Recent Advances in 100 Mbps LAN Technologies

Raj Jain
Professor of Computer and Information Sciences

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/
Why This Seminar Series?

- Technology is moving too fast
- Throughout 1980's everyone believed Ethernet was not scalable
- September 1992: First time 100 Mbps Ethernet was discussed publicly and products appeared 13 months later
- Middle 1995: No one imagined Ethernet at Gigabit. Middle 1996: Gigabit Ethernet products announced
- Network engineer, managers and users need to keep track of the latest
ATM vs Legacy LANs

- Last year, every one planned for ATM. This year, many are not so sure.
- One network for all. Which network that is? ATM or Ethernet?
- Switching is better than routing. What should be switched? Cells or Frames?
- Multimedia needs quality of service. Do we really need reservations or is priority enough?
- Need a technology that is scalable in speed from Mbps to Gbps. Is that ATM or Ethernet?
More About This Series

- Designed for Industry
  ⇒ Covers both research and developments
- Tutorials on latest developments
  - LAN Switching
  - QoS on LANs
  - Multimegabit Access to Home
  - QoS on Internet
  - Virtual LANs
  - Gigabit Ethernet
  - Multimedia on Internet
  - Wireless and Mobility on Internet
- Please fill out the participant information/survey on the last page.
FDDI, Copper FDDI
Ethernet: History, Access Method
IEEE 802.3 Notation: 10BASE5
Repeater, hub, bridge, router
100 Mbps Ethernet
100VG-AnyLAN
FDDI

- Fiber Distributed Data Interface
- ANSI Standard for 100 Mbps timed token access
- Up to 500 stations on a single FDDI network
- Inter-node links of up to 2 km on multimode fiber, 60+ km on single mode fiber, Longer SONET links, 100 m on UTP.
- Round-trip path limited to 200 km ⇒ 100 km cable.
- Maximum frame size is 4500 bytes.
- Eight priority levels
- Arranged as single- or dual-ring logical topology
Dual-Ring of Trees Topology

- Main Frame
- High-End Workstation
- Concentrator
- Workstation
- Personal Computer
- High-End Workstation
- Server
- Server
TP-PMD

- Twisted-Pair Physical Media Dependent
  - Copper FDDI or CDDI
- Allows 100 m over Cat-5 unshielded twisted pair (UTP)
  - **Cat-3**: 15 MHz Voice grade
  - **Cat-4**: 20 MHz
  - **Cat-5**: 100 MHz data grade
Full Duplex FDDI

- The stations transmit and receive simultaneously.
- Works only on a 2-station ring.
- 200 Mbps.
- Network starts in ring mode.
- After detecting a two node ring using management frames, stations negotiate & enter full duplex mode.
- On error, stations enter the ring mode.
CSMA/CD

- Aloha at University of Hawaii:
  Transmit whenever you like
  Worst case utilization = $1/(2e) = 18\%$

- Slotted Aloha: Fixed size transmission slots
  Worst case utilization = $1/e = 37\%$

- CSMA: Carrier Sense Multiple Access
  Listen before you transmit

- CSMA/CD: CSMA with Collision Detection
  Listen while transmitting. Stop if you hear someone
CSMA/CD PHY Standards

- **10BASE5**: 10 Mb/s over coaxial cable (ThickWire)
- **10BROAD36**: 10 Mb/s over broadband cable, 3600 m max segments
- **10BASE2**: 10 Mb/s over thin RG58 coaxial cable (ThinWire), 185 m max segments
- **1BASE5**: 1 Mb/s over 2 pairs of UTP
- **10BASE-T**: 10 Mb/s over 2 pairs of UTP
- **10BASE-F**: Fiber Optic inter-repeater link (FOIRL), 10BASE-FL (link), 10BASE-FB (backbone), or 10BASE-FP (Passive)
Fast Ethernet Standards

- **100BASE-T4**: 100 Mb/s over 4 pairs of CAT-3, 4, 5
- **100BASE-TX**: 100 Mb/s over 2 pairs of CAT-5, STP
- **100BASE-FX**: 100 Mbps CSMA/CD over 2 fibers
- **100BASE-X**: 100BASE-TX or 100BASE-FX
- **100BASE-T**: 100BASE-T4, 100BASE-TX, or 100BASE-FX

Based on FDDI Phy
10BASE5 vs 10BASE-T

The Ohio State University  Raj Jain
Interconnection Devices

- **Repeater**: PHY device that restores data and collision signals.

