Introduction to LAN/WAN

Medium Access Sublayer (Part II)
Now, Where Were We?

- Introduction
- Multiple Access Protocols
- IEEE 802 Standard
  - Ethernet (802.3)
- Wireless LAN Protocols
- Misc
Ethernet Performance

- Mean frame transmission time, $P$ sec
- Probability that a frame transmits, $A$
  - (complicated stuff skipped)
- Channel Efficiency $= \frac{P}{P + 2\tau/A}$

The longer the cable, the longer the contention period

This is why Ethernet specifies maximum cable length (i.e. put limit on $2\tau$)
- Longest allowed path is 2.5km + 4 repeaters $\approx 50\ \mu$secs
- Minimum frame must allow for at least this
- At 10 Mbps is 512 or 64 bytes, shortest frame
- 1 Gbps Ethernet is even longer! (or shorter cable)
Ethernet Performance (cont.)

- Convert previous formula to:
  - Frame length $F$
  - Network bandwidth $B$
  - Cable len $L$
  - Cable propagation speed $c$
  - (complicated stuff skipped)

- Channel Efficiency $= \frac{1}{1 + \frac{2BLe}{cF}}$

- Increasing $B \times L$ reduces efficiency
- But everyone wants high-bandwidth, **WAN**!
  - Then they better not use Ethernet
Ethernet Performance and Frame Size

![Graph showing channel efficiency vs. number of stations trying to send for different frame sizes.](image)
Ethernet Perf Final Thoughts ...

- Lots of theoretical work on Ethernet perf
  - all assumes traffic is Poisson
- Turns out, traffic is self-similar
  - averaging over long-periods of time does not smooth out traffic (same variance each time interval)
  - bi-modal (packets are either big or small)
- Take models with grain of salt
Saturated LAN

- Net saturated? Add bandwidth … good idea?
  - Expensive to replace cards
  - Efficiency
  - Instead *Switched LANs*

- Switch with high-speed *backplane* with connected *cards* (typically, 1 Gbps)

- 4 to 32 plug-in cards

- Each plug in card can support 1 to 8 connectors (computers)

- Can reduce or eliminate contention
Switched LANs

- When receives frame, sees if destined for another on same line, forwards as needed
  - different than hub or repeater
  - Run classic ethernet on same card
  - Proprietary protocol between cards
Fast Ethernet

As 10 Mbps proved too slow, two proposal:

- FDDI (Fiber Distributed Data Interface)
- Fibre Channel (uses crossbar switch)

FDDI

- Two fiber rings, one in each direction
- Token-based protocols (token bus, token ring)
- Several tokens (packets) in the ring.
- Station must grab 1 token to transmit
- Priority tokens based on timers

![Diagram of FDDI rings](image)

**Fig. 4-45.** (a) FDDI consists of two counterclockwise rings. (b) In the event of failure of both rings at one point, the two rings can be joined together to form a single long ring.
Fast Ethernet

- FDDI, Fibre channel too complicated, didn’t become LAN
- Used as backbones, no widespread success
- Made 802.3 committee think tank (in 1992)
  - keep Ethernet, make faster (winner, 802.3u)
  - make new LAN, call Ethernet (802.12) (loser: flopped!!)
- Reasons 802.3 won:
  - Backwards compatible
  - New protocol = new unforeseen problems
  - Quicker deployment
Fast Ethernet

- Change bit time from 100 nsec to 10 nsec
  - all must use hubs
  - shorter “wire-length” to hub
  - Wiring changes
  - Mostly copper (10BaseT) (successful)

<table>
<thead>
<tr>
<th>Name</th>
<th>Cable</th>
<th>Max. segment</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>100Base-T4</td>
<td>Twisted pair</td>
<td>100 m</td>
<td>Uses category 3 UTP</td>
</tr>
<tr>
<td>100Base-TX</td>
<td>Twisted pair</td>
<td>100 m</td>
<td>Full duplex at 100 Mbps</td>
</tr>
<tr>
<td>100Base-FX</td>
<td>Fiber optics</td>
<td>2000 m</td>
<td>Full duplex at 100 Mbps; long runs</td>
</tr>
</tbody>
</table>

The original fast Ethernet cabling.
Gigabit Ethernet

Even faster ethernet!!

802.3z (z indicates the end of the road)

Design goals:
- make Ethernet 10 times as fast but backwards compatible (again??)
- Offer unacknowledged datagram service
- Same 48-bit addressing scheme

All configurations are point-to-point
Gigabit Ethernet

- Two modes:
  - Full-duplex
  - Half-duplex

- Full duplex used when a switch is used (b)
- No contention since line is FD, so no CSMA/CD

(a) A two-station Ethernet. (b) A multistation Ethernet.
**Gigabit Ethernet**

- Half-duplex used when a hub is used instead of a switch
- Hub cannot buffer packets, switch can
- Collisions are possible so CSMA/CD
- Higher bandwidth means shorter longest distance
- **Solutions:**
  - Carrier extension: stations pad min. frames to 512 bytes
  - Frame bursting: concatenate multiple outgoing streams
- Result: extends network radius to 200 meters
Gigabit Ethernet (2)

- Supports both copper and Fiber
- Manchester encoding at 1Gbps would require 2Gbaud signal. New encoding used on fiber
- New encoding scheme used: 8B/10B
- Basically encodes an 8-bit byte as 10 bits on fiber

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<tr>
<td>1000Base-SX</td>
<td>Fiber optics</td>
<td>550 m</td>
<td>Multimode fiber (50, 62.5 microns)</td>
</tr>
<tr>
<td>1000Base-LX</td>
<td>Fiber optics</td>
<td>5000 m</td>
<td>Single (10 μ) or multimode (50, 62.5 μ)</td>
</tr>
<tr>
<td>1000Base-CX</td>
<td>2 Pairs of STP</td>
<td>25 m</td>
<td>Shielded twisted pair</td>
</tr>
<tr>
<td>1000Base-T</td>
<td>4 Pairs of UTP</td>
<td>100 m</td>
<td>Standard category 5 UTP</td>
</tr>
</tbody>
</table>

Gigabit Ethernet cabling.
IEEE 802.2: Logical Link Control

- So far Ethernet and MAC protocols offer no reliable service (e.g. stop-and-wait, etc)
- IEEE defined LLC to run above MAC to provide these services
- Closely based on HDLC

(a) Position of LLC. (b) Protocol formats.
Ethernet Retrospective

- Been around for over 20 years
- Few technologies make it that long (operating system, architecture, etc)

Ethernet
- pros: popular, simple, reliable, flexible, cheap
- cons: non-deterministic, no priorities, min frame size
Now, Where are We?

- Introduction
- Multiple Access Protocols
  - contention
  - collision-free
- Ethernet
- Wireless LAN Protocols
- Bridges
- Misc (brief)
  - High-Speed LANs
  - Satellite Networks