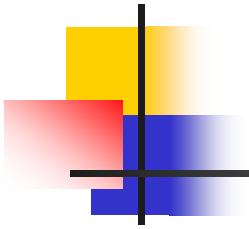
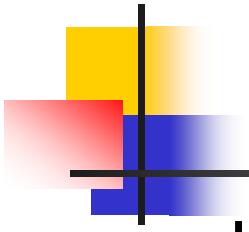
Ethernet



Medium Access Control (MAC)

- MAC is a sublayer of the data link layer
- MAC is to control access to multiaccess (multiple-access or random access) channels (links, lines)
- Usually used in LANs
- Ethernet (IEEE 802.3 standard)
- Token ring (802.5, FDDI)
- Wireless (802.11)

Ethernet Cabling



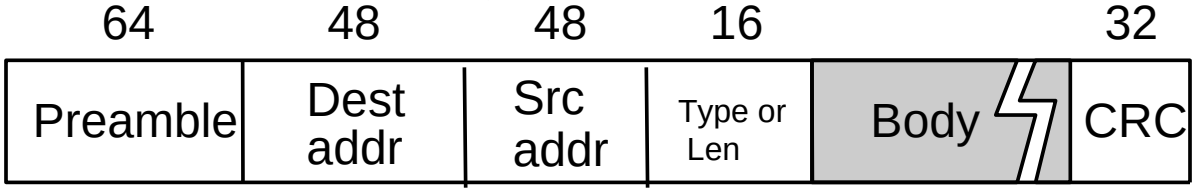
- Hosts are connected to Ethernet cable through adapters
- Usually an adapter is inside the host
- Transceiver is used either at the adapter or at the connector at the cable
- Bandwidth: 10Mbps, 100Mbps, 1Gbps
- Length: 2500m (500m segments with 4 repeaters)
- Ethernet uses CSMA/CD technology and a 1-persistent protocol

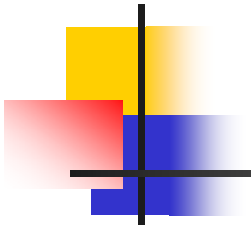
Different kinds of Ethernet LANs

Name (10Mbps)	cable	Max segment	Nodes/ segment
10Base5	Thick coax	500 m	100
10Base2	Thin coax	200 m	30
10Base-T	Twisted pair	100 m	1024
10Base-F	Fiber optics	2000 m	1024

Ethernet Frame Format

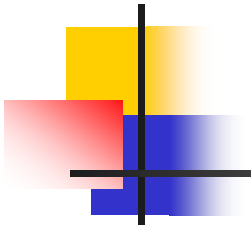
- Manchester encoding is used
- Preamble
  - 7 bytes (10101010) used for clock synchronization
  - 1 byte (10101011) used to mark the start of frame
- Type (or length)
  - Used as a demultiplexing key. Usually >1500
  - Can also be used as a length field (0to 1500 bytes)
  - Frame format showing fields and their size (in bits)





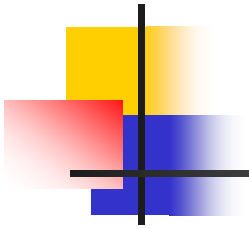
Ethernet Addresses

- Addresses
  - Unique world-wide, 48-bit unicast address assigned to each adapter
  - example: **`08:c0:65:b1:2a:5d`**
  - broadcast: all **`1`**s: **ff: ff: ff: ff: ff: ff**
  - multicast: first bit is **`1`**
- Ethernet adapter receives all frames and accepts
  - Frames addressed to it
  - Frames addressed to the broadcast address
  - Frames addressed to a multicast address if instructed
  - All frames if it operates in promiscuous mode