- **Hub**: Multiport repeater + fault detection and recovery.

- **Bridge**: Datalink layer device connecting two or more collision domains. MAC multicasts are propagated throughout “extended LAN.”


- **Switch**: Multiport bridge with parallel paths.

These are functions. Packaging varies.
Efficiency = Max throughput / Media bandwidth

Efficiency is a decreasing function of $\alpha$

$\alpha = \frac{\text{Propagation delay}}{\text{Transmission time}}$

$= \frac{\text{Distance}/\text{Speed of light}}{\text{(Transmission size)/Bits/sec}}$

$= \frac{\text{Distance} \times \text{Bits/sec}}{(\text{Speed of light})(\text{Transmission size})}$

Bit rate-distance-transmission size tradeoff.

100 Mb/s $\Rightarrow$ Change distance or frame size
Fast Ethernet

- Same access method (CSMA/CD) as in Ethernet
- Same frame sizes (64 B to 1518 B) as in Ethernet
- Ten times faster. Ten times shorter.
- Extent = 2.5 km (10 Mbps) 205 m (100 Mbps)
- 10/100 adapters ⇒ Autonegotiate the speed
## Ethernet vs Fast Ethernet

<table>
<thead>
<tr>
<th></th>
<th>Ethernet</th>
<th>Fast Ethernet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speed</strong></td>
<td>10 Mbps</td>
<td>100 Mbps</td>
</tr>
<tr>
<td><strong>MAC</strong></td>
<td>CSMA/CD</td>
<td>CSMA/CD</td>
</tr>
<tr>
<td><strong>Network diameter</strong></td>
<td>2.5 km</td>
<td>205 m</td>
</tr>
<tr>
<td><strong>Topology</strong></td>
<td>Bus, star</td>
<td>Star</td>
</tr>
<tr>
<td><strong>Cable</strong></td>
<td>Coax(^1), UTP, Fiber</td>
<td>UTP(^2), Fiber</td>
</tr>
<tr>
<td><strong>Standard</strong></td>
<td>802.3</td>
<td>802.3u</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>X</td>
<td>2X</td>
</tr>
</tbody>
</table>

\(^1\) Coax users may need to rewire to upgrade
\(^2\) 100 BASE-T4 does not allow full duplex
100BASE-T Options

- Autonegotiation: Automatically select 10 or 100 Mbps
- Priority Order: 100BASE-TX Full Duplex, 100BASE-T4, 100BASE-TX, 10BASE-T Full Duplex, 10BASE-T (T4 connected to phone line ⇒ Burnout on ringing)
- Exposed Medium Independent Interface
  Some place the transceivers on the adapter
- Far-end Fault Indication: Link failure in one direction. End not receiving the signal sends an indication to other
- Cross-over correction: swapping the transmit and receive pairs
- Polarity Reversal: Swapping the two wires in a pair
Full-Duplex Ethernet

- Uses point-to-point links between **TWO** nodes
- Full-duplex bi-directional transmission
- Transmit any time
- Not yet standardized in IEEE 802
- Many vendors are shipping switch/bridge/NICs with full duplex
- No collisions ⇒ 50+ Km on fiber.
- Between servers and switches or between switches
Planning for Growth

