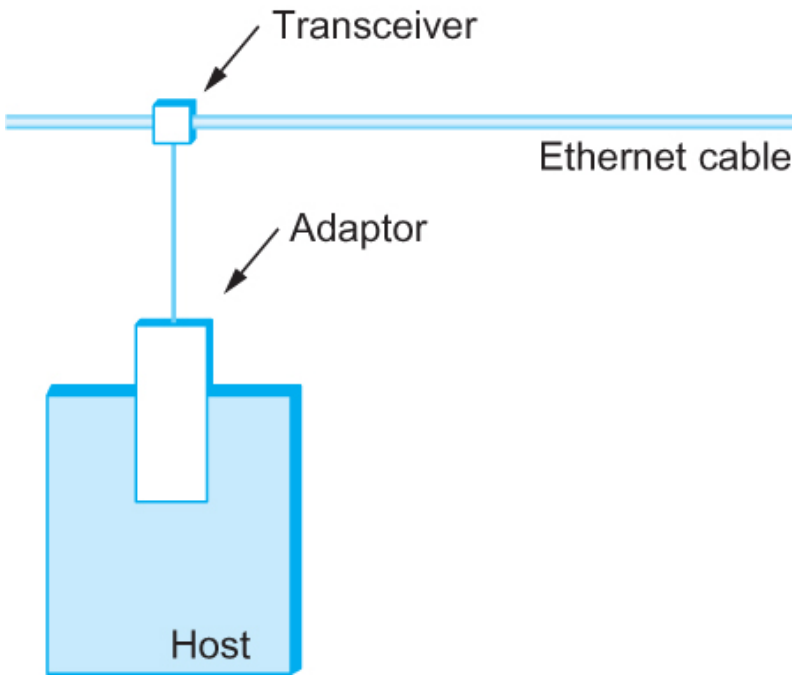
- Uses CSMA/CD technology
  - Carrier Sense Multiple Access with Collision Detection.
  - MA: A set of nodes send and receive frames over a shared link.
  - CS: all nodes can distinguish between an idle and a busy link.
  - CD: a node listens as it transmits and can therefore detect when a frame it is transmitting has collided with a frame transmitted by another node.

- Uses ALOHA (packet radio network) as the root protocol
  - Developed at the University of Hawaii to support communication across the Hawaiian Islands.
  - If link is idle, transmit the packet

Ethernet - adaptor

- A classical Ethernet segment is implemented on a coaxial cable of up to 500 m.
- A transceiver tapes the cable, transmits and receives signal.
- The transceiver is connected to an Ethernet adaptor which is plugged into the host.
- The protocol is implemented on the adaptor.

