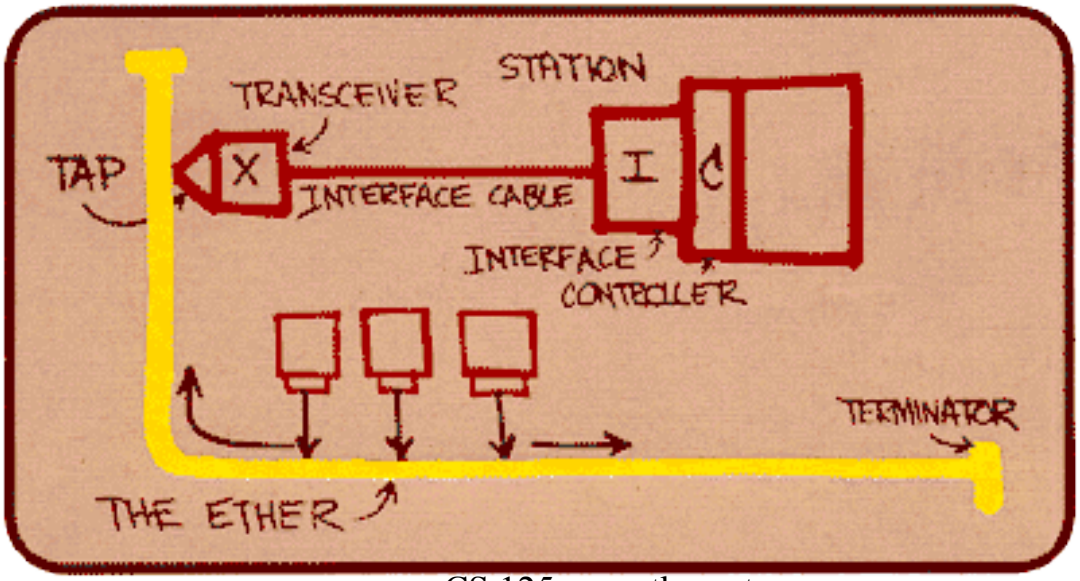
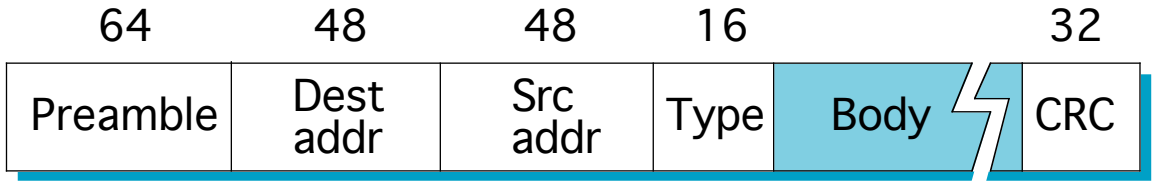
Shared Access Networks: bus - Ethernet

Metcalfe's Ethernet sketch



Ethernet Overview

- History
  - Dominant wired LAN technology
  - Simpler, cheaper than token ring and ATM
  - developed by Xerox PARC in mid-1970s
  - roots in Aloha packet-radio network
  - standardized by Xerox, DEC, and Intel in 1978
- CSMA/CD
  - carrier sense
  - multiple access
  - collision detection
- Frame Format

