Networking and TCP/IP

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Topology

- **Bus**
  - Ethernet, Wireless

- **Star**
  - ATM, Switched Ethernet, Gigabit Ethernet

- **Ring**
  - Token Ring, FDDI
Speeds

- **DS – Digital Signals**
  - DS – 0 64Kbs (.064 Mbs)
  - DS – 1 (T1, or PRI) 1.54 Mbs (24 DS-0’s)
  - DS – 3 (T3) 45 Mbs (29 DS-1’s)

- **OC – Optical Carrier**
  - OC – 3 155 Mbs
  - OC – 12 622 Mbs
  - OC – 48 2.4 Gbs
  - OC – 192 9.6 Gbs
Speeds (cont.)

- **Ethernet**
  - 2 Mb
  - 10 Mb
  - 100 Mb
  - 1 Gb (Gigabit Ethernet)
  - 10 Gb (10 Gig)

- **Wireless**
  - 2 Mb
  - 11 Mb (802.11 b)
  - 54 Mb (802.11 a/g)
  - 108 Mb
Media

- Glass or Fiber
- Copper Wire
- Air
PSU Backbone (Overview)

Integrated Backbone 2004

Overview URL
PSU Backbone (detail)

Backbone URL
Routing

- **What is a router?**
  - A device that chooses a path which to send packets over.

- **Routers**
  - Cisco 7600
  - Macintosh
  - Windows PC
  - Linksys
Routing Protocols

- BGP – Border Gateway Protocol
- RIP – Routing Information Protocol
- OSPF – Open Shortest Path First
- IGRP – Interior Gateway Routing Protocol
- …
TCP/IP Networking

- TCP/IP or "IP" is what we call the protocol stack that forms the base of the current "Internet".
- Interesting and Distinguishing features of TCP/IP:
  - Network technology independence - The protocol stack allows the underlying technology to change without affecting the upper level protocols.
  - Universal interconnection - Any computers with a TCP/IP stack can communicate with each other over the network. (e.g., unique addresses)
  - End-to-End Acknowledgements - Some of the Internet protocols provide a method to allow the endpoints to acknowledge traffic, even if the two machines are not on a common physical network.
  - Application Protocol Standards - In addition to basic transport standards, many applications can be standardized and built on top of the basic TCP/IP transport layers.
- Internet vs internet vs intranet.

*intra is "inside" so traditional meaning would be "inside the net", not "inside net".*
Think of as a layer cake.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>The user-level protocol; e.g. FTP, HTTP, SMTP, etc.</td>
</tr>
<tr>
<td>Transport</td>
<td>Manages all aspects of data routing and delivery. (TCP and UDP)</td>
</tr>
<tr>
<td>internet</td>
<td>Addressing, Transmission, SAR. (IP protocol)</td>
</tr>
<tr>
<td>Network Access</td>
<td>Physical access layer, specifies actual transmission of data on a physical medium. (eg Ethernet, FDDI, ATM, SONET)</td>
</tr>
</tbody>
</table>

Layers 1 and 2 are the network hardware.
Layers 3 and 4 are the operating system's network stack.
TCP Stack - TCP

- TCP - Transmission Control Protocol
  - A "Reliable" protocol, it includes signaling to ensure that any packets sent are delivered at their destination.
  - 3-way handshake:
    - Host A (the "sender") transmits a TCP packet with the SYN bit set to host B.
    - Host B (the "receiver") increments the "sequence number" in A's packet and transmits a TCP packet with the ACK bit set and the new sequence number back to host A.
    - Host A increments the sequence number from Host B's ACK packet and transmits a TCP packet with the ACK bit set back to host B.
    - The connection is now "established" and the two hosts can send data back and forth using the TCP/IP protocol.
**TCP Stack - UDP**

- **UDP - User Datagram Protocol**
  - Simple, protocol is said to be "connectionless". Packets can be sent directly to a host with no handshaking.
  - Inherently unreliable, since packets are not retransmitted. Upper layer protocol must allow for this.
# IP Address

## What is an address?

<table>
<thead>
<tr>
<th>Class</th>
<th>field</th>
<th>field</th>
<th>Internet Protocol address in binary</th>
<th>Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>24</td>
<td>0NNNNNNNN.HHHHHHHH.HHHHHHHH.HHHHHHHH</td>
<td>1-126.x.x.x</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>16</td>
<td>10NNNNNN.NNNNNNNN.HHHHHHHH.HHHHHHHH</td>
<td>128-191.x.x.x</td>
</tr>
<tr>
<td>C</td>
<td>22</td>
<td>8</td>
<td>110NNNNN.NNNNNNNNN.NNNNNNNNNN.HHHHHHHH</td>
<td>192-223.x.x.x</td>
</tr>
</tbody>
</table>

There are 126 Class A networks with 16,777,214 hosts each.
There are 65536 Class B networks with 65534 hosts each.
There are 16777216 Class C networks with 254 hosts each.
The 127 network is reserved for the "loopback network."
Private IP address ranges (RFC 1918)

- There are IP address ranges specified by RFC 1918 which are reserved for organizations to use on their private networks. In theory, packets from those addresses must never escape to the Internet. In practice, this does account for a measureable use of network bandwidth...

<table>
<thead>
<tr>
<th>Class</th>
<th>First address</th>
<th>Last address</th>
<th>CIDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10.0.0.0</td>
<td>10.255.255.255</td>
<td>10.0.0.0/8</td>
</tr>
<tr>
<td>B</td>
<td>172.16.0.0</td>
<td>172.31.255.255</td>
<td>172.16.0.0/12</td>
</tr>
<tr>
<td>C</td>
<td>192.168.0.0</td>
<td>192.168.255.255</td>
<td>192.168.0.0/16</td>
</tr>
</tbody>
</table>
What is a Subnet Mask?

- A subnet mask allows an organization to further subdivide networks. At Penn State we have 3 Class B networks. In general, 128.118.X.X uses an 8-bit subnet mask and 146.186.X.X uses a 10-bit subnet mask. This allows for 254 networks of 254 hosts on the 128.118.X.X network and 2216 networks of 62 hosts on the 146.186.X.X network at Penn State.
Ports/Sockets

**TCP/UDP ports**
- Ports are a way of running many services on a single machine, sort of like telephone extentiones. A single host (ip) can have many services running at the same time, with each service answering on a separate port.
- Some ports are "Well Known" or published in RFCs. Port 80 for HTTP, 25 for SMTP, 110 for POP3, 22 for SSH, etc.
- An example would be a host that runs a WWW server and an SMTP server at the same time.

**Sockets**
- Sockets are a special type of file (properly called a Unix Domain Socket) which programs running on a UNIX system can use to communicate with each other on the local machine and via network resources.
- The services that listen on the various TCP and UDP ports may use sockets to access the network.
DNS

- **Domain Name Service**
  - Translates host names to IP address

- **Hierarchical Structure**
  - cnn.com, psu.edu, army.mil

- **Read in reverse**
Questions?

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