10 Mbps NICs

10 Mbps Hub

10/100 Mbps NICs

10 Mbps Switch

100 Mbps NICs

100 Mbps Hub

100 Mbps Switch
Prices

- 10BASE-T NICs: $29-$100
- 10/100 100BASE-T NICs: $89-$259
- 10BASE-T Hubs: $39-$150 (8 ports)
- 100BASE-T Hubs: $2375 (12 ports)
- 100BASE-FX Hubs: $600/port
- Hybrid 10/100 Switches: $4995 (24×10+1×100)
- 100BASE-T Switches: $1000/port
- 100BASE-FX Switches: $1700/port
100VG-AnyLAN: Key Features

- IEEE 802.12 standard. Also known as 100BASE-VG.
- **AnyLAN:**
  - Supports both Ethernet and token ring frame formats
  - Only one format in any LAN
  - Allows 10BASE-T and Token ring wiring infrastructure.
  - 2.5 km network diameter
- Priorities: Normal and High ➞ Multimedia
  - But, need new software for new features
- Multi-level Configuration.
Many current products recommend limiting to 3 repeaters/path. 10BASE-T allows 4 repeaters.

Store-and-forwarding repeaters. Repeater monitor destination address.

Privacy: Unicast packets not delivered to other end-nodes.

All repeaters and promiscuous nodes hear all traffic.
Demand Priority Protocol

- Round-robin in physical port order. One packet per grant.
- Two Priorities: Normal and High
  - Higher priority requests preempt normal priority round.
  - Higher priority requests served after current normal priority packet finishes. No preemption.
# LANs: Comparison

<table>
<thead>
<tr>
<th></th>
<th>100VG-AnyLAN</th>
<th>100BA SE-T4</th>
<th>100BA SE-TX</th>
<th>TP-PMD</th>
<th>10BAS E-T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat5 Links</td>
<td>200</td>
<td>100</td>
<td>100</td>
<td>190</td>
<td>100+</td>
</tr>
<tr>
<td>Network Diameter</td>
<td>2,000m</td>
<td>250m</td>
<td>250m</td>
<td>N/A</td>
<td>2,500m</td>
</tr>
<tr>
<td>Cat3 Links</td>
<td>100m</td>
<td>100m</td>
<td>No</td>
<td>No</td>
<td>100m</td>
</tr>
<tr>
<td># of pairs</td>
<td>4 (2 on STP)</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2,4</td>
</tr>
<tr>
<td>10/100</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cost</td>
<td>1.5X</td>
<td>1.5X</td>
<td>1.5X</td>
<td>5X</td>
<td>X</td>
</tr>
<tr>
<td>Standard</td>
<td>802.12</td>
<td>802.3u</td>
<td>802.3u</td>
<td>TP-PMD</td>
<td>802.3i</td>
</tr>
</tbody>
</table>
FDDI is designed for campus backbone

Fast Ethernet: 100BASE-T4, 100BASE-TX, 100BASE-FX, 100BASE-T2

Shared Ethernet is limited in distance.
Can use switched and full duplex links for campus.

