Administrivia

- Midterm out today
  - Will post when I get back to my desk, before noon
  - Due Friday by 11:59pm
  - Take-home format, designed for ~2hrs
  - Open book, open notes, open Internet
  - No collaboration: no sharing with peers; no posting on StackOverflow, etc
  - Ask questions in office hours, or make private EdStem posts
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• **Upcoming office hours**
  – **Today**: 3-5pm (CIT506), 5:30-7pm (Zoom), with Me
  – **Tomorrow**: noon-2pm (me, via Zoom); 4-6pm (Yongjeong, CIT203)
Administivivia

Deadlines

• Summer work apps: Sunday, Mar 20 by 11:59pm
• IP project: Mar 22 by 11:59pm
Administivia

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- Summer work apps: Sunday, Mar 20 by 11:59pm
- IP project: Mar 22 by 11:59pm

Class next week will be light (please stay checked-in!)
- Tuesday: fun network tools, port scanning, IP spoofing
- Thursday: short intro to TCP
Questions?
Homework 2

Due: 17 March 2022, 9:00am (No late days)

Meta-note

This assignment is designed to help you review for the midterm. We will review most of the assignment (and anything else you want) during class on Thursday, March 17. Accordingly, the assignment is due before the start of class on Thursday, ie. by 9:00am on Thursday, March 17.

Additionally, since the midterm (and homework solutions) will be released immediately after class, no late days may be used on this assignment.

If (after reading the assignment) you feel these timing constraints would be problematic for you, please contact Nick before the deadline.

(Continued on next page)
1 Almost Local Networks

Fun fact: This is an old midterm problem.

Consider the network pictured below, which has two private subnets connected to router R1 via Ethernet switches S1 and S2. R1 also connects both subnets to the Internet using Network Address Translation (NAT), as the 192.168.0.0/16 prefix is not routable on the Internet. p0...p2 are the names of ports on switch S1 (not MAC addresses).

Initially, all ARP tables and MAC learning caches are empty. Assume that all hosts are configured correctly with an IP address, network mask, and default gateway to match the figure. Additionally, assume that the router’s forwarding table is configured appropriately to access both private subnets and the Internet (using NAT).

a. First, H1 sends an IP packet to H3. (Assume that this sends an ARP request, which happens successfully.) For the IP packet, write the source and destination addresses in both the L2 (Ethernet) and L3 (IP) header when it is crossing the link labeled A in the figure. For MAC addresses, you can use names based on the name of the host or router interface, eg. MAC_H1 for H1, MAC_IF1 for R1’s IF1, etc.

<table>
<thead>
<tr>
<th></th>
<th>Src Addr</th>
<th>Dest Addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>MAC_H1</td>
<td>MAC_IF0</td>
</tr>
<tr>
<td>IP</td>
<td>192.168.12.10</td>
<td>192.168.3.161</td>
</tr>
</tbody>
</table>
b. Router R1 is a cheap model and can only hold 4 entries in its forwarding table. Given that it has to route packets to both local subnets, and to the entire Internet (including H4), what are the entries in R1’s forwarding table? (Assume a default route has already been provided, as shown.)

<table>
<thead>
<tr>
<th>Destination Network</th>
<th>Out Port/Next Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>192.168.12.0/24</td>
<td>150</td>
</tr>
<tr>
<td>192.168.3.0/24</td>
<td>152</td>
</tr>
<tr>
<td>192.213.10.0/20</td>
<td>151</td>
</tr>
<tr>
<td>Default</td>
<td>130.213.10.1</td>
</tr>
</tbody>
</table>

c. Similar to part (a), write the source and destination addresses in both the L2 (Ethernet) and L3 (IP) header for the IP when it is crossing the link labeled B in the figure. (Again, assume any relevant ARP queries are made and handled successfully.)

<table>
<thead>
<tr>
<th>Src Addr</th>
<th>Dest Addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>MAC-1P2</td>
</tr>
<tr>
<td>IP</td>
<td>192.168.12.10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Src Addr</th>
<th>Dest Addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>MAC-1P2</td>
</tr>
<tr>
<td>IP</td>
<td>192.168.3.161</td>
</tr>
</tbody>
</table>

d. After the IP packet successfully reaches H3, what are the contents of H1’s ARP table, and of switch S1’s MAC learning table? (Use can the tables like the ones below, though you don’t necessarily need as many entries as shown here.)

<table>
<thead>
<tr>
<th>H1 ARP Cache</th>
<th>S1 MAC Learning Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
<td>HW Addr</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HW Addr</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

e. Now H1 wants to send a packet to H4, which is a server out on the Internet. Note that R1 uses NAT to send the outgoing packet, as the 192.168.0.0/16 addresses are not routable on the Internet. What are the source and destination L2 and L3 addresses for this packet when it is crossing link C in the figure?

<table>
<thead>
<tr>
<th>Src Addr</th>
<th>Dest Addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet</td>
<td>MAC-1P2 (R1)</td>
</tr>
<tr>
<td>IP</td>
<td>136.213.10.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dest Addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
</tr>
</tbody>
</table>
LETS SAY RI GETS A RANDOM PACKET

NEXT: 130.213.10.2:7777

IF NO TABLE RULE FOR PACKET, RI DROPS PACKET.
In order to have an outside host connect to a host behind a NAT:

- S needs to know H1's outside IP
- R1 needs a rule in its NAT table to allow connection
**Distance Vector**
- e.g. RIP
- each node updates neighbors w/ its routing table
- update message
  - I know about 1.2.3.0/24 at cost 0
  - I know about 5.6.7.8/21 at cost 2
- each node learns about reachability from neighbors
- simpler to implement
- no count to infinity
- problem (loops possible)

**Link State**
- e.g. OSPF
- each node sends info about its links to all other nodes
- update message
  - I have 1.2.3.0/24 on 1PO
- each node has full view of network
- more computation
- more messages
- no loops problem (loops possible)
2  BGP - Gao-Rexford Principles

Consider the Gao-Rexford model of BGP route propagation.

In the following graph, nodes represent ASes, directed edges go from customers to providers, and bidirectional edges represent peering relationships. For example, node A is a customer of node X, and node Y peers with node Z.

Hosts in A are upset: they cannot communicate with any hosts in C.

a. Why not? In the current topology, who would be in a disadvantage if this communication were to happen, and how so?

b. List four distinct modifications to the graph (changing the type or direction of edges, adding or removing edges) that would allow nodes at A, B, and C to all talk to each other. (e.g., have AS $i$ become a customer of AS $j$, etc). In other words, list 4 alternative topologies where nodes in A, B, and C could all mutually communicate.
3 In a world without...

What do you need to do manually for a network with IP over Ethernet to work, if you don't have the following protocols/features working. For example, your answer might be in the form of “give each X a table mapping A to B,” “determine unique IDs for Z,” or “nothing.”

a. ARP
b. DHCP
c. MAC learning (at switches)
d. RIP