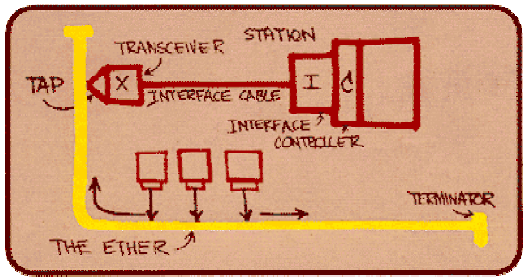
Ethernet

"dominant" LAN technology:

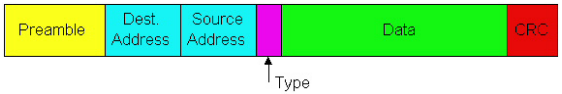
- cheap -- $20 for 100Mbs!
- first widely used LAN technology
- Simpler, cheaper than token rings and ATM
- Kept up with speed race: 10, 100, 1000 Mbps



Metcalfe's Etheret sketch

Ethernet Frame Structure

Sending adapter encapsulates IP datagram (or other network layer protocol packet) in Ethernet frame

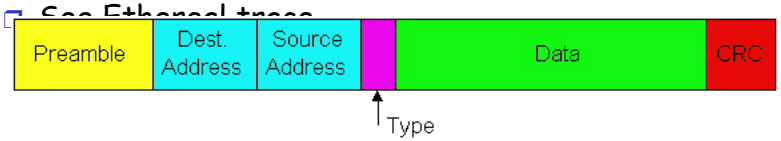


Preamble:

- 7 bytes with pattern 10101010 followed by one byte with pattern 10101011
- used to synchronize receiver, sender clock rates

Ethernet Frame Structure (more)

- Addresses: 6 bytes, frame is received by all adapters on a LAN and dropped if address does not match
- Type: indicates the higher layer protocol, mostly IP but others may be supported such as Novell IPX and AppleTalk)
- CRC: checked at receiver, if error is detected, the frame is simply dropped
- See Ethereal trace



Ethernet: uses CSMA/CD

A: sense channel, **if** idle

```
then {
        transmit and monitor the channel;
        If detect another transmission
          then {
             abort and send jam signal;
             update # collisions;
             delay as required by exponential backoff algorithm;
             goto A
             }
         else {done with the frame; set collisions to zero}
    }
else {wait until ongoing transmission is over and goto A}
```

Ethernet's CSMA/CD (more)

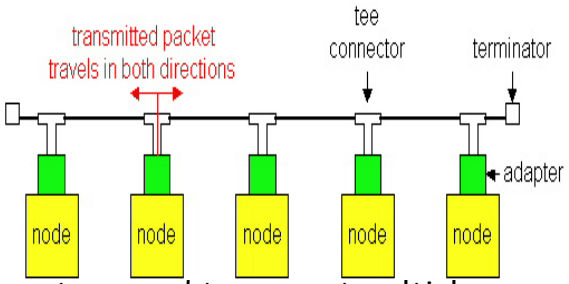
Jam Signal: make sure all other transmitters are aware of collision; 48 bits;

Exponential Backoff:

- *Goal*: adapt retransmission attempts to estimated current load
  - heavy load: random wait will be longer
- first collision: choose K from {0,1}; delay is K x 512 bit transmission times
- after second collision: choose K from {0,1,2,3}…
- after ten or more collisions, choose K from {0,1,2,3,4,…,1023}

Ethernet Technologies: 10Base2

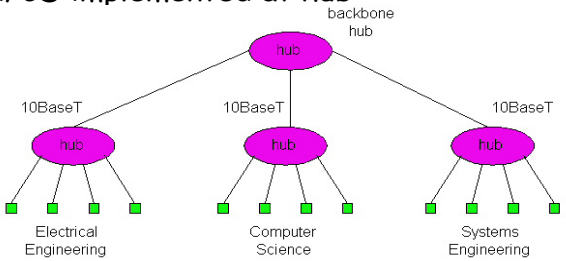
- 10: 10Mbps; 2: under 200 meters max cable length
- thin coaxial cable in a bus topology



- repeaters used to connect 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"
- CSMA/CD implemented at hub



10BaseT and 100BaseT (more)

- Max distance from node to Hub is 100 meters
- Hub can disconnect "jabbering adapter
- Hub can gather monitoring information, statistics for display to LAN administrators