Ethernet - adaptor



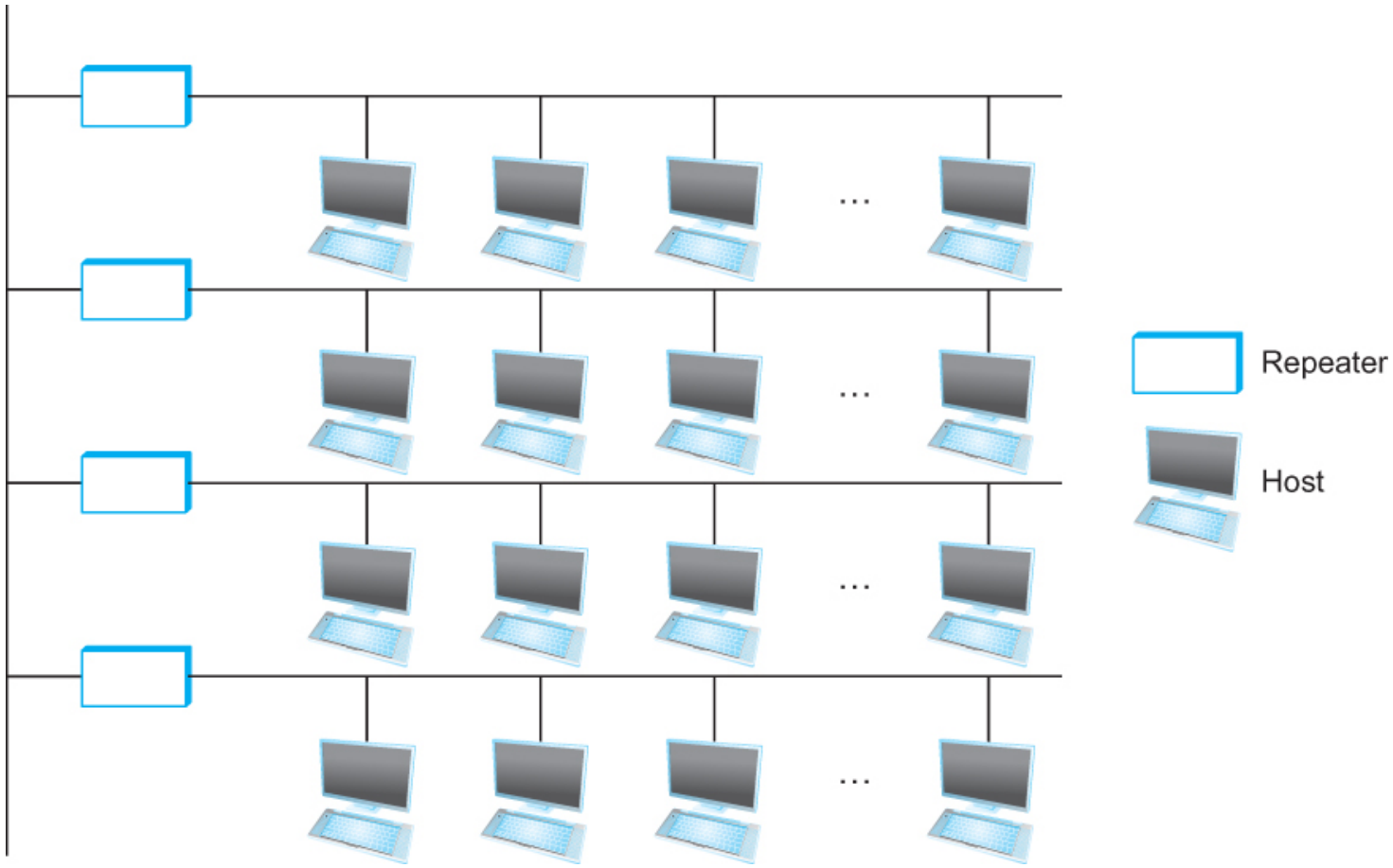
Ethernet transceiver and adaptor

Ethernet – repeater

- Multiple Ethernet segments can be joined together by *repeaters.*
- A *repeater* is a device that relays digital signals.
- No more than four repeaters may be positioned between any pair of hosts.
  - A classical Ethernet has a total reach of only 2500 m.
  - Maximum of 1024 hosts

- Modern Ethernets
  - use category 5 twisted copper pair (cat 6 or cat 7 for 10Gbps)
  - Use optical fibers
  - Can be longer than 500 meters between repeaters

Ethernet – repeater



Ethernet repeater

Ethernet – cont'

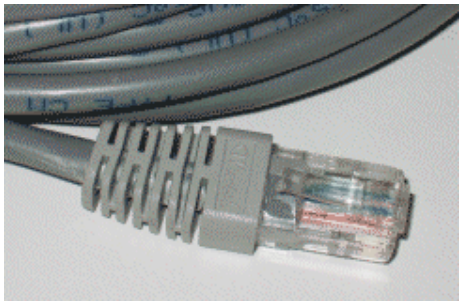
- Any signal placed on the Ethernet by a host is broadcast over the entire network
  - Signal is propagated in both directions.
  - Hosts can detect the signal from the cable.
- Classical Ethernet uses Manchester encoding scheme.
- Higher speed Ethernets use 4B/5B or 8B/10B encoding

