Supplement to Local Area Neworks
Fast Ethernet

• We want 100 Mbps bandwidth per host!
  • Servers and high performance work stations

• How to increase transmission speed by 10

• Keep the same Ethernet protocol
  • 100 Mbps $\rightarrow$ 1 bit-time = 10 ns
  • Minimum frame size still 64 bytes (512 bits)
    • Collision detection time = 5.12 µs
  • Signal propagation speed is still same
Fast Ethernet

\[
\text{efficiency} \approx \frac{1}{1 + 5.4a}
\]

\[
a = \frac{PROP}{TRANS} = \frac{\text{cablelength}}{\text{signalspeed}} \times \frac{\text{bandwidth}}{\text{framesize}}
\]

• Solution: reduce cable length by 10
  • Maximum network diameter: 250 m
  • Limit number of stations attached
Gigabit Ethernet

• We want 1 Gbps bandwidth per host!
• How to increase transmission speed by 100
• Keep the same Ethernet frame formats and sizes
  • 1 Gbps $\rightarrow$ 1 bit-time $= 1$ ns
  • Minimum frame size still 64 bytes
    • Collision detection time $= 0.512\ \mu s$
• Reduce cable length by 100
  • Maximum network diameter: 25 m
  • Resulting LAN is too small to be useful
Gigabit Ethernet (cont’d)

• Gigabit Ethernet with diameter > 25m?
  • Switched full duplex network
  • One station per segment, no collision
    • CSMA/CD becomes void!

• How to maintain min/max frame sizes?
  • Carrier extension
    • Each frame is made at least 4096 bits (512 bytes)
    • Add some junk at the end (after checksum)
Carrier Extension

Fig 1. Ethernet Frame Format with Carrier Extension
Gigabit Ethernet (cont’d)

• If we have only small frames (64 bytes)
  • Max throughput will be \( \frac{1000}{8} = 125 \) Mbps
  • Only 25% increase over Fast Ethernet

• Can we do better?
  • Frame bursting
    • Allow multiple transmissions by a station
    • Need to preserve frame boundary
Frame Bursting

• First frame will always be carrier extended
  • Subsequent frames will not

• More frames to send after the first one
  • Send them one after the other
  • Inter-frame gap of 96 extended carrier bits
  • Stop sending when burst timer expires

• Performance: can achieve > 700 Mbps
Frame Bursting

Fig. 2. Packet Bursting
IEEE 802.4 Token Bus

• Logic Ring
• A token is a short packet
• Each station knows its predecessor and successor
• All stations are the same
• Ring Operations: ring initialization, token passing, who follows, open for joining
Ring Topology
**Token Ring (IEEE 802.5)**

- **Station**
  - Wait for token to arrive
  - Hold the token and start data transmission
    - Maximum token holding time ➞ max packet size
  - Strip the data frame off the ring
    - After it has gone around the ring
  - When done, release the token to next station

- **When no station has data to send**
  - Token circulates continuously
  - Ring must have sufficient delay to contain the token
Token Ring Performance

- Efficiency

$$\approx \frac{1}{1+a}$$

where

$$a = \frac{PROP}{TRANS}$$
Release After Transmission

• Early token release
  • Pass token as soon as last frame sent

• No waiting time
  • For all frames to circulate ring
  • More bandwidth for data frames

• Treatment of frames arriving after token passed
  • Examine each source address
  • Drain rest of frame only if it is the source
  • Stop draining when if frame is from another source
Tokens and Data Frames

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<td>AC</td>
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<table>
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<th>6</th>
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<th>1</th>
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</thead>
<tbody>
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<td>FC</td>
<td>DA</td>
<td>SA</td>
<td>DATA</td>
<td>CRC</td>
<td>ED</td>
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</tbody>
</table>
Token Ring Frame Fields

• Access Control
  • Token bit: 0 ➔ token  1 ➔ data
  • Monitor bit: used for monitoring ring
  • Priority and reservation bits: multiple priorities

• Frame Status
  • Set by destination, read by sender

• Frame control
  • Various control frames for ring maintenance
Priority and Reservation

• Token carries priority bits
  • Only stations with frames of equal or higher priority can grab the token

• A station can make reservation
  • When a data frame goes by
    • If a higher priority has not been reserved

• A station raising the priority is responsible for lowering it again
Ring Maintenance

• Each ring has a monitor station
• How to select a monitor?
  • Election/self-promotion: CLAIM_TOKEN
• Responsibilities
  • Insert additional delay
    • To accommodate the token
  • Check for lost token
    • Regenerate token
  • Watch for orphan frames
    • Drain them off the ring
  • Watch for garbled frames
    • Clean up the ring and regenerate token
Fault Scenarios

• What to do if ring breaks?
  • Everyone participates in detecting ring breaks
  • Send beacon frames
  • Figure out which stations are down
  • By-pass them if possible

• What happens if monitor dies?
  • Everyone gets a chance to become the new king

• What if monitor goes berserk?
Failed Station
Token Ring Summary

• Stations take turns to transmit
• Only the station with the token can transmit
• Sender receives its own transmission
  • Drains its frame off the ring
• Releases token after reception
• Deterministic delivery possible
• High throughput under heavy load
Ethernet vs Token Ring

- Non-deterministic
- No delays at low loads
- Low throughput under heavy load
- No priorities
- No management overhead
- Large minimum size

- Deterministic
- Substantial delays at low loads
- High throughput under heavy load
- Multiple priorities
- Complex management
- Small frames possible
HERE'S YOUR PROBLEM. THE CONNECTION TO THE NETWORK IS BROKEN.

Uh-oh. It's a "token ring" LAN. That means the token fell out and it's in this room someplace.

You are the wind beneath my wings.

I'll wait a week then tell him the token must be in the "Ethernet."
FDDI

- Two counter-rotating rings
  - Failure recovery
- Optical fiber
  - High bandwidth
  - Difficult to tap without detection
- 100 Mbps data rate
- Up to 200 kms, 1000 stations
FDDI and Token Ring

• Operationally are very similar
  • In frame format and contents

• Some differences
  • Special 4B/5B symbols in FC field
    • To indicate token or type of frame
  • Maximum frame size of 4,500 bytes
  • Release token after transmission
  • Enhanced quality of service
    • Synchronous and asynchronous frames
Timed Token-Passing Mechanism

• Target Token Rotation Time (TTRT)
• Token Rotation Timer (per station)
  • Times the duration since last token
• Token Holding Timer (per station)
  • TTRT - TRT
  • Time to transmit asynchronous data
    • Can only send if ahead of schedule
    • After synchronous frames are transmitted
Synchronous Frames

• Synchronous frames always transmitted first
  • After station receives token

• Synchronous Allocation Time
  • Time allowed for transmitting synchronous frames
    • Even if behind schedule
  • Each time station receives token
  • Based on need and negotiation

• % bandwidth guaranteed for this traffic
  • Controlled by SAT and TTRT values
FDDI Failure Recovery