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
- uses hubs, called here "Buffered Distributors"
- Full-Duplex at 1 Gbps for point-to-point links

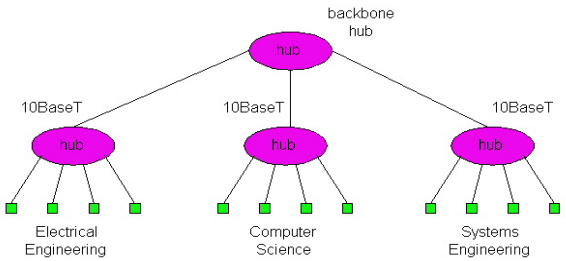
Interconnecting LANs

Q: Why not just one big LAN?

- Limited amount of supportable traffic: on single LAN, all stations must share bandwidth
- limited length: 802.3 specifies maximum cable length
- large "collision domain" (can collide with many stations)
- limited number of stations: 802.5 have token passing delays at each station

Hubs

- Physical Layer devices: essentially repeaters operating at bit levels: repeat received bits on one interface to all other interfaces
- Hubs can be arranged in a hierarchy (or multi-tier design), with backbone hub at its top



Hubs (more)

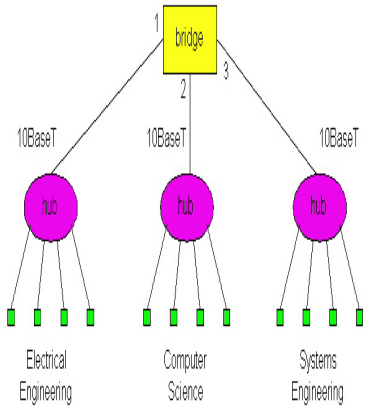
- Hubs do not isolate collision domains: node may collide with any node residing at any segment in LAN
- Hub Advantages:
  - simple, inexpensive device
  - Multi-tier improves robustness: portions of the LAN continue to operate if one hub malfunctions
  - extends maximum distance between node pairs (100m per Hub)
  - What is the maximum number of chained hubs?

Hub limitations

- single collision domain results in no increase in max throughput
  - multi-tier throughput same as single segment throughput
- Thus, limits on number of nodes in same collision domain and on total allowed geographical coverage
- cannot connect different Ethernet types (e.g., 10BaseT and 100baseT)

Bridges

- Link Layer devices: operate on Ethernet frames, examining frame header and selectively forwarding frame based on its destination
- Bridge isolates collision domains since it buffers frames
- When frame is to be forwarded on segment, bridge uses CSMA/CD to access segment and transmit



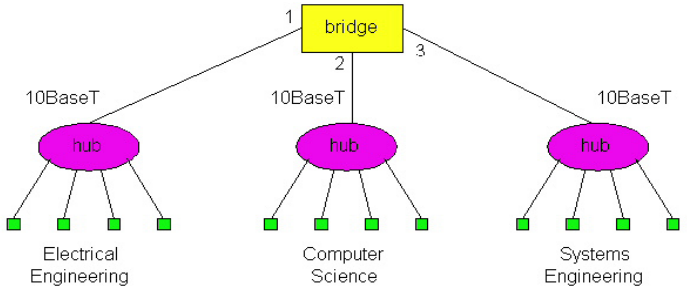
Bridges (more)

- Bridge advantages:
  - Isolates collision domains resulting in higher total max throughput, and does not limit the number of nodes nor geographical coverage
  - Can connect different type Ethernet since it is a store and forward device
  - Transparent: no need for any change to hosts LAN adapters

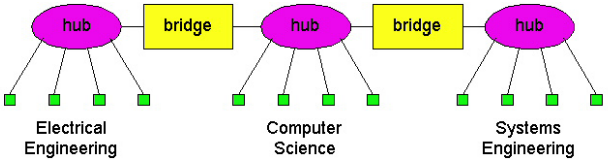
Bridges: frame filtering, forwarding

- bridges filter packets
  - same-segment frames not forwarded onto other segments
- forwarding:
  - how to know which LAN segment on which to forward frame?
  - looks like a routing problem!

Backbone Bridge



Interconnection Without Backbone



- Not recommended for two reasons:
  - single point of failure at Computer Science hub
  - all traffic between EE and SE must path over CS segment