TCP/IP NETWORKS

Chapter 12

Objectives

• Understand structure of TCP/IP
• Understand ways in which the net ID and the host ID can be extracted from the IP address
• Understand migration to IPv6
TCP/IP Network Architecture

Datagrams can take any route available to them without human intervention.

- Contains a lean protocol stack
- Can be used with any type of network, even different types of networks within a single session.
**IP Layer**

- Provides essentially the same services as the Network and Data Link layers of the OSI Reference Model.
- Divides TCP packets into protocol data units called datagrams, and then attaches routing information.

**IPv4**

- Current version of IP.
- Not adequate to serve millions of network components scattered across the globe.
- Limitations:
  - 32-bit addresses
  - a packet length limited to 65,635 bytes
  - all security measures are optional
- Network addresses have been assigned with little planning resulting in slow and cumbersome routing hardware and software.
IP Addressing

- Hosts and other devices have network interfaces identified by an IP address
- IP (IPv4) addresses are 32-bit numbers represented as four groups of 8 bits (byte)
- Written in dotted-decimal notation
- Network ID - portion of the IP address that defines the network to which the device is connected
- Host ID – portion of the IP address that defines the host

Actually due to allocation issues, there are fewer than \(2^{32}\) IP addresses

Dotted Decimal Notation

An IPv4 address (dotted-decimal notation)

\[
172 \cdot 16 \cdot 254 \cdot 1
\]

\[
10101100.00010000.11111110.00000001
\]

One byte = Eight bits

Thirty-two bits (4 x 8), or 4 bytes
IP Example

• You can find the IP address of a site using Windows Command Prompt
• You can use the IP address in your browser

IPv4 Packet

• Header
• Data section (payload)

Can be used to distinguish differing levels of service

IPv4 or IPv6

Usually TCP or UDP
IPv4 Address Space

<table>
<thead>
<tr>
<th>Network prefix</th>
<th>Host number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Host (24 bits)</td>
</tr>
<tr>
<td>10</td>
<td>Network (14 bits)</td>
</tr>
<tr>
<td>110</td>
<td>Network (21 bits)</td>
</tr>
<tr>
<td>1110</td>
<td>(28 bits)</td>
</tr>
<tr>
<td>11110</td>
<td>(27 bits)</td>
</tr>
</tbody>
</table>

Initial allocation approach is referred to as classful network addressing.

Internet routing based on the network component of address.

Note that the only approach is to allocate 2^8 addresses, 2^16 addresses, or 2^24 addresses.

Transport Protocols

**TCP**
- Transmission Control Protocol
- Connection based
- Reliable flow of data between two computers

**UDP**
- User Datagram Protocol
- Connectionless service
- Order of delivery is not guaranteed
TCP

- Consumer of IP services
- Engages in a conversation (connection) with the TCP process running on the remote system

Application Interface

- Interface is designated by a port number
- Socket - combination of the port number, the host ID, and the protocol designation (equivalent to a file name to the application running above TCP)
- Port numbers 0 through 1023 are reserved for particular TCP applications
- Examples
  - telnet – 23
  - smtp – 25
  - http - 80
TCP Segment Format

Notice the wrapping of payload data with protocol data

TCP Session Handshake

A

SYN = True, SEQ# = j
SYN = True, SEQ# = l
ACK = True, ACK# = j + 1
ACK = True, ACK# = l + 1

B

T

time
TCP Data Exchange

TCP Flow Control
Subnet

- Logically visible subdivision of an IP network
- Divides the 32 bit IP address into
  - Network ID – network routing
  - Host ID (Host number)
- Number of bits used for network ID and host ID can vary
- Efficient way of allocating IP addresses
- Host ID can be further divided into subnet number and host ID

Network ID Specification

- Specification of the size of network prefix (and subnet prefixes) is done with
  - Sub-mask notation – IPv4 (network/host boundary in increments of 8 bits)
    - Initial approach
    - Inefficient allocation of blocks of IP addresses
  - CIDR notation – IPv4 and IPv6 (arbitrary network/host boundary)
    - Newer approach
    - Extended the life of IP addresses
    - Largely in use today
Bit Manipulation

- You often need to “and” and “or” bit strings
- Example - and
  1000 1111
  1110 0011
  1000 0011
  1000 0011
- Example – or
  1000 1111
  1110 0011
  1110 0011
  1110 1111

1 “and” 1 is 1
1 “and” 0 is 0
0 “and” 0 is 0

Are We on Track?

