Fast Ethernet
and
Gigabit Ethernet
Fast Ethernet (100BASE-T)

How to achieve 100 Mbps capacity?

Media Independent Interface provides three choices.

Media Independent Interface provides three choices.
Fast Ethernet

- Three Physical Layer Choices
  - 100BASE-T4
  - 100BASE-TX
  - 100BASE-FX

* Concept facilitated by 10Mbps/100Mbps Adapter Cards
## 100 BASE T

<table>
<thead>
<tr>
<th></th>
<th>100BASE-TX</th>
<th>100BASE-FX</th>
<th>100BASE-T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission medium</td>
<td>2 pair, STP</td>
<td>2 pair, Category 5 UTP</td>
<td>2 optical fibers</td>
</tr>
<tr>
<td>Signaling technique</td>
<td>MLT-3</td>
<td>MLT-3</td>
<td>4B5B, NRZI</td>
</tr>
<tr>
<td>Data rate</td>
<td>100 Mbps</td>
<td>100 Mbps</td>
<td>100 Mbps</td>
</tr>
<tr>
<td>Maximum segment length</td>
<td>100 m</td>
<td>100 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Network span</td>
<td>200 m</td>
<td>200 m</td>
<td>400 m</td>
</tr>
</tbody>
</table>
Fast Ethernet Details

• UTP Cable has a 30 MHz limit
  ➔ Not feasible to use clock encoding (i.e., NO Manchester encoding)

• Instead use bit encoding schemes with sufficient transitions for receiver to maintain clock synchronization.
100 BASE T4

- Can use **four** separate twisted pairs of Cat 3 UTP
- Utilize three pair in both directions (at 33 1/3 Mbps) with other pair for carrier sense/collision detection.
- Three-level ternary code is used **8B/6T**.

Prior to transmission each set of 8 bits is converted into 6 ternary symbols.
100 BASE T4

- The signaling rate becomes

\[ 100 \times \frac{6}{8} = \frac{25}{3} \text{ MHz} \]

- Three signal levels: +V, 0, -V

- Codewords are selected such that line is d.c. balanced \( \Rightarrow \) all codewords have a combined weight of 0 or 1.
100 BASE T4

- Ethernet Interframe gap = 9.6 microseconds becomes 960 nanoseconds.
- 100 m. station to hub; 200 meters between stations
- Maximum of two Class II repeaters.
100 Base TX

- Uses two pair of twisted pair, one pair for transmission and one pair for reception. Uses either STP or Cat 5 UTP.
- Uses MTL-3 signaling scheme that involves three voltages.
100 BASE FX

• Uses two optical fibers, one for transmission and one for reception.
• Uses FDDI technology of converting 4B/5B to NRZI code group streams into optical signals.
Fast Ethernet Repeaters and Switches

• Class I Repeater – supports *unlike* physical media segments (*only one per collision domain*)

• Class II Repeater – limited to single physical media type (*there may be two repeaters per collision domain*)

• Switches – to improve performance can add *full-duplex* and have *autonegotiation* for speed mismatches.
Collision Domains

Figure 7.9 Collision Domains
Figure 7.10  100BASE-T Repeater Types
Gigabit Ethernet History

• In February 1997 the Gigabit Ethernet Alliance announced that IEEE802.3z Task Force met to review the first draft of the Gigabit Ethernet Standard
• According to IDC by the end of 1997 85% of all network connections used Ethernet.
⇒ Higher capacity Ethernet was appealing because network managers can leverage their investment in staff skills and training
• 1000 BASE X (IEEE802.3z) was ratified in June 1998.
Gigabit Ethernet (1000 BASE X)

- Provides speeds of 1000 Mbps (i.e., one billion bits per second capacity) for half-duplex and full-duplex operation.
- Uses Ethernet frame format and MAC technology
  - CSMA/CD access method with support for one repeater per collision domain
  - Backward compatible with 10 BASE-T and 100 BASE-T
- Uses 802.3 full-duplex Ethernet technology
- Uses 802.3x flow control.
Figure 4. Gigabit Ethernet Architecture Standard
Source: IEEE
Gigabit Ethernet Technology

Fiber:
1000 BASE SX  short wavelength
1000 BASE LX  long wavelength

Copper:
1000 BASE CX  shielded twisted pair
1000 BASE T   unshielded twisted pair

* Based on Fiber Channel physical signaling technology.
<table>
<thead>
<tr>
<th></th>
<th>1000BaseSX</th>
<th>1000BaseLX</th>
<th>1000BaseCX</th>
<th>1000BaseT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medium</strong></td>
<td>Optical fiber mutli-mode two strands</td>
<td>Optical fiber single mode two strands</td>
<td>Shielded copper cable</td>
<td>Twisted pair category 5 UTP</td>
</tr>
<tr>
<td><strong>Maximum segment length</strong></td>
<td>550 m Star</td>
<td>5 km Star</td>
<td>25 m Star</td>
<td>100 m Star</td>
</tr>
<tr>
<td><strong>Topology</strong></td>
<td>Star</td>
<td>Star</td>
<td>Star</td>
<td>Star</td>
</tr>
</tbody>
</table>