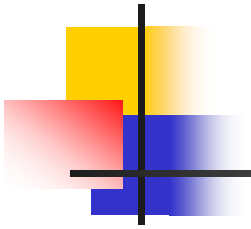
CSMA - CD

- Ethernet uses CSMA-CD technique
- CSMA-CD: carrier sense multiple access – collision detection
- Carrier sense
  - A host senses the link and can distinguish if the link is idle or busy
- Collision detect
  - A host listens what it is transmitting and therefore can detect if it collides with any other frame transmitted by some other host



1-Persistent CSMA

- p-persistent CSMA
  - If a host is ready to send a frame, it continuously senses the channel (link). If it is idle, then transmit frame with probability p
- 1-persistent CSMA
  - If a host is ready to send a frame, it continuously senses the channel (link). If it is idle, then transmit frame with probability 1
  - Ethernet uses 1-persistent protocol

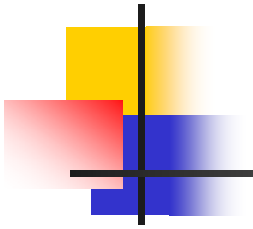


Transmit Algorithm

- A node can transmit independent of what other nodes are doing.
- uses *exponential backoff algorithm* to dynamically adapt to the number of nodes trying to send
- If line is idle...
  - send immediately
  - upper bound message size of 1500 bytes
- If line is busy...
  - wait until idle and transmit immediately

Transmit Algorithm (contd.)

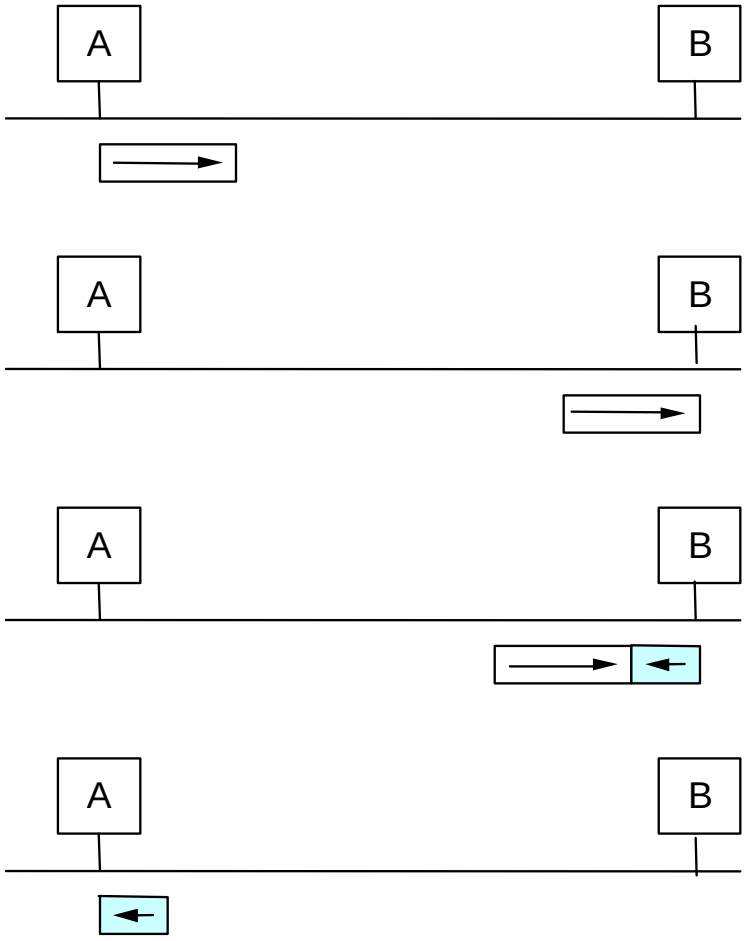
- If collision...
  - Transmit a 32 bit jamming sequence along with 64 bit preamble, then stop transmitting frame (Why?)
  - delay and try again
  - 1st collision: waits for n slots where n is chosen randomly from the interval [0,1], 1 slot is usually 51.2μs
  - 2nd collision: waits for n slots where n is chosen randomly from the interval [0,3]
  - ith collision: waits for n slots where n is chosen randomly from the interval [0,2^{i} -1]
    - for i > 10, the interval used is [0,2 ^{10} –1]
    - give up after several tries (usually 16)

