Ethernet

- 1976, Metcalfe & Boggs at Xerox
  - Later at 3COM
- Based on the Aloha network in Hawaii
  - Named after the "*luminiferous ether*"
- Centered around a broadcast bus
- Can use different physical links
- Simple link-level protocol, scales well
- Simple algorithm for sharing the network well under load

Ethernet Goals

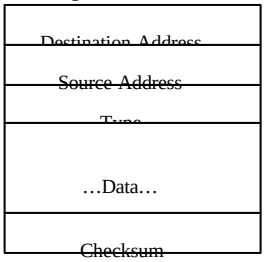
- Connect local area networks
  - Few buildings, short distances (<1 km)
- Inexpensively
  - Low infrastructure costs
- Without bottlenecks
  - No expensive routers, bridges, switches etc.
  - No state in the network, no store-and-forward
- Tremendously successful
- Simple conceptual model still in use
  - Despite two orders of magnitude increase in bandwidth

"CSMA/CD"

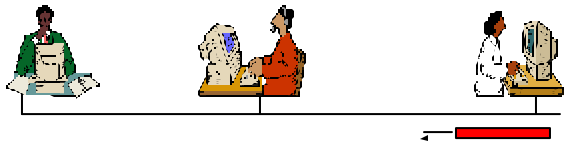
- Carrier sense
  - Listen before you speak
- Multiple access
  - Multiple hosts can access the network
- Collision detect
  - Detect and respond to cases where two hosts collide

Ethernet basics

- An ethernet packet

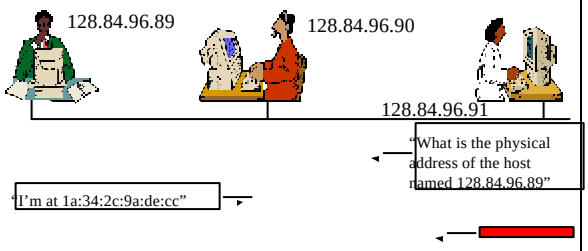


Sending packets



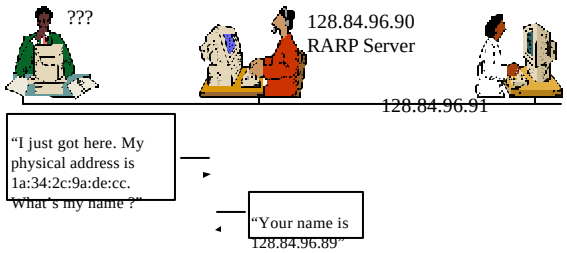
- Carrier sense, broadcast if ether is available

Addressing & ARP



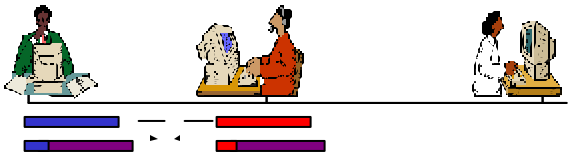
- ARP is used to discover physical addresses
  - ARP = Address Resolution Protocol

Addressing & RARP



- RARP is used to discover virtual addresses
  - RARP = Reverse Address Resolution Protocol

Collisions

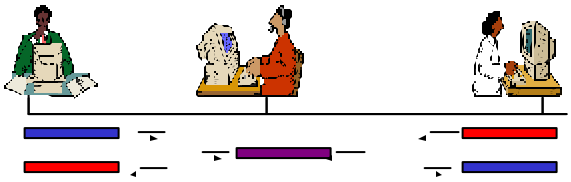


- What happens if two people decide to transmit simultaneously ?

Collision Detection & Retransmission

- The hosts involved in the collision stop data transmission, sleep for a while, and attempt to retransmit
- How long they sleep is determined by how many collisions have occurred before
- They abort after 16 retries, hence no guarantee that a packet will get to its destination
- Advantages:
  - Packet can be retransmitted at the link level immediately without high-level timeouts,
  - Packets are truncated early to avoid wasting bandwidth
  - Collision rates can be used to gauge net usage

Collisions



- What happens if the packets are really short ?

Odds & Ends

- Minimum packet size is 64 bytes, which is just right for the given length for all hosts to detect a collision
- Truncated packets are filtered out of the network
- CRC is used to detect malformed packets, e.g. electrical interference, noise

Ethernet Features

- Completely distributed
  - No central arbiter
- Inexpensive
  - No state in the network
  - No arbiter
  - Cheap physical links (twisted pair of wires)

Ethernet Problems

- The endpoints are trusted to follow the collision-detect and retransmit protocol
  - Certification process tries to assure compliance
  - Not everyone always backs off exponentially
- Hosts are trusted to only listen to packets destined for them
  - But the data is available for all to see
  - Can place ethernet card in promiscuous mode and listen

Ethernet Lessons

- Best-effort delivery simplifies network design
- A simple, distributed protocol can tolerate failures and be easy to administer
- Networking infrastructure represents a large sunk cost
  - Best to keep it simple
  - Interoperable
  - Hard to upgrade means change occurs infrequently, when the gains are sizeable