- Calculate the “and” of the following bit strings
  1000 1111 1100 0011
  1110 0011 0000 0001

- Calculate the “or” of the following bit strings
  1000 1111 1100 0011
  1110 0011 1111 1111
Were We on Track?

- Calculate the “and” of the following bit strings
  
<table>
<thead>
<tr>
<th>Bit String</th>
<th>And Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 1111 1100 0011</td>
<td>1000 0000 0000 0000</td>
</tr>
<tr>
<td>1110 0011 0000 0001</td>
<td>0000 0000 0000 0000</td>
</tr>
<tr>
<td>1000 0011 0000 0001</td>
<td>0000 0000 0000 0000</td>
</tr>
</tbody>
</table>

- Calculate the “or” of the following bit strings
  
<table>
<thead>
<tr>
<th>Bit String</th>
<th>Or Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 1111 1100 0011</td>
<td>1110 1111 1100 1010</td>
</tr>
<tr>
<td>1110 0011 1111 1111</td>
<td>1110 1111 1111 1111</td>
</tr>
<tr>
<td>1110 1111 1111 1111</td>
<td>1110 1111 1111 1111</td>
</tr>
</tbody>
</table>

Classful Networks

- Older approach to assigning IP addresses
- Subnet mask is implied
- Classes
  - Class A - subnet mask of 255.0.0.0 (slash 8 network)
  - Class B - subnet mask of 255.255.0.0 (slash 16 network)
  - Class C - subnet mask of 255.255.255.0 (slash 24 network)
Subnet Mask Notation

- Only for IPv4
- A bit mask is shown in dotted decimal notation
- Bitmask is logically “anded” with the IP address to form the network ID
- A subnet mask of 255.255.255.0 specifies the first 24 bits as the network ID
  - $255_{10} = 11111111_2$
- A subnet mask of 255.255.255.224 specifies the first 27 bits as the network ID

Subnet Mask Example

- IP address 10.10.10.101 with a subnet mask of 255.255.255.0.

```
00001010.00001010.00001010.01100101
11111111.11111111.11111111.00000000
00001010.00001010.00001010.00000000
```

Logical and operation

Network ID
CIDR Notation

- Classless Inter-Domain Routing
- Method for allocating IP addresses and routing packets
- First address of a network, followed by a slash character (/), and ending with the bit-length of the prefix
- Compact specification of
  - IP address
  - Associated routing prefix
- Constructed using IP address and network prefix size
- Host identifier - least-significant bits following the prefix
- For example: 192.168.100.0/24 denotes a 24-bit network ID for Internet routing

CIDR is pronounced “cider” or “cedar”

Called a slash 24 network

IPv6

- In 1994, the Internet Engineering Task Force began work on what is now IP Version 6
- Motivation
  - Extend IP’s address space beyond its current 32-bit limit to 128 bits for both the source and destination host addresses
- Deployment
  - Will take time
  - Requires that devices involved in an Internet request support IPv6

IPv4
IPv6

192.168.10.25 ... fe80::fff:c0a8:a19
IPv6 Address Format

- Eight sets of four hexadecimal addresses (16 bits in each set), separated by a colon (:
  - This notation is commonly called string notation.
  - Hexadecimal values can be displayed in either lower- or upper-case for the numbers A–F.
  - A leading zero in a set of numbers can be omitted;
    - E.g., you could either enter 0012 or 12 in one of the eight fields—both are correct.
  - Successive fields of zeroes can be represented as two colons (::) at most once in an address.

IPv6 Header Format
Have You Achieved the Objectives

• Understand structure of TCP/IP
• Understand ways in which the net ID and the host ID can be extracted from the IP address
• Understand migration to IPv6