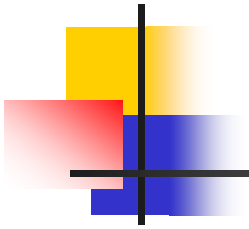


Minimum frame size

- Minimum size is 64 bytes: 14 bytes header 46 bytes data, and 4 bytes CRC (WHY?)
- A situation should not arise wherein, the sending host has transmitted the frame, without detecting any collision, but there is actually a collision
- From the Figure (shown in next slide, see reference book Peterson and Davie), it is observed that a host needs to send for “RTT” to detect all possible collisions
  - Host A finds the link is free and sends a frame
  - Just before the arrival of frame bits, host B finds that the link is free and starts transmitting a frame
  - Collision occurs near host B’s link interface which is detected by Host B
  - If host A does not transmit its frame for “RTT”, it cannot detect collision
- Ethernet length is limited to 2500 m and four repeaters; for this case RTT is estimated to be 51.2μs = 512 bits for 10 Mbps Ethernet

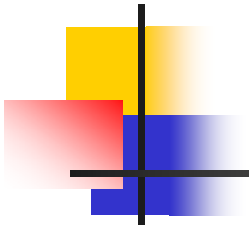
Collisions





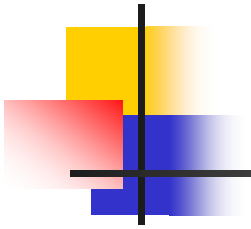
LAN Hubs and Switches

- Shared-Medium Bus (also referred to as a bus)
- Shared-Medium Hub (also referred to as a hub)
- Switching Hub (also referred to as a switch)



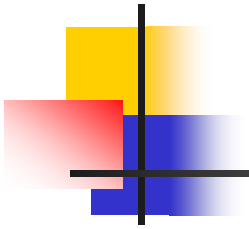
Bus-based LAN

- Shared-Medium Bus (or simply a bus)
  - Bus configuration
  - Traditional Ethernet (e.g. 10BASE 5)
  - Single collision domain
  - All stations share the total capacity of the LAN or bus
  - One station transmits, others receive
  - Cable cut disconnects the network



Hub-based LAN

- Shared-Medium Hub (or simply a hub)
  - Star configuration
  - e.g. 10BASE-T Ethernet
  - E.g. 802.3u 100 Mbps Fast Ethernet (e.g. 100 BASE T)
  - Single collision domain, hub transmits jam signal to all when collision occurs
  - All stations share the total capacity of the LAN or hub
  - One station transmits, others receive
  - Can exploit building wiring practices for cable layout
  - Hub can recognize a malfunctioning station that jams the network and remove it from the network
  - Cable cut does not disconnect the network