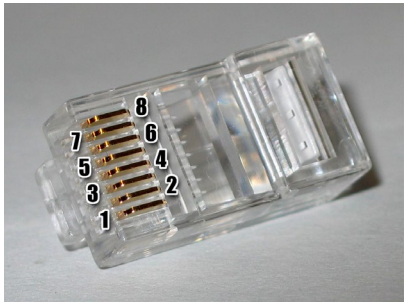
Ethernet – cont'

- New Technologies in Ethernet
  - Instead of using coax cable, an Ethernet can be constructed from a thinner cable known as 10Base2
    - 10 means the network operates at 10 Mbps
    - Base means the cable is used in a baseband system
    - 2 means that a given segment can be no longer than 200 m

Ethernet – cont'

- New Technologies in Ethernet
  - Another cable technology is 10BaseT
    - T stands for twisted pair
    - Limited to 100 m in length
  - With 10BaseT, the repeater has multiple outputs, called *Hub*

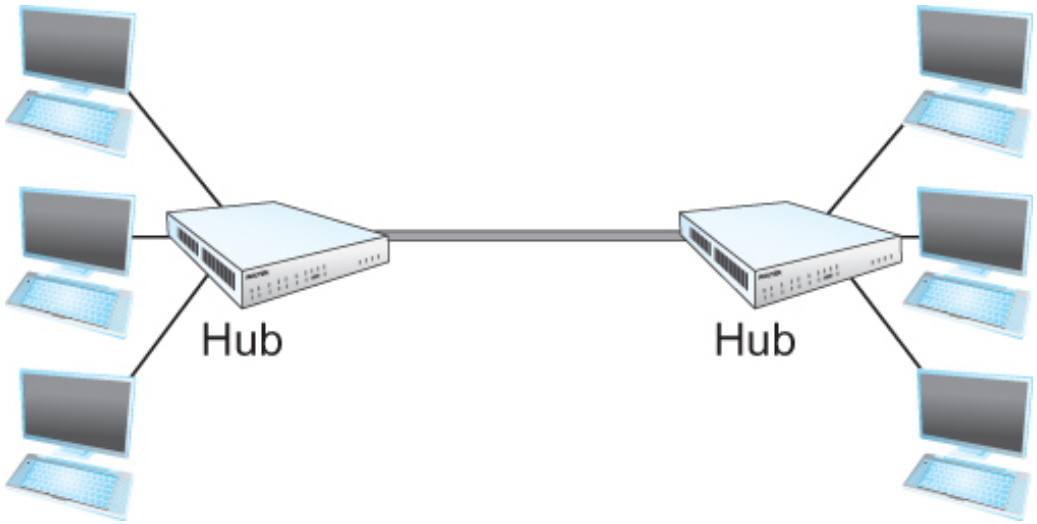




TIA/EIA-568 T568A termination

Pin	Pair	Wire[e]	Color
1	3	tip	white/green
2	3	ring	green
3	2	tip	white/orange
4	1	ring	blue
5	1	tip	white/blue
6	2	ring	orange
7	4	tip	white/brown
8	4	ring	brown

Ethernet – cont'

