Project 2 – Discussion 2
Simple Router
ICMP Type 11

- Verify that the packet is not destined to the router. How?
- Check if the dst ip address of the packet is not equal to the ip addresses of the router interfaces.
- If not destined and ttl of the ip header packet == 1, create ICMP type 11 (time exceeded) packet.
- ICMP Type 11 structure is already defined for you.
- Then, send the packet using sr_send_packet. The data field in the ICMP segment is 28 bytes starting from the IP header of the original packet which the router received.

![Time exceeded message](image)

Where:
- **Type** must be set to 11
- **Code** specifies the reason for the time exceeded message, include the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Time-to-live exceeded in transit.</td>
</tr>
</tbody>
</table>
LPM – Longest Prefix Match

- If packet not destined to router and ttl != 1, check routing table to see if a matching entry for the destination IP address exists (LPM). How?

- You have the routing table (sr->routing_table) and destination ip address. The routing_table is a structure of type sr_rt (defined in sr_rt.h). The routing table has dest and mask variables of type in_addr.

- Do & (bitwise AND) between dest and mask. Also, between the destination ip address and mask. Compare to see if they match.

- If multiple matches, check to see which match has the longest mask.s_addr.
ICMP Type 3 Code 0

- If LPM returns empty, then create ICMP type 3 (network unreachable) packet.

  Note: ICMP Type 11 structure can be used for this as they are similar.

- Then, send the packet using sr_send_packet.

![Destination unreachable message](image)
Creating ARP Request

- If LPM entry (type sr_rt) is found, then reduce ttl and update checksum for the IP header.
- Now, you need to update the frame header’s source and destination fields.
- Do a `sr_arpcache_lookup`. ‘gw.s_addr’ (next hop ip address) is one of the variables to be passed to the function.
- If it returns NULL, use `sr_arpcache_queuereq` function to add the ARP request to the ARP request queue.
  
  Send the sr instance and the queue to `handle_arpreq`.
  
  Handle_arpreq - Function to be implemented. Check comments in sr_arpcache.h for pseudocode.
- If the lookup returned an arp entry, then modify the Ethernet source and destination values and use `sr_send_packet`. 
To test your LPM logic

- To test your routing table lookup, you can change the entries in rtable file to have different subnet masks. For instance, to check your router’s longest prefix match logic, you can have multiple entries in your rtable file that match a single destination IP. The following routing table has two matching entries for the packet destined to 192.168.2.2.

<table>
<thead>
<tr>
<th>IP Address</th>
<th>Matched IP</th>
<th>Subnet Mask</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.2.2</td>
<td>192.168.2.2</td>
<td>255.255.255.0</td>
<td>eth2</td>
</tr>
<tr>
<td>192.168.2.2</td>
<td>192.168.2.2</td>
<td>255.255.255.255</td>
<td>eth1</td>
</tr>
<tr>
<td>172.64.3.10</td>
<td>172.64.3.10</td>
<td>255.255.255.255</td>
<td>eth2</td>
</tr>
<tr>
<td>10.0.1.100</td>
<td>10.0.1.100</td>
<td>255.255.255.255</td>
<td>eth3</td>
</tr>
</tbody>
</table>
With some changes to the routing table, you can trigger a Destination Host Unreachable ICMP (type 3, code 1) by making your router send ARP request to a host which is not present. To simulate that scenario, change the next hop gateway to a non-existing IP address in rtable.
Endianness

- Network byte order - Big endian (LSB goes to lower address)
- Host - little endian (LSB goes to higher address)
- If (variable <= 1 byte)
  Big endian = little endian
  //e.g.: ip_tos, ip_ttl
- Else
  Big endian = htons(little endian)
  Little endian = ntohs(big endian)
  //e.g.: ip_len, ip_id
- Print_utils() has examples for such conversions.
HOPE YOUR SOLUTION CAN PING ROUTER INTERFACES BY NOW!