15-441 Computer Networks — Homework 3
Assigned: Oct. 23, 2002 — Due: Oct. 31, 2002, 5 p.m.

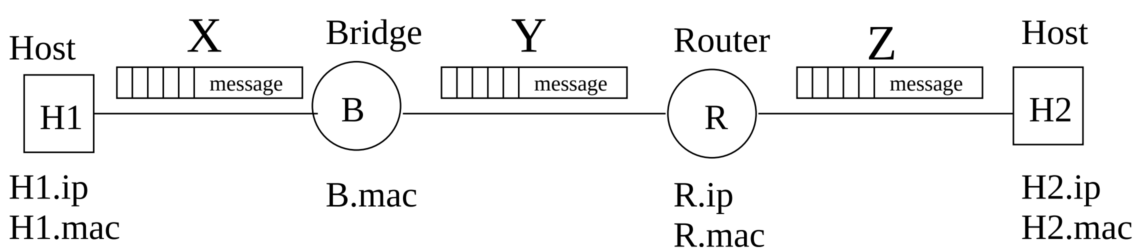
Homework 3

1 Understanding Packet Headers

This problem pertains to the figure below. Consider a message being transmitted along the path shown in the figure. The message was sent from an application running on Host 1, port 8888 to an application running on Host 2, port 9999. The transport protocol being used is TCP. The figure shows one packet of the message at several points along its path (points X, Y, and Z). This problem asks you some questions about what's stored at the headers at these three points.

Start by numbering the headers in the packet at points X, Y, and Z. That is, each header should be assigned a number from 1 to 5, where 1 corresponds to the wire layer, 2 corresponds to the datalink layer, ... , 5 corresponds to the application layer.

For all the questions below, your answer should take the form of a list. For example: {(packet X, layer 3), (packet Y, layer 2)}. Your answer may be the null list: { }.



1. List all places where H2.ip is written.

   { (X,3), (Y,3), (Z,3) }

2. List all places where R1.ip is written.

   { }

3. List all places where B.mac is written.

   { }

4. List all places where TCP is written.

   { (X,3), (Y, 3), (Z,3) } TCP is written in the protocol field of the IP header

5. List all places where R1.mac is written.

   { (X,2), (Y,2) , (Z,2) } You need to include (Z,2) because it turns out that R1.mac replaces H1.mac as the source MAC address when the packet passes through router R.

6. List all places where H2.mac is written.

   {(Z,2)}

7. List all places where port 9999 is written.

   {(X,4), (Y,4), (Z,4) }

Note that in this problem we have simplified the address assignment by assigning MAC and IP addresses to routers and bridges instead of to their interfaces. In reality, as explained in the lecture notes, each router and bridge would have two IP and MAC addresses, one for each interface.

2 CIDR

Here is short forwarding table:

Mask	Network Number	Outgoing Interface
255.0.0.0	128.0.0.0	1
255.240.0.0	128.208.0.0	3
default	-	15

Or, equivalently:

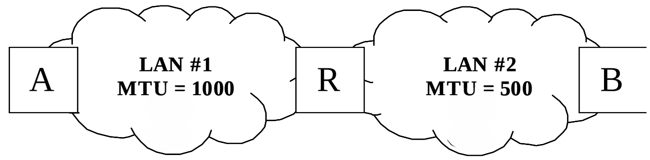
Number bits	Subnet Number	Outgoing Interface
8	10000000	1
12	100000001101	3
default	-	15

What interface will the packets with the following destination address be forwarded to:

1. 128.3.208.23
2. 123.34.206.9
3. 128.209.98.9
4. 128.240.98.126

Answers:

1. 128.3.208.23 – Interface 1 (Reason: only the first mask results in a match).
2. 123.34.206.9 – Interface 15 (Reason: Neither the first nor second masks result in a match).
3. 128.209.98.9 – Interface 3 (Reason: Both the first and second masks result in matches, but we need to go with the longest prefix match.)
4. 128.240.98.126 – Interface 1 (Reason: Only the first mask results in a match).



3 MTU

Host A is on LAN #1 and Host B is on LAN #2. The two LANs are interconnected via a router. The MTU of LAN #1 and LAN #2 are 1000 and 500 bytes respectively. Suppose an application on Host A executes 1000 writes to an application running on host B; each write results in one MTU-sized IPv4 packet on LAN #1. Each packet consists of only an IP header and data and the IP header is 20 bytes (no options).

Question: How many packets from Host A to Host B traverse LAN #2 ?

Answer: 3000 datagrams on LAN2. One maximum-size (LAN1) packet consists of 20 bytes header and 980 bytes data. The three corresponding (LAN 2) packets are two of 20 bytes header and 480 bytes data and one of 20 bytes header and 20 bytes data.

4 Subnets

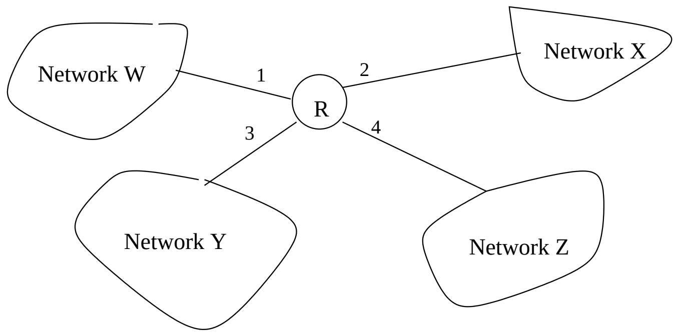
You are a poor system administrator. You could only afford to purchase one, class C, network number. You have 4 networks W, X, Y, Z, which are connected by a single router, R, shown below:

Each network requires < 64 IP addresses.

Your job is to describe the forwarding table at router R. To do this, you will need to assume one particular class C network number.

State your choice of class C network number here: ____________________

Answer: 205.89.72 is what I picked.



Fill in Table at R:

Answer:

Mask	Subnet Number	Outgoing Interface
255.255.2555.192	205.89.72.192	1
255.255.255.192	205.89.72.128	2
255.255.255.192	205.89.72.64	3
255.255.255.192	205.89.72.0	4

5 Tunneling

Suppose that there are 22 hops from source A to destination B, but 7 of the hops are through an IP tunnel. If A sets the TTL of a packet to 31, then what will be the value of the TTL when the packet arrives at B?

Answer: The TTL will have a value 16. The TTL is decremented by every router that processes the IP header. Along the 22 hop path, there are 21 routers that could decrement the TTL field, so without the tunnel, the TTL would have been $31 - 21 = 10$. However, 6 of these routers are "inside" the tunnel, so only 15 of these router will have access to the ent-to-end IP header. The TTL will therefore be $31 - 15 = 16$.

6 Network Tools: `netstat` and `route`

The UNIX utility `netstat` displays the contents of certain network-related data structures in various formats. Another useful utility `route` is used to manually manipulate the forwarding table of the machine. Use `man` to learn more about these two utilities, and then answer the questions below:

1. The `netstat -rn` command shows the forwarding table for your machine. What is the IP address of the router that `unix44.andrew.cmu.edu` will use to connect to `www.yahoo.com`?

   Answer: 128.2.10.254 (the default gateway).

2. The Solaris version of `route` requires root access to the machine to run, so you cannot actually run it, however you can understand how to run it from the `man` page. Suppose after your machine (IP address: 128.2.11.203) boots-up, its forwarding table has the following entries:

