15-441: Computer Networks
Homework 2

Assigned: Feburary 19th
Due: Feburary 28th

1. Frank Fandango runs a 10Mbit/s Ethernet between the CMU campus and the homes of his friends. All of these hosts are in a single broadcast domain. Fortunately, they are located *just* within the maximum distance of an Ethernet. The total size of an Ethernet can be about 2.5 kilometers, , and an Ethernet has a minimum packet size of 512 bits.

   Frank upgrades his network to 100Mbit/s Ethernet, and notices that when only one person sends at a time, or when he sends very large packets, his network works. But when many people send very small packets, things don't work at all.

   (a) Explain how a minimum packet size can help to detect collisions in Ethernet:

   Solution: Consider the extreme case, suppose there is no minimum packet size, host A at one end sends a frame of only 1 bit to host B at the other end. After sending the 1-bit frame, host A is convinced that there is no collision because it does not hear any interference. However, the frame is still on its way to the other end, and if host B sends another frame at this time, collision can happen. To determine the minimum packet size, consider the worst case for Ethernet's collision detection:

   1. At t_0: A sends a frame
   2. At $t_0 + prop$: B sends another frame right before it can carrier sense the A's frame
   3. At $t_0 + 2 * prop$: A is still transmitting while the B's frame arrived at A

   thus the minimum packet size is $2 * prop * bandwidth$.

   (b) Help Frank out. Compute the threshold of how big packets must be in order for things to work:

   Solution:
   One solution: The Ethernet is 10 times faster, and Frank's users were at the boundary. Therefore, the packets must be 10 times larger – 5120 bits.
   Another solution: Calculate the propagation delay as $2500/(1.8*10^8) = 14\mu s$, and then the minimum packet size is $2*14*10^{-6}*100*10^6 = 2800$ bits. Note that the result is different from the first solution. This is because the design choice of 512 bits in 10Mbps Ethernet is roughly twice conservative, to take into consideration of many practical factors, e.g. slower propogation speed, delay introduced by repeaters, etc.

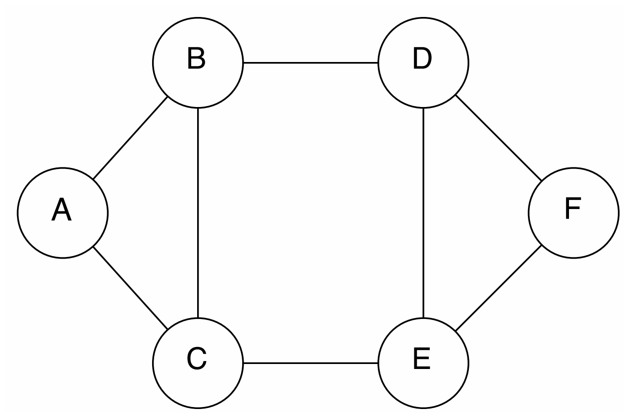
   (c) One solution that Frank came up with is to raise the minimum packet size to the answer from part (b). Suppose that Frank cannot modify the minimum packet size, move the endpoints, lay new cable, or change the software or configuration on the endpoints. You may add new devices to the network. How could Frank change the topology to fix his problems anyway?

Solution:

full credit: Add bridges or switches to separate the network into multiple collision domains.

partial credit: Add routers. Adding routers would require that he change the IP address / gateway configuration on the hosts.

2. For this question, assume that the routers use RIP to calculate their forwarding tables.



(a) Fill in the routing table for node A, after convergence.

Solution:

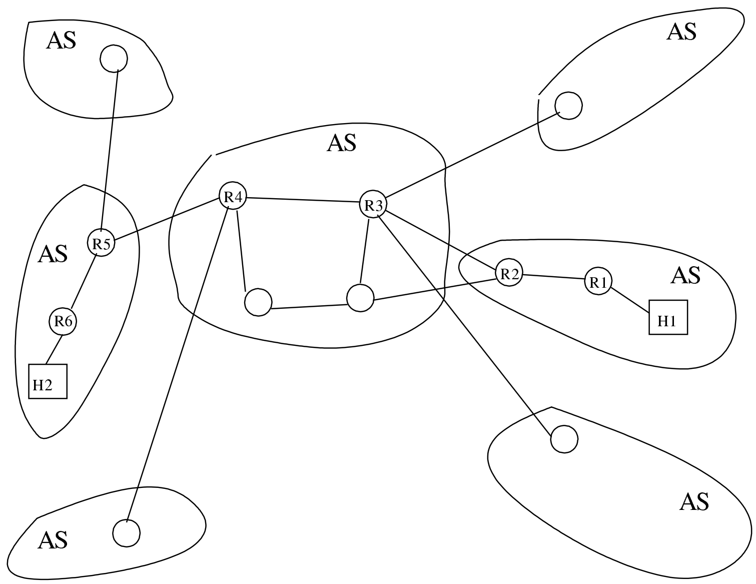
Destination	Cost	Next Hop
A	0	-
B	1	B
C	1	C
D	2	B
E	2	C
F	3	B/C

(b) After convergence, node E goes down. Fill in the final routing table for B, after re-convergence.