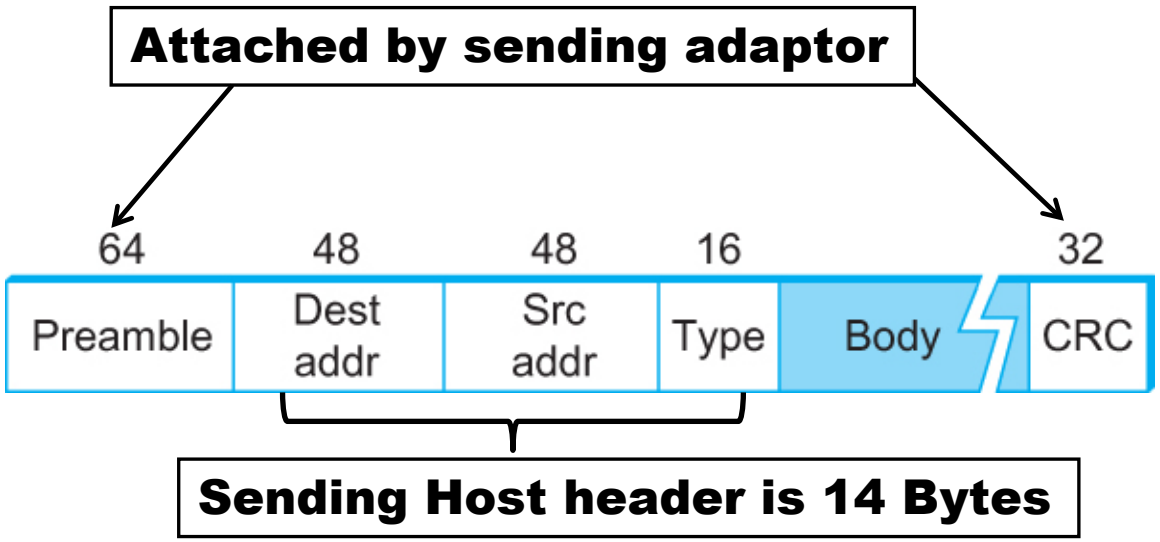


Ethernet Hub

Ethernet – frame

- Frame format
  - Preamble (64bit or 8 Bytes): allows rcvr to synchronize.
  - Src and Dst Address (48bit or 6 Bytes each).
  - Packet type (16bit or 2 Bytes): acts as demux key to identify the higher level protocol.
  - Data (up to 1500 bytes)
    - Minimally a frame must contain at least 46 bytes of data. WHY?
    - Frame must be long enough to detect collision, but no more than 1,500 bytes to avoid always occupying the line.
  - CRC (32bit or 4 Bytes)

Ethernet – frame



Ethernet Frame Format

Link to Slide 22

Ethernet – address

- Each host on an Ethernet has a unique Ethernet Address (e.g., IP, MAC address).
- The address belongs to the adaptor, not the host.

Ethernet – address

- MAC address is typically printed in a human readable format
  - As a sequence of six numbers separated by colons.
  - Each number is given by a pair of hexadecimal digits, one for each of the 4-bit nibbles in the byte
  - For example, 8:0:2b:e4:b1:2 is
    - 00001000 00000000 00101011 11100100 10110001 00000010

Ethernet – address

- MAC-48 is now being called EUI-48 (Extended Unique Identifier)
- 48 bits, so number of addresses: 2^{48} = 281.47E12!
- It is projected to be exhausted in 2100!

Ethernet – address

IP address:

- *Unicast* address – one-to-one addressing
- *broadcast* address – one-to-all addressing
- *multicast* address – one-to-many addressing

We will elaborate on next chapter

– network layer technology

Ethernet – access protocol

- It transmits the frame immediately when the line is idle.
- It holds the transmission when the line is busy.

Ethernet – access protocol – issue

- No coordination, so it is possible for two (or more) adaptors far-away to transmit at the same time,
- When this happens, the two (or more) frames are said to *collide* on the network.

Ethernet – access protocol – issue

How does CSMA/CD come into play?

- When an adaptor detects its frame colliding with another,
  - it first transmits a frame of 32-bit jamming sequence.
  - it then stops transmission.

Ethernet – access protocol – issue

- Worst case collision: two hosts are at opposite ends of the Ethernet.

