Problem Set 5

Due: Friday, April 8th

You will hand in your solution using svn and follow the instructions on Piazza to add and commit new files.

Link-State Routing

1. Show how the link-state algorithm builds the routing table for node A in the following network by completing the table below (similar to the format in P&D Table 3.14, page 258). If you need more rows, just simply add the rows into the table.

![Network Diagram]

<table>
<thead>
<tr>
<th>Step</th>
<th>Confirmed</th>
<th>Tentative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(A, 0, -)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>(A, 0, -)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>(A, 0, -), (B, 2, B)</td>
<td>(C, 7, C)</td>
</tr>
<tr>
<td>4</td>
<td>(A, 0, -), (B, 2, B)</td>
<td>(C, 7, C), (D, 7, B), (E, 5, B)</td>
</tr>
<tr>
<td>5</td>
<td>(A, 0, -), (B, 2, B), (E, 5, B)</td>
<td>(C, 7, C), (D, 6, B), (F, 14,</td>
</tr>
</tbody>
</table>

Sol:
2. Consider a router that interconnects three subnets: Subnet A, Subnet B and Subnet C. Suppose all of the interfaces in each of these three subnets are required to have the prefix 233.255.10/23. Also suppose that Subnet A is required to support up to 200 interfaces, and Subnets B and C are each required to support up to 100 interfaces. Provide three network addresses (of the form a.b.c.d/x) that satisfy these constraints.

Sol:
- A: 233.255.10.0/24
- B: 233.255.11.0/25
- C: 233.255.11.128/25

3. Suppose a router has built up the routing table shown below. Recall that for CIDR addresses, the “/22” part indicates a mask of 22 1’s followed by 10 0’s.

<table>
<thead>
<tr>
<th>Net / Mask length</th>
<th>Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.174.248.0 / 20</td>
<td>Router 2</td>
</tr>
<tr>
<td>128.174.248.128 / 26</td>
<td>Interface 1</td>
</tr>
<tr>
<td>128.174.252.0 / 23</td>
<td>Interface 2</td>
</tr>
<tr>
<td>128.174.254.7</td>
<td>Interface 3</td>
</tr>
<tr>
<td>128.174.254.16 / 28</td>
<td>Router 1</td>
</tr>
<tr>
<td>128.174.224.0 / 19</td>
<td>Router 3</td>
</tr>
<tr>
<td>Default</td>
<td>Router 4</td>
</tr>
</tbody>
</table>

a. The router can deliver packets directly over interfaces 1, 2, or 3, or it can forward to routers 1, 2, 3, or, 4. Specify the next hop for each of the following destinations. Recall that if a destination matches more than one IP prefix in the table, the longest match is used.

   i. 128.174.255.7
   ii. 128.174.254.7
   iii. 128.174.253.7
   iv. 128.174.240.7
   v. 128.174.220.7
   vi. 128.174.254.18
b. How many individual IP addresses match each of the Net / Mask length pairs? (For simplicity, ignore there is some overlap. For this question, you have to show why you get your answer. Only a value without reasoning will get no credits)

*Sol:*

a. i.  R2  
   ii.  I3  
   iii. I2  
   iv.  R3  
   v.   R4  
   vi.  R1  

b. **Router 2:**  128.174.1111/xxx.xxxxxxxx:  $2^{12} = 4096$
   
   **Interface 1:**  128.174.11111000.10/xxxxxx:  $2^6 = 64$
   
   **Interface 2:**  128.174.11111110/xxx.xxxxxxxx:  $2^9 = 512$
   
   **Interface 3:**  128.174.11111110.00000111 (only one host since the whole IP address is shown)
   
   **Router 1:**  128.174.11111110.0001/xxxx:  $2^4 = 16$
   
   **Router 3:**  128.174.111/xxxx.xxxxxxxx:  $2^{13} = 8192$
   
   **Router 4:**  Default: NA

**Multicast vs. Unicast**

4. Suppose host A is sending to a multicast group. The destinations are leaf nodes of a tree rooted at A with depth $N$ and with each non-leaf node having $k$ children, so there are $k^N$ destinations. Ignore counting the ACK’s for this question.

   a. How many individual link transmissions are involved if A sends a multicast message to all destinations?

   b. How many individual link transmissions are involved if A sends a unicast message to each destination?

   c. Suppose A sends a multicast message to all destinations, but a fraction $f$ of the destinations fail to receive the message. Option (i) is to send a separate unicast transmission to each of those destinations that fail to receive messages. Option (ii) is to send a single multicast transmission to all destinations. What value of $f$ that makes these two options require equal amount of individual link transmissions? (Your answer should depend on the values of $N$ and $k$.)

*Sol:*

a. One multicast transmission involves all $k + k^2 + \ldots + k^N = (k^{(N+1)} - k) / (k-1)$ links.

b. One unicast retransmission involves $N$ links; sending to everyone would require $N * k^N$ links.
c. The additional unicast transmission to $x$ fraction of the recipients uses $x \cdot N \cdot k^N$ links. Equating this to the answer in (a), we get $x = \frac{(k^{N+1} - k)}{(k-1)} \cdot N \cdot k^N$

**IP Fragmentation**

5. Suppose an IP packet is fragmented into 8 fragments, each with a 10% (independent) probability of loss.

   a. What is the probability of losing the whole packet due to loss of fragments?

   Based on the previous answer, what is the probability of net loss of the whole packet if the packet is transmitted twice,

   b. assuming all fragments received must have been part of the same transmission?

   c. assuming any given fragment may have been part of either transmission?

   d. Explain how use of the *Ident* field might be applicable here.

   **Sol:**

   a. $\binom{8}{1} \cdot 10\% = 0.8$

   b. The probability of losing both transmission of the packet would be $0.8 \cdot 0.8 = 0.64$.

   c. The probability of loss is now the probability that for some pair of identical fragments, both are lost. For any particular fragment the probability of losing both instances $10\% \cdot 10\% = 0.01$, and the probability that this happens at least once for the 8 different fragments is thus $1-(1-0.01)^8 = 0.077$.

   d. An implementation might (though generally most do not) use the same value for *Ident* when a packet had to be retransmitted. If the retransmission timeout was less than the reassembly timeout, this might mean that case (c) applied and that a received packet might contain fragments from each transmission.

**Networking Utilities**

6. The *ifconfig* utility is used to assign and examine network interface parameters. Read the man page on ifconfig and study the different options. Show information about all interfaces, both active and inactive.

   **Sol:**

   a. ifconfig -a