Solution:

Destination	Cost	Next Hop
A	1	A
B	0	-
C	1	C
D	1	D
E	$16/\infty$	-
F	2	D

3. Imagine the Internet is divided into the Autonomous Systems shows below. In this problem we assume *NO subnetting* and *NO supernetting* and *NO CIDR* is used. A packet is being sent from Host H1 to Host H2. The packets takes the following route: H1 $\longrightarrow$ R1 $\longrightarrow$ R2 $\longrightarrow$ R3 $\longrightarrow$ R4 $\longrightarrow$ R5 $\longrightarrow$ R6 $\longrightarrow$ H2



Some information: R2, R3, R4, and R5 are gateway routers. **Assume that there are many routers and networks within each AS that are not shown. Assume also that there are NO default entries in routers. Please answer the questions below in 10 words or less. We are NOT looking for numerical answers.**

(a) Which of the *labeled* routers above likely use the BGP routing algorithm to create their forwarding tables?

> **Solution:** R2, R3, R4, R5. Recall that gateway routers speak BGP when computing routes

(b) How many entries does R1's forwarding table have?

> **Solution:** Number of networks in the AS containing R1. Recall that R1 needs to be able to reach any of the networks within its AS, not just those networks that it is directly connected to.

(c) Assume that host H1's IP address is 205.96.17.172, What can we say about the IP address of R1

> **Solution:** It has the same network number prefix as H1, namely 205.96.17. Recall that H1 must have the same network number as R1, since R1 is the next IP hop from H1 and thus R1 has an interface on the same network as H1. Observing that H1 has a class C IP address, we know that R1 and H1 share the network number 205.96.17.

(d) Give an example of an entry in R1's forwarding table (don't leave out any fields).

> **Solution:** (205.95.17, 2, 8:0:2b:e4:b:1:2) where (network prefix, outing interface, MAC)

(e) How many entries are there in R2's forwarding table?

> **Solution:** Number of networks in whole Internet. Remember that R2 is a gateway router and thus needs to know about every network in the Internet.

(f) Suppose AS X thinks that AS Y drops too many packets. Using only BGP, is it possible for AS X to implement a policy stating that "traffic outbound from my AS should not cross Y?" Why or why not?

Solution: Yes, assuming it has an alternative route. Prefer paths that don't contain Y. Of course, if the only path to a destination contains Y, it can not reach that destination without going through Y.

(g) Now suppose AS X thinks that AS Y generates a lot of illegal file sharing traffic. Using only BGP, is it possible for AS X to implement a policy stating that, "I don't want to carry traffic from Y to my customers?" Why or why not? Assume that AS X does not want to deny transit to traffic from any other AS.

Solution: Not in general. Traffic from a neighbor might be from both good ASs and Y. BGP can only accept all the traffic by advertising a route or deny all of it by not advertising.

4. Maggie decides to start a small company. She asks her ISP, Acme Networks, to give her enough addresses for 1200 hosts. ACME allocates a subblock from the 192.1.* address range that they own and tells Maggie to use the following addresses:

192.1.0.*
192.1.1.*
192.1.2.*
192.1.3.*
192.1.4.*

(a) Maggie has heard that the size of the Internet routing table has grown to huge proportions, and that to be a good citizen, she should announce the fewest number of routes possible to exactly cover her IP addresses.

Under CIDR, what is the smallest *set* of network numbers that the rest of the world would use to describe Maggie's networks (please use address & prefix format - e.g. 128.2/16)?

Solution: 192.1.0/22 and 192.1.4/24

(b) Maggie has a second ISP that she uses, RoadRunner Networks. She announces some of her network addresses to both Acme and RoadRunner. (Maggie hadn't talked to you yet—these announcements do not correspond to the answers you provided to the previous question). As a result, some router far away in the network produces a forwarding table with the following entries:

Destination	Next Hop
192.1/16	1.2.3.4
192.1.0/23	1.2.3.5
192.1.4/24	1.2.3.6
192.1.1/24	1.2.3.7

Which next hop should the router use for a packet destined to 192.1.0.1?

Solution: Using longest prefix match, it should use 1.2.3.5