Broadcast Networks

Particularly Ethernet

Ethernet (IEEE 802.3)

- Multiple access network
  - Nodes send and receive frames over a shared link
- Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
  - CSMA: all nodes can distinguish between an idle and busy link
  - CD: nodes listen as they transmit and can therefore detect when frame it is transmitting has interfered with a frame transmitted by another node
- Evolved philosophically from the Aloha packet radio network (both mediate access to a shared medium—for Aloha it was the atmosphere, for Ethernet a coaxial cable).

- DEC, Intel, Zerox joined forces to define 10Mbps Ethernet standard in 1978.
  - 100Mbps and 1Gps Ethernet are designed for point-to-point switched network, so not the "true" ethernet algorithm.
- IEEE Standard 802.3 is the "official" protocol, though not every Ethernet follows this standard (slight differences in certain packet header fields, etc).

Physical Properties

- Implemented on coaxial cable of up to 500 meters in length
- Hosts connect by "tapping" into it.
  - Taps at least 2.5 meters apart
- Transceiver is small device directly attached to tap
  - Detects when line is idle and drives signal when host is transmitting
- All protocol logic implemented in the adaptor (i.e. the network card), not transceiver
Multiple Ethernet Segments

- Multiple Ethernet segments can be joined together by repeaters
  - No more than four repeaters between any two hosts (so Ethernet has a total reach of only 2500 meters).
  - Like single Ethernet, each host hears every message sent on network
- An Ethernet is limited, regardless of whether repeaters used to 1024 hosts
- Again, any signal is heard by everyone
  - Terminators attached to end of each segment absorb signal and keep it from reflecting back and interfering with trailing signals

Frame Format

- 64 bit preamble for synchronization (unseen by host)
- 48 bit address fields for both destination and source
- Type field (to which higher level protocol should this frame be delivered)

Frame Format (cont.)

- Minimum of 46 and maximum of 1500 bytes of data
  - Minimum required so frames long enough for collision detection
- 32 bit CRC (cyclic redundancy check)
- 802.3 format slightly different (16 bit length field replaces the type field)
  - Software kludged so that it can handle either

Addresses

- Typically written in hex notation
  - Ex. 8:0:2b:e4:b1:2
- Every Ethernet Adaptor in world has unique Ethernet address
  - Burned into ROM at factory
  - Each manufacturer has different prefix
    - Ex. AMD starts with x080020
- Each frame transmitted on Ethernet received by every adaptor

Adaptor Accepts:

- Frames addressed to its own address
- Frames addressed to the broadcast address (all 1s)
- Frames addressed to a multicast address (first bit 1) if instructed to listen for that address by host
- All frames, if it is in promiscuous mode
- It passes to host only the frames that it accepts
Transmitter Algorithm

- When adaptor has frame to send and line is idle, it transmits frame immediately
  - Upper bound of 1500 bytes ensures that no adaptor can occupy the line for too long
- If adaptor has frame to send and line is busy, it waits for line to go idle then transmits immediately
  - Well, all adaptors wait 9.6\(\mu\)s after one frame before sending next

Transmitter Algorithm (cont.)

- It is possible for two or more adaptors to begin transmitting at same time (a collision)
- If collision occurs, both adaptors transmit a 32 bit jamming sequence, then stop transmitting.
  - So in minimal case an adaptor sends 96 bits: 64 bit preamble and 32 bit jamming sequence (this is called a runt frame)
  - Runt frame only occurs if senders are near. In worst case they may need to send as many as 512 bits (64) bytes past preamble to detect collision (thus the 46 data byte mininum: 14 bytes of header plus 46 bytes of data plus 4 byte CRC = 64 bytes).
  - Why 512 bits?!

512 Bits...

Worst case scenario:

- A sends frame at time \(t\)
- A's frame arrives at B at time \(t+d\)
- B begins transmitting at time \(t+d\) and collides with A's frame
- B's runt (32 bits) arrives at A at time \(t+2d\)

Host A must transmit for 2d to be sure it detects all possible collisions!

512 Bits (cont.)

- A maximally configur ed Ethernet is 2500 meters long
- Has max of 4 repeaters
- Round trip delay has been determined to be 51.2\(\mu\)s long, which on 10Mbps Ethernet is 512 bits
- Bottom line: limits placed on Ethernet are designed to limit latency on the network, and thus allow the access algorithm to work somewhat efficiently

Ethernet Success

- Extremely easy to administer and maintain
  - No switches that can fail
  - No routing or configuration tables to maintain
  - Easy to add new hosts
- Inexpensive
  - Cable is cheap
  - Only additional cost is network adapter for each host