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

<table>
<thead>
<tr>
<th>Destination Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Address</td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>...Data...</td>
</tr>
<tr>
<td>Checksum</td>
</tr>
</tbody>
</table>
Sending packets

• Carrier sense, broadcast if ether is available

Addressing & ARP

128.84.96.89
128.84.96.90
128.84.96.91

What is the physical address of the host named 128.84.96.89?

128.84.96.90

128.84.96.91

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

“i'm at 1a:34:2c:9a:de:cc”

Addressing & RARP

128.84.96.89
128.84.96.90

What is my name ?

128.84.96.90

RARP Server

“Your name is 128.84.96.89”

• 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)
<table>
<thead>
<tr>
<th>Ethernet Problems</th>
<th>Ethernet Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The endpoints are trusted to follow the collision-detect and retransmit protocol</td>
<td>• Best-effort delivery simplifies network design</td>
</tr>
<tr>
<td>• Certification process tries to assure compliance</td>
<td>• A simple, distributed protocol can tolerate failures and be easy to administer</td>
</tr>
<tr>
<td>• Not everyone always backs off exponentially</td>
<td>• Networking infrastructure represents a large sunk cost</td>
</tr>
<tr>
<td>• Hosts are trusted to only listen to packets destined for them</td>
<td>• Best to keep it simple</td>
</tr>
<tr>
<td>• But the data is available for all to see</td>
<td>• Interoperable</td>
</tr>
<tr>
<td>• Can place ethernet card in promiscuous mode and listen</td>
<td>• Hard to upgrade means change occurs infrequently, when the gains are sizeable</td>
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