Lecture 2
Terminology, Concepts & Philosophy

Computer networks are typically broken into 4 components:

1. Nodes: Computers, end hosts, routers, etc. Anything that terminates a cable
2. Links: Coax cable, fiber, wireless
4. Applications: Browser, Media player, telnet, etc

Network Issues: Performance & Reliability

Types of Networks:

1. Point to Point Link:
   - Twisted pair (100 Mbs) (100 meters)
   - Coax (100 Mbs) (500 Meters)
   - Fiber (10Gbs) (10's of miles)

2. Multiple Access Links: Links shared by more than one node. Examples include Ethernet and Wireless
   - Contention resolution
   - Addressing

3. LAN's MAN's & WAN's
   - Mechanisms for routing
   - Mechanisms for path selection and packet flow

Performance Issues: Latency and Throughput

- Latency: Time taken between source sending and receipt of a packet at the destination
- RTT: Round trip time.
- Latency: Propagation Delay + transmission delay + queuing delay
- Propagation Delay = (distance)/(speed of light)
- Transmission Delay = (message size) / (bandwidth)
- Queuing delay is variable
- RTT = 2 * latency

US coast to coast ping times: 60-70ms
  Round Trip Distance ≈ 6000 miles
  Speed of Light ≈ 200 Miles per ms
  6000/200 = 30ms
  Internet typically gives us ½ the speed of light, not bad.

Throughput & Bandwidth:
  Throughput = (# of transmitted bits)/(latency)
  Bandwidth = Max Throughput

<table>
<thead>
<tr>
<th>Bandwidth</th>
<th>Prop Delay</th>
<th>Latency</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>1Mbs</td>
<td>100ms</td>
<td>100ms + 8s</td>
<td>.987 Mbps</td>
</tr>
<tr>
<td>1 Gps</td>
<td>100ms</td>
<td>100ms + 8ms</td>
<td>74 Mbps</td>
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</tbody>
</table>

Jitter: Variation in throughput or latency

Routing Fabric & Switching
1. Circuit Switching (PSTN)
   - Allocation of resources
   - Dedicated connection
   - Same path entire connection
   - Admission Control
   - No issues of fairness
   - Use of Multiplexing results in shared data lines
• Types of Multiplexing:
  • TDM – Time Division Multiplexing
  • FDM – Frequency Division Multiplexing

2. Packet Switched Networks
• Packet take whatever route is available
• Connection is determined packet by packet
• No admission control
• Fairness issue

Layered OSI Reference Model
Layering is good because it provides modularity (allowing components to be designed/used separately) and abstraction (hides nonessential details). It is possible to improve the efficiency of layered stacks by violating the layering abstraction and doing cross-layer optimizations.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Protocol</th>
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<tbody>
<tr>
<td>Application</td>
<td>SMTP/HTTP/Telnet</td>
</tr>
<tr>
<td>Presentation</td>
<td>TCP / UDP</td>
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<tr>
<td>Session</td>
<td>IP Addressing</td>
</tr>
<tr>
<td>Transport</td>
<td>Mac Addressing, Ethernet, 802.11</td>
</tr>
<tr>
<td>Network</td>
<td></td>
</tr>
<tr>
<td>Link</td>
<td>Current, Voltages, Light</td>
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<tr>
<td>Physical</td>
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End to End Principle: Internet should be dumb at the core, and all intelligences should be at the edges

Hour Glass Principle: The Internet has been so successful mostly because of IP. The protocols and layers above IP and below IP are interchangeable, but if you have something that speaks IP, it can get on the Internet.
HTTP, SMTP, TCP, UDP, QT

IP

Ethernet, WiMax, etc.