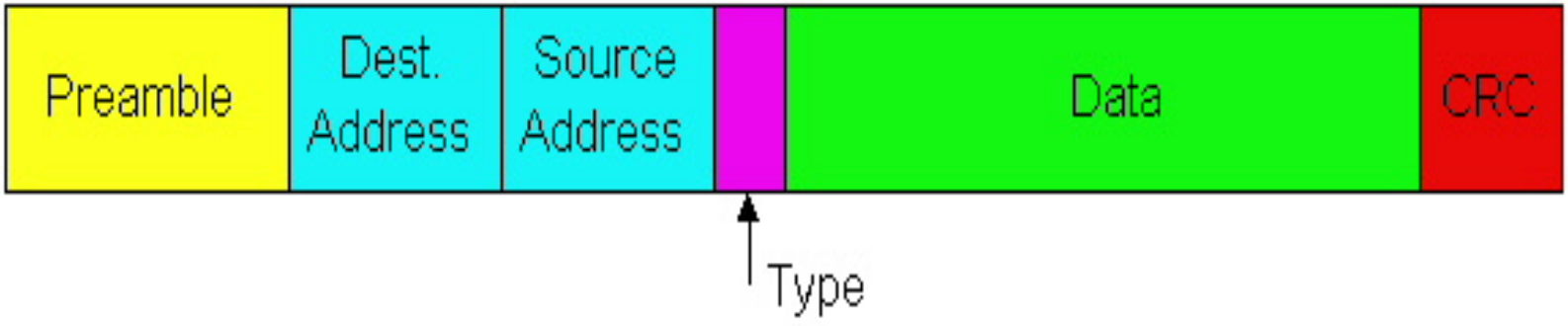


Ethernet Uses CSMA/CD

- Carrier sense: wait for link to be idle
  - Channel idle: start transmitting
  - Channel busy: wait until idle
- Collision detection: listen while transmitting
  - No collision: transmission is complete
  - Collision: abort transmission, and send jam signal
- Random access: exponential back-off
  - After collision, wait a random time before trying again
  - After m^{th} collision, choose K randomly from {0, …, 2^m-1}
  - … and wait for K*512 bit times before trying again

Ethernet Frame Structure

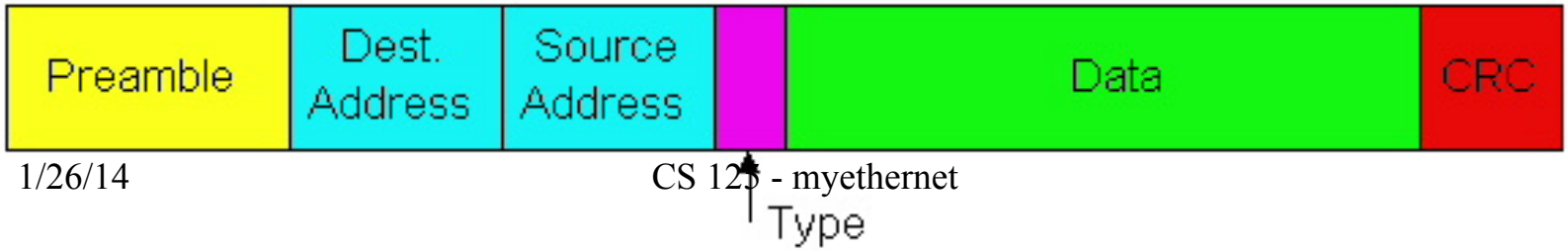
- Sending adapter encapsulates packet in frame



- Preamble
  - Seven bytes with pattern 10101010, followed by one byte with pattern 10101011
  - Used to synchronize receiver, sender clock rates

Ethernet Frame Structure (Continued)

- Addresses: source and destination MAC addresses
  - On reception Adaptor passes frame to network-level protocol
    - If destination address matches the adaptor
    - Or the destination address is the broadcast address
  - Otherwise, adapter discards frame
  - What does this mean??
- Type: indicates the higher layer protocol
  - Usually IP
  - But also Novell IPX, AppleTalk, …Google
- CRC: cyclic redundancy check
  - Checked at receiver
  - If error is detected, the frame is simply dropped



Unreliable, Connectionless Service

- Connectionless
  - No handshaking between sending and receiving adapter.
- Unreliable
  - Receiving adapter doesn't send ACKs or NACKs
  - Packets passed to network layer can have time gaps
  - Gaps will be filled if application is using TCP
    - i.e., TCP creates a data stream
  - Otherwise, the application will see the gaps

Ethernet (cont)

- Addresses
  - unique, 48-bit unicast address assigned to each adapter
  - example: **`8:0:e4:b1:2`**
  - broadcast: all **`1`**s
  - multicast: first bit is **`1`**
- Bandwidth: 10Mbps, 100Mbps, 1Gbps, & climbing
- Max Length: 2500m (500m segments with 4 repeaters)
  - Signal timing
- Approach (Problem?): Distributed algorithm that provides fair access

