Lecture 17: Networking Introduction

- Although the standard OSI data comm reference model is a _______ layer model, the TCP/IP protocols don’t match its structure exactly. The TCP/IP protocols are usually presented in a 4 layer model:
  1. Network Access Layer (ARP, RFC 984)
  2. Internet Layer (Routing protocols - IP)
  3. Transport Layer (TCP, UDP)
  4. Application Layer (HTTP, FTP, SSH, etc)

- Note that a separate ______________ layer is not listed. This layer is included in the Network Access layer. TCP/IP protocols can be used on various hardware technologies: Ethernet, FDDI, ATM, serial lines, Packet Radio, etc.

- Each layer has its own independent data structures. Each layer encapsulates information from the layer above and adds its own control information (header) to ensure proper delivery.

Lecture 17: Networking Ethernet

- Ethernet is the most common physical layer protocol. There are several types:
  - Thicknet (10Base5) uses RG-5 coax (obsolete).
  - _______ (10Base3) uses RG-58 coax (very rare).
  - Twisted Pair (10BaseT) should use Cat-5 cable.
  - Fast Ethernet (100BaseT) uses Cat-5 cable
  - Gigabit Ethernet (1000BaseT) uses Cat-5+ cable.
  - Wireless Ethernet (WIFI)
Lecture 17: Networking

Ethernet

• Each Ethernet card (network interface card or NIC) has a 48 bit hardware address (_______, physical, or hardware address).
• An Ethernet address can address a single card (unicast), the entire network (a broadcast address), or a group (multicast).
• The Ethernet frame contains several fields in the header including the destination and source (MAC) addresses.

Lecture 17: Networking

IP Addresses

• At the Internetworking level each machine has a 32 bit (4 byte) IP address, usually given in dotted quad notation: 10.58.240.55. Each number in _________ notation represents a byte of the address. The numbers are decimal and lie in the range 0 - 255.
• Each address can be broken down into a network part and a host id part.

Lecture 17: Networking

IP Addresses

• In the original _________-based addressing method, the IP address space was divided into a few fixed-length address classes.

<table>
<thead>
<tr>
<th>Class</th>
<th>0</th>
<th>8</th>
<th>16</th>
<th>24</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>a</td>
<td>netid</td>
<td>hostid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>netid</td>
<td>hostid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>11</td>
<td>netid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lecture 17: Networking

IP Addresses

• There could be 127 Class A networks (1.0.0.0 - 127.0.0.0) with 16x10^6 hosts (2^24).
• There could be _________ Class B networks (128.0.0.0 - 191.255.0.0) with 65,024 hosts.
• There could be 2.1x10^9 Class C networks (192.0.0.0 - 223.255.255.0) with 254 hosts.

Lecture 17: Networking

IP Addresses

• The number of class B addresses was rapidly depleted. Assigning multiple class C addresses to an organization would make the routing tables too large.
• The solution was to move to Classless Internet Domain Routing (CIDR). With _________ a bit mask (the network mask) is applied to an IP address to split it into network and host parts.

Lecture 17: Networking

IP Addresses

• Here's an example:
  Host Address: 192.168.110.130
  Net Mask: 255.255.255.128
• The network address is 192.168.110.128. The host address above corresponds to the host number 2 (of 127) on this network.
• A host part of all zeros refers to the network and should not be assigned to any host. A host part of all _____ is used for a broadcast.
Lecture 17: Networking
Routing

- At the TCP/IP level all addressing is done by IP number.
- If the network portion of the destination address does not correspond to the local network the packet is passed to a ________.
- If the network portion of the destination address matches the local network address, it is passed directly to the destination host.

Lecture 17: Networking
Name Resolution

- All datagram addressing is by IP number. How is a name (google.com) converted to an IP address?
- An IP address is obtained either from the /etc/hosts file or by ________ (dynamic name services). A DNS server translates names into addresses.

Lecture 17: Networking
Name Resolution

- As an application programmer, if our computer is properly configured, we don’t need to worry about the details. We can use the ________ routine to convert a name to a binary network address.
- The inet_ntoa() routine will convert a network address to dotted-quad notation. inet_aton() will convert from dotted quad notation to a (32-bit) binary address.

Lecture 17: Networking
Name Resolution

- The getaddrinfo() routine replaces gethostbyname() which is now obsolete. gethostbyname() is used in (lots) of older software, books or documentation.
- getaddrinfo() allows us to write code that will work with either IPv4 or ________
  Similarly inet_ntop() will work with either IPv4 or IPv6. inet_ntoa() works with only IPv4 addresses.

Lecture 17: Networking
Name Resolution

- Note binary network addresses should be in “network byte order” (big endian order). ________ processors are little endian and the following will NOT work when trying to convert “10.5.50.100” to a network address:
  unsigned int addr = (10<<24) + (5<<16) + (50<<8) + 100;

Lecture 17: Networking
Name Resolution

- The preceding example would work correctly on a big endian architecture. To convert 32-bit addresses between host and network order use the htonl() and ntohl() routines.
- These routines do nothing on big endian machines, but should be used for ________.
- Pay careful attention to the documentation to determine if a routine needs (or returns) an address in network or host order.
Lecture 17: Networking
Network Comm. APIs

- There are two major APIs for network programming: ____________ and LTI/XTI. XTI is not included by default with most Linux distributions (it is available as an open-source library) and is not widely used. We will only discuss sockets.
- An implementation of the Berkeley sockets API under Windows is known as Winsock.

Lecture 17: Networking
TCP and UDP

- We will discuss only the sockets API to the ____________ layer. (Raw sockets can be used to directly interface to the IP layer.)
- There are two major TCP/IP transport protocols: TCP (Transport Control Protocol) and UDP (User Datagram Protocol). UDP is a simple, unreliable, datagram protocol, while TCP is a sophisticated, reliable, byte-stream (unlimited length) protocol.

Lecture 17: Networking
TCP and UDP

- There is no guarantee that a UDP datagram will reach its destination. To ensure delivery our application must handle time-outs, acknowledgments, retransmissions, etc. UDP is a connectionless protocol.
- TCP provides a ____________ between two machines. When data is sent via TCP to the other end, it requires an acknowledgment. If one is not received the data will be resent.

Lecture 17: Networking
TCP and UDP

- TCP provides _____________. When a large amount of data is sent via TCP, the data will be sent in segments. If they arrive out of order, they will automatically be reordered.
- TCP provides flow control. A TCP peer advertises how many bytes it can accept. This prevents overflow of the receive buffer.
- A TCP connection is full-duplex. Data can be sent and received on the same socket.

Lecture 17: Networking
TCP and UDP

- Modify the **getip.cpp** program to display the IPv4 address of the specified host in dotted-quad notation.
- Try the following:
  . /getip localhost
  . /getip cserver
  . /getip cserver.evansville.edu
  . /getip google.com
  . /getip microsoft.com