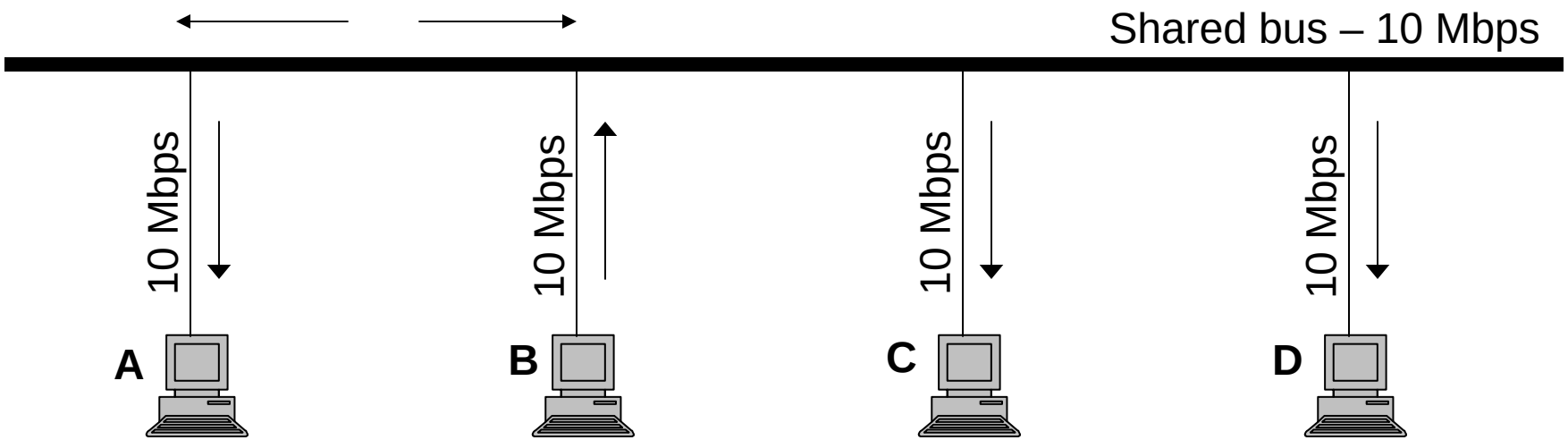


Switch-based LAN

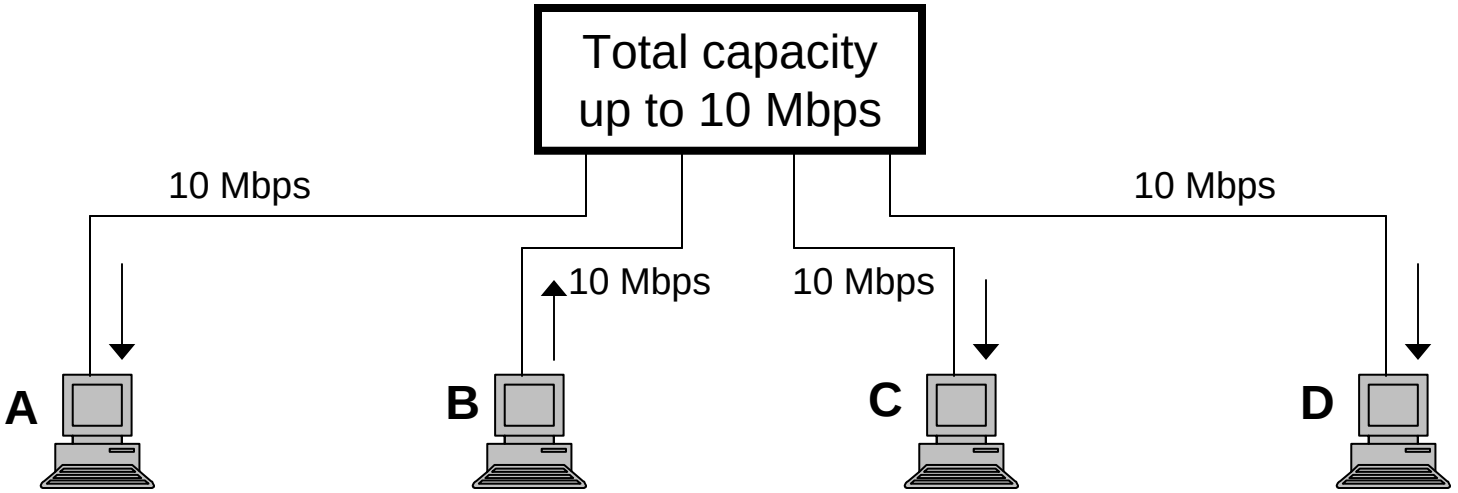
- Switching Hub (or simply a switch)
  - Star configuration
  - E.g. 802.3u 100 Mbps Fast Ethernet (e.g. 100 BASE T)
  - E.g. 802.3z Gigabit Ethernet (e.g. 1000 BASE SX, 1000 BASE LX)
    - SX: short wavelength 0.85 micron, multimode fiber
    - LX: long wavelength 1.3 micron, singlemode fiber
  - No collision between ports, Port is the collision domain, when only one station is connected to a port, there is no collision
  - More than one pair can communicate simultaneously.