- Let's first put the design rule here:
  - Every Ethernet frame must be at least 512 bits (64 bytes) long.
    - 14 bytes of header + 46 bytes of data + 4 bytes of CRC
    - Not include the preamble of 8 Bytes – otherwise minimum frame is 576 bits

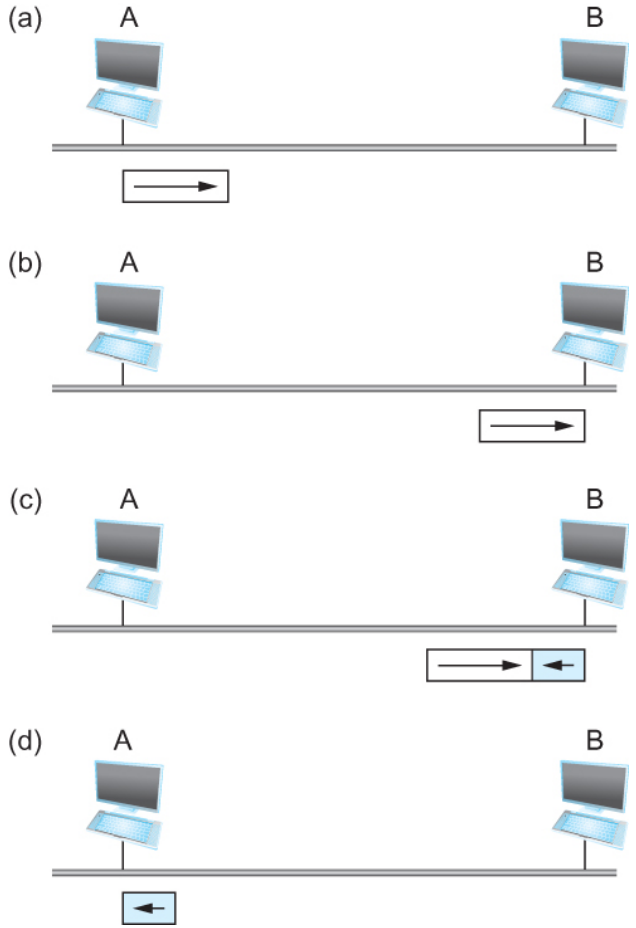
Ethernet – access protocol – issue

Why 512 bits? Why is its length limited to 2500 m?

- The farther apart, the longer it takes for transmitting a frame.

- On 10 Mbps Ethernet,
  - Round trip delay of transmitting 512-bit frame is 51.2 uS for 2500 meter length and 4 repeaters

Ethernet – access protocol – issue



Worst-case scenario: (a) A sends a frame at time *t; (b) A's frame arrives* at B at time *t + d; (c) B begins transmitting at time t + d and collides with A's frame;* (d) B's runt (32-bit) frame arrives at A at time *t + 2d.*

Ethernet – access protocol

- Once detecting a collision,
  - transmission is stopped,
  - wait a certain amount of time,
  - try again.
- After several trials,
  - double waiting time,
  - try again

Exponential Backoff

Ethernet – access protocol

- At first collision,
  - the adaptor delays either 0 or 51.2 μs, selected at random.
- At second collision,
  - it waits 0, 51.2, 102.4, 153.6 μs (selected randomly);
  - This is $k * 51.2$ for $k = 0, 1, 2, 3$.
- At third collision,
  - it waits $k * 51.2$ for $k = 0 \ldots 2^3 - 1$ (selected at random).

Ethernet – access protocol

- In general, the algorithm
  - randomly selects a *k* between 0 and $2^n - 1$;
  - and waits for *k* * 51.2 μs;
  - *n* is the number of collisions experienced so far.

- After a successful transmission,
  - n may be reset to 0
  - or reduced by some factor (1, ½, ¼, etc)

Ethernet – some experience

- Ethernets work best under lightly loaded conditions.
  - Under heavy loads (typically >30% utilization), too much of the network's capacity is wasted by collisions.
- Most Ethernets are used in a conservative way.
  - Have fewer than 200 hosts connected to them which is far fewer than the maximum of 1024.
- Hosts can plug-and-play.