**TABLE 6.4** IEEE 802.3z Gigabit Ethernet medium alternatives
Gigabit Ethernet (1000 BASE-T)

- Physical Layer
- Media Dependent Interface
- Gigabit Media Independent Interface
- Data Link Layer
- LLC
- MAC

GMII

Gigabit Media Independent Interface
GMII

Gigabit Media Independent Interface

• Allows any Physical Layer to be used with a given MAC

• Namely, Fiber channel Physical Layer can be used with CSMA/CD

• Permits both full-duplex and half-duplex
1000 BASE SX

• Short wavelength
  – Supports duplex links up to 275 meters.
  – 770-860 nm range; **850 nm laser wavelength**
  – *Fiber Channel technology*
    – *PCS (Physical Code Sublayer)* includes **8B/10B encoding** with 1.25 Gbps line.
    – Only multimode fiber
  – Cheaper than LX.
8B/10B Encoder
## Examples of Eight-Bit Code Groups

<table>
<thead>
<tr>
<th>Code Group</th>
<th>Code</th>
<th>Actual Byte</th>
<th>RD- Encoding</th>
<th>RD+ Encoding</th>
<th>Effect on RD after Sending</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1.0</td>
<td>000 00001</td>
<td>011101 0100</td>
<td>100010 1011</td>
<td>same</td>
<td></td>
</tr>
<tr>
<td>D4.1</td>
<td>001 00100</td>
<td>110101 1001</td>
<td>001010 1001</td>
<td>flip</td>
<td></td>
</tr>
<tr>
<td>D28.5</td>
<td>101 11100</td>
<td>001110 1010</td>
<td>001110 1010</td>
<td>same</td>
<td></td>
</tr>
<tr>
<td>D28.5</td>
<td>101 11100</td>
<td>001110 1010</td>
<td>110000 0101</td>
<td>flip</td>
<td></td>
</tr>
</tbody>
</table>
1000 BASE LX

• Long wavelength
  – Supports duplex links up to 550 meters.
  – 1270-1355 nm range; **1300 nm laser wavelength**
  – *Fiber Channel technology*
  – *PCS (Physical Code Sublayer)* includes **8B/10B encoding** with 1.25 Gbps line.
  – Either single mode or multimode fiber.
1000 BASE CX

- Shielded twisted pair
  - ‘Short haul’ copper jumpers
  - 25 meters or less *typically within wiring closet.*
  - PCS (Physical Code Sublayer) includes **8B/10B encoding** with 1.25 Gbps line.
  - Each link is composed of a separate shielded twisted pair running in each direction.
1000 BASE T

- **Four** pairs of Category 5 UTP
- **IEEE 802.3ab** ratified in June 1999??
- Category 5, 6 and 7 copper up to 100 meters
- *This requires extensive signal processing.*
Gigabit Ethernet compared to Fiber Channel

• Since Fiber Channel (FC) already existed, the idea was to *immediately* leverage physical layer of FC into Gigabit Ethernet.

• The difference is that fiber channel was viewed as *specialized* for high-speed I/O lines. Gigabit Ethernet is general purpose and can be used as a high-capacity switch.
Gigabit Ethernet

- Viewed as LAN solution while ATM is WAN solution
- Gigabit Ethernet can be shared (hub) or switched.
- Shared types:
  - CSMA/CD with MAC changes:
    - carrier extension
    - Frame bursting
  - Buffered repeater {called Buffered Distributor}
Carrier Extension

<table>
<thead>
<tr>
<th>Frame</th>
<th>RRRRRRRRRRRRRRRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Carrier Extension</td>
</tr>
<tr>
<td></td>
<td>512 bytes</td>
</tr>
</tbody>
</table>

- For 10BaseT: 2.5 km max; slot time = 64 bytes
- For 1000BaseT: 200 m max; slot time = 512 bytes
- Carrier Extension :: continue transmitting control characters [R] to fill collision interval
  - This permits minimum 64 byte frame to be handled.
- Control characters discarded at destination
- For small frames net throughput is only slightly better than Fast Ethernet

Based on Raj Jain slide
Frame Bursting

| Frame | Extension | Frame | Frame | Frame |

• Source sends out burst of frames without giving up control of the network
• Uses Ethernet Interframe gap filled with extension bits (96 bits)
• Maximum frame burst is 8192 bytes
• *Three times more throughput for small frames*
Buffered Distributor

- New type of 802.3 Hub where incoming frames are buffered in FIFOs
- CSMA/CD arbitration is inside the distributor to transfer frames from an incoming FIFO to all outgoing FIFOs
- All links are full-duplex
- Frame-based 802.3x flow control to handle buffer congestion

Based on Raj Jain slide