Transmit Algorithm

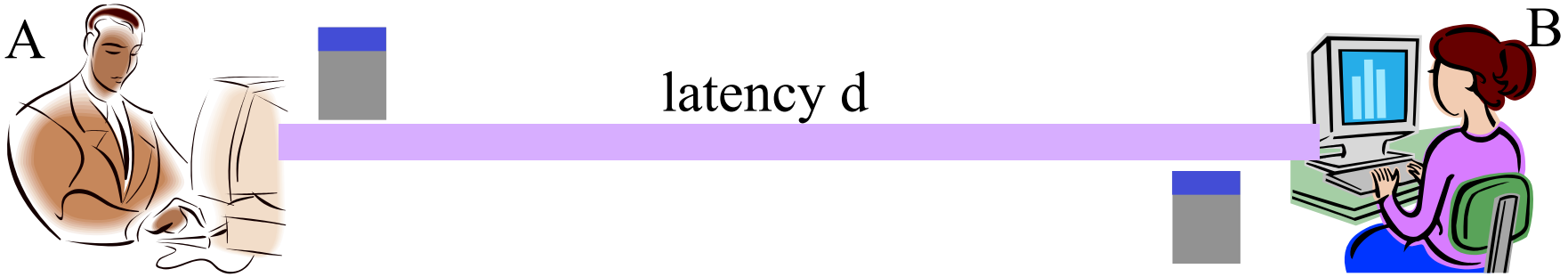
- If line is idle…
  - send immediately
  - upper bound message size
  - must wait 9.6us between back-to-back frames, why?

- If line is busy…
  - wait until idle and transmit immediately
  - called *1-persistent* (special case of *p-persistent*)

Algorithm (cont)

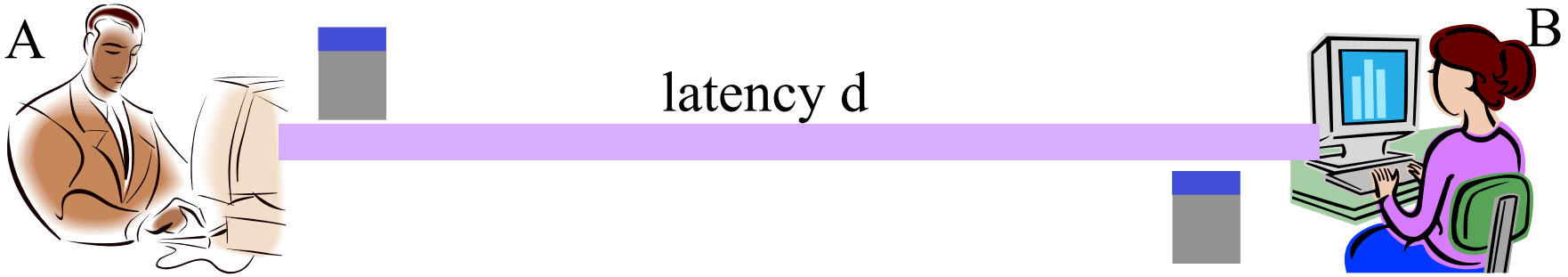
- If collision…
  - jam for 32 bits, then stop transmitting frame
  - minimum frame is 64 bytes (header + 46 bytes of data)
  - delay and try again
    - 1st time: 0 or 51.2us
    - 2nd time: 0, 51.2, or 102.4us
    - 3rd time51.2, 102.4, or 153.6us
    - *nth* time: k x 51.2us, for randomly selected k=0..2^n - 1
    - give up after several tries (usually 16)
    - exponential backoff

Limitations on Ethernet Length



- Latency depends on physical length of link
  - Time to propagate a packet from one end to the other
- Suppose A sends a packet at time t
  - And B sees an idle line at a time just before t+d
  - … so B happily starts transmitting a packet
- B detects a collision, and sends jamming signal
  - But A doesn't see collision till t+2d

Limitations on Ethernet Length



- A needs to wait for time 2d to detect collision
  - So, A should keep transmitting during this period
  - … and keep an eye out for a possible collision
- Imposes restrictions on Ethernet
  - Maximum length of the wire: 2500 meters
  - Minimum length of the packet: 512 bits (64 bytes)

Benefits of Ethernet

- Easy to administer and maintain
- Inexpensive
- Increasingly higher speed
- Moved from shared media to switches
  - Change everything except the frame format
  - A good general lesson for evolving the Internet
- Can Ethernet become so congested that it dies??