    Total capacity of the LAN or switch is the sum of the capacities of the individual lines connecting the stations
  - By increasing the capacity of the switch additional stations can easily be added
  - Cable cut does not disconnect the network
  - Without any change in hardware or software of the attached stations, a bus LAN can be converted into a hub LAN or to a switch LAN.

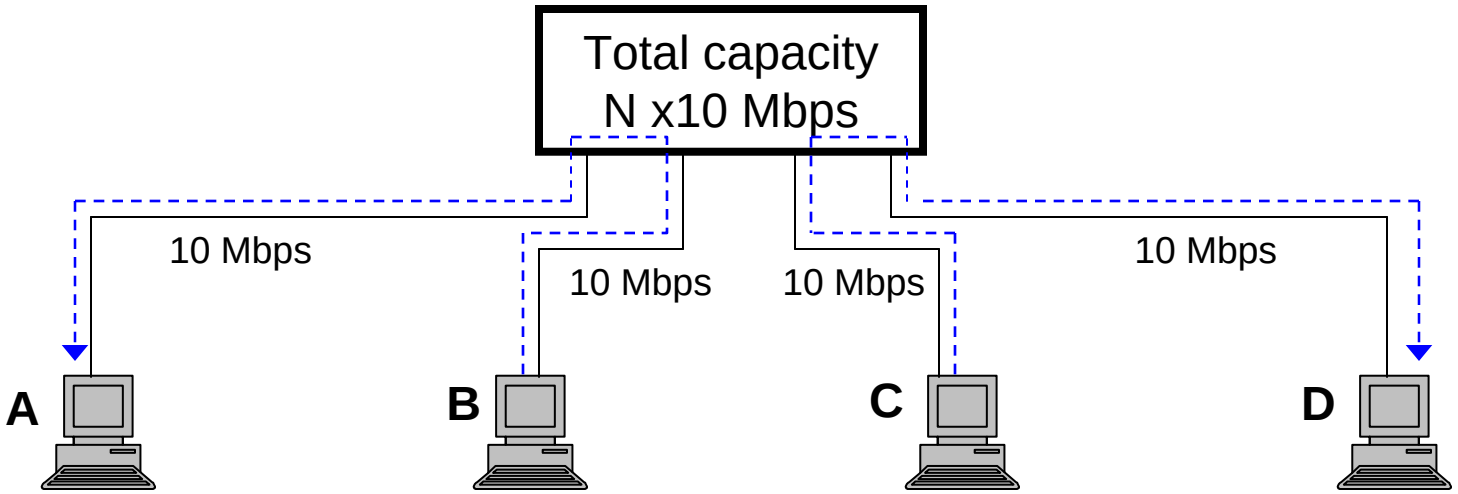
Bus LAN

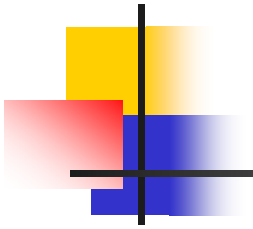


Hub LAN


Total capacity
up to 10 Mbps
10 Mbps
10 Mbps
10 Mbps
10 Mbps
A
B
C
D

Switch LAN

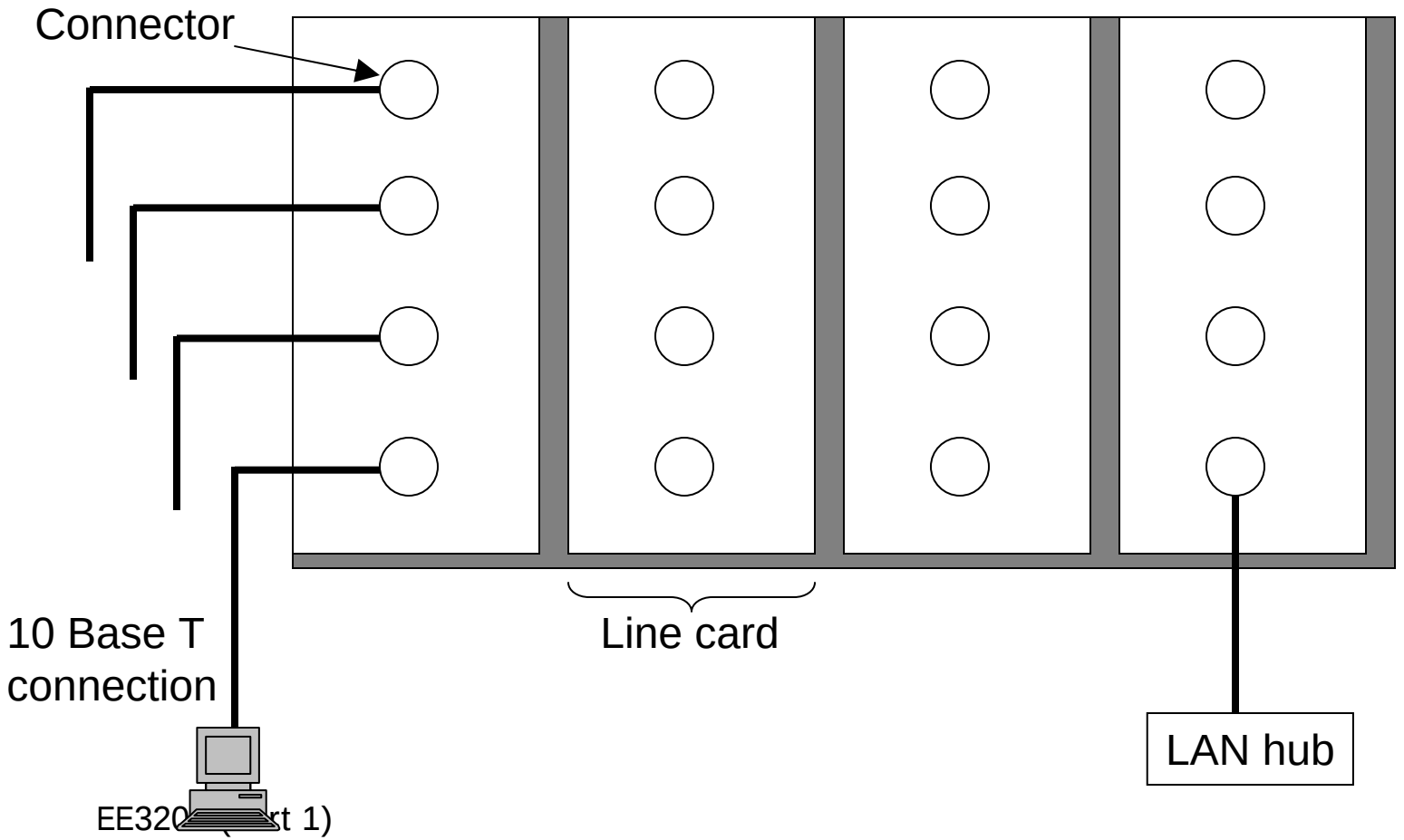




A LAN Switch

- Comprises a number of (4-32) line cards each of which has a number of connectors (1-8)
- Connectors are connected through a high speed backbone
- Stations are connected to the connectors through 10 BASE T twisted pair connections
- When a frame is received, line card checks if it is destined to a station in the same card
  - If Yes, copy it to the destination station
  - If No, send it over the backbone to the destination station's line card
- Line card can be a single collision domain (resembles shared-medium hub)
- A connector or a line in the line card can be a single collision domain (resembles switching hub)

LAN switch



Ethernet Configuration in a Campus Network