CSBridge – Net 4

A history of IP

- Originally designed by the DOD for military purposes
- Used to create the DARPANET
- DARPANET later evolved into the Internet for Educational purposes
- Recently been utilized more for commercial purposes

IP Header

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th><th>31</th><th>bits</th></tr>
<tr><td colspan="4">Ver</td><td colspan="4">IHL</td><td colspan="8">Type of Service</td><td colspan="16">Total Length</td><td rowspan="6">IP Header (Minimum length 20 Octets)</td></tr>
<tr><td colspan="16">Identifier</td><td colspan="4">Flags</td><td colspan="12">Fragment Offset</td></tr>
<tr><td colspan="8">Time To Live</td><td colspan="8">Protocol</td><td colspan="16">Header Checksum</td></tr>
<tr><td colspan="32">Source Address</td></tr>
<tr><td colspan="32">Destination Address</td></tr>
<tr><td colspan="32">Options + Padding</td></tr>
</table>

IP Routing

- Routing is making a decision as to where the packet is to go next.
- Simple for a host:
  1. To an application on this host
  2. To the network attached locally
  3. To the default gateway

Routing tables

- Routing tables are composed of:
  - A Destination Address, either host or network in nature
  - The IP Address of the next “hop”
  - The Metric, or cost of sending to that router
  - The network inte rface which is closest to the next hop

Routing Decisions

- The routing table is queried for the destination network. The entry with the smallest network mask that qualifies is returned
- The TTL in the packet is decremented by the metric number
  - If the TTL is now zero, the packet is discarded and an ICMP time exceeded message is sent back to the source
- If the packet size is greater than the MTU of the network, the packet is fragmented
- The hardware address of the next-hop is determined and the DLC header is applied to the packet(s)
  - If the HA cannot be determined and the route is still active in the table, send an ICMP Host/Network unreachable message to the source
- The packet(s) are sent to the next-hop.

Fragmentation

- IP considers everything in the ULP section of the packet as data which can be fragmented. If fragmentation is necessary perform the following:
  1. Decide how much data can be “stuffed” into the first packet. Consider the following equation:
     (MTU - IP Header)
     as an acceptable size for the new packet.
  2. Take the old header and apply it to the new packet, however change the flags to “001.” Bit 0 must be set to 0, bit one says other routers may fragment, and bit 2 says this is not the last fragment. Send this packet immediatly

Fragmentation (cont)

3. Take as much of the original data as is left up to the (MTU – IP Header), put it in a new packet with the same header as before except set the fragment offset to:

   count*(MTU-IP header) + original fragment offset

   where count is the number of packets sent before this one. If this is the last fragment set the flags to “000.”
4. Continue doing step 3 until no more data remains.

Old Routing

- Networks were divided into classes by size
  - Class A, starts with (0XXX) First octet: 1-127
  - Class B, Starts with (10XX) First Octet: 128-191
  - Class C, Starts with (1100) First Octet: 192-223
  - Class D, Starts with (1110) First Octet: 224-239
  - Class E, Starts with (1111) First Octet: 240-247
- Classes A, B and C were reserved for hosts, class D was for routing, class E was reserved

Old Routing continued

- Sizes were:
  - Class A: 8 network bits, 24 host bits
  - Class B: 16 network bits, 16 host bits
  - Class C: 24 network bits, 8 host bits
- By examining the first octet we can quickly determine if routing is necessary or if the destination is on the directly connected network.

Old Routing Problems

- Class sizes were too large
- Did not allow administrators to control the routing very well
- A division of the network required the intervention of InterNIC

IP Subnetting

- IPv4 allows the opportunity for Administrators to intervene and break up a network. Class A, B, and C are still assigned, but the administrator can make the network smaller as s/he feels is necessary.
- If there are 20 computers in an office in San Francisco and 20 in an office in New York. Only one class C is necessary and can be broken down into two different networks.

Determining routing

- If a host is on our network, we say it will have the same Network Address as us, otherwise we forward the packet to the default router
- The network address is determined by doing a logical AND operation between the IP address and the Subnet Mask.
- By doing this calculation on our IP address and the destination address we can determine if they are on the same network.

Subnet example 1

```
SRC Ip:192.168.1.1
SRC SM:255.255.0.0
DST IP:192.168.2.2


Bin SRC     IP: 11000000.10101000.00000001.00000001
Bin SRC     SM: 11111111.11111111.00000000.00000000
Bin DST net #: 11000000.10101000.00000000.00000000

Bin SRC     IP: 11000000.10101000.00000010.00000010
Bin SRC     SM: 11111111.11111111.00000000.00000000
Bin DST net #: 11000000.10101000.00000000.00000000

Numbers match so they are on the same network
```

Subnet Example 2

```
SRC Ip:192.168.1.1
SRC SM:255.255.255.0
DST IP:192.168.2.2



Bin SRC     IP: 11000000.10101000.00000001.00000001
Bin SRC     SM: 11111111.11111111.11111111.00000000
Bin DST net #: 11000000.10101000.00000001.00000000

Bin DST     IP: 11000000.10101000.00000010.00000010
Bin DST     SM: 11111111.11111111.11111111.00000000
Bin DST net #: 11000000.10101000.00000010.00000000

Numbers do not match so the are not on the same net
```

Subnetting Example

- We have been assigned:
  - IP Network: 192.1.1.0/24
  - 20 computers which need IP addresses in NYC
  - 20 Computers which need IP addresses in SF
  - Two routers and one WAN link

Subnetting example (cont)

- First we recognize that we can only decide how many subnet bits we use in the last octet, the first three octets are fixed by the authority that assigned them and cannot be changed.
- We examine how many networks we have and how many hosts/network we need, leaving room for expansion.
- By manipulating the number of subnet bits and host bits in the last octet we can create the different network.

Reminders

- Remember to leave room for more hosts as well as more networks.
- Remember that networks can be subnetted more than once
- Remember that you cannot use the all ones and all zeros networks or hosts
- Remember that the routers need a IP address also.
- Remember that the WAN link between the two routers is a network of it’s own.