10/100 NICs are preferable over 10 Mbps.
Acronyms

- AUI  Attachment Unit Interface
- Cat-3  Category 3 Cable
- Cat-4  Category 4 Cable
- Cat-5  Category 5 Cable
- CRC  Cyclic Redundancy Check
- DTE  Data Terminal Equipment
- FCS  Frame Check Sequence
- FDDI  Fiber Distributed Data Interface
- FEXT  Far-end Crosstalk
- FOIRL  Fiber Optic Inter-Repeater Link
- FLP  Fast Link Pulse
- FOMAU  Fiber Optic Medium Attachment Unit
- FOMDI  Fiber Optic Media Dependent Interface
- FOPMA  Fiber Optic Physical Medium Attachment
- HH  Header Hub
- IH  Intermediate Hub
- IPG  Inter-packet Gap
- IRL  Inter-Repeater Link
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LLC</td>
<td>Logical Link Control</td>
</tr>
<tr>
<td>MAC</td>
<td>Medium Access Control</td>
</tr>
<tr>
<td>MAU</td>
<td>Medium Attachment Unit</td>
</tr>
<tr>
<td>MDI</td>
<td>Medium Dependent Interface</td>
</tr>
<tr>
<td>MIB</td>
<td>Management Interface Base</td>
</tr>
<tr>
<td>MII</td>
<td>Media independent interface</td>
</tr>
<tr>
<td>NEXT</td>
<td>Near-end Crosstalk</td>
</tr>
<tr>
<td>NLP</td>
<td>Normal Link Pulse</td>
</tr>
<tr>
<td>NRZI</td>
<td>N</td>
</tr>
<tr>
<td>PCS</td>
<td>Physical Coding sublayer</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>PHY</td>
<td>Physical Layer Device Sublayer</td>
</tr>
<tr>
<td>PLS</td>
<td>Physical signaling sublayer</td>
</tr>
<tr>
<td>PMA</td>
<td>Physical Medium Attachment</td>
</tr>
<tr>
<td>PMD</td>
<td>Physical Medium Dependent</td>
</tr>
<tr>
<td>PMI</td>
<td>Physical Medium Independent</td>
</tr>
<tr>
<td>SSD</td>
<td>Start of Stream Delimiter</td>
</tr>
<tr>
<td>SFD</td>
<td>Start of Frame Delimiter</td>
</tr>
<tr>
<td>STP</td>
<td>Shielded Twisted Pair</td>
</tr>
<tr>
<td>UTP</td>
<td>Unshielded Twisted Pair</td>
</tr>
</tbody>
</table>
References: Books


References: Standards


- ANSI X3T9.5 TP-PMD/312, "FDDI Twisted Pair Physical Layer Medium Dependent (TP-PMD)," Revision 2.1, 1 March 1994 (Phone: 212-642-4900)
References: Papers


Moses, Jack T., "Fast Ethernet update: 100BaseT has arrived", Telecommunications (Americas Edition) v 29 n 3 Mar 1995. 2pp

Somer, Greg, "Ethernet transceiver offers upgrade from existing networks", Electronic Engineering (London) v 67 n 820 Apr 1995. 4pp
References: On-Line

- Ethernet FAQ on comp.dcom.lans.ethernet
  ftp://steph.admin.umass.edu/pub/faqs/ethernet.faq

- Fast Ethernet Index,
  http://alumni.caltech.edu/~dank/fe/

- Campus wide networking FAQ,
  http://www.cis.ohio-state.edu/hypertext/faq/usenet/LANs/big-lan-faq/faq.html

- Quick reference guide to 100 Mb/s Fast Ethernet,
  http://www.ots.utexas.edu/ethernet/descript-100quickref.html
- 100 Mb/s Fast Ethernet, http://www.ots.utexas.edu/ethernet/100mbps.html
- Faster Ethernet,
  http://www.well.com/user/wkmn/feature.html
- USENET: comp.dcom.* (many groups with prefix)
- Fast Ethernet Manufacturers,
  http://www.iol.unh.edu/consortiums/fe/fethvend.html
- 100VG-AnyLAN Manufacturers,
  http://www.io.com/~richardr/vg/vgvend.htm
- Fast Ethernet Consortium,
  http://www.iol.unh.edu/consortiums/fe/fast_ethernet_consortium.html
- 100VG-AnyLAN Consortium,
  http://www.iol.unh.edu/consortiums/vganylan/vg_consortium.html
Participant Information

Name: ____________________________________________
Job Title: __________________________________________
Company: __________________________________________
Address: ___________________________________________
Phone: __________________ Fax: ___________________
Email: ____________________________________________
Comments/Suggestions for Today’s Seminar:
________________________________________________________________
________________________________________________________________
________________________________________________________________

The Ohio State University Raj Jain
Participant Survey

Future Topics of Interest: Please indicate your interest level 0=None, 1=Some, 2=OK, 3=High

[ ] Virtual LANs
[ ] Quality of Service on LANs
[ ] Gigabit Ethernet
[ ] ATM Networks
[ ] Multimedia networking
[ ] Wireless Networking
[ ] Others (specify) ________________________________

Seminar Time Preference:

[ ] 10AM-11:30AM       [ ] 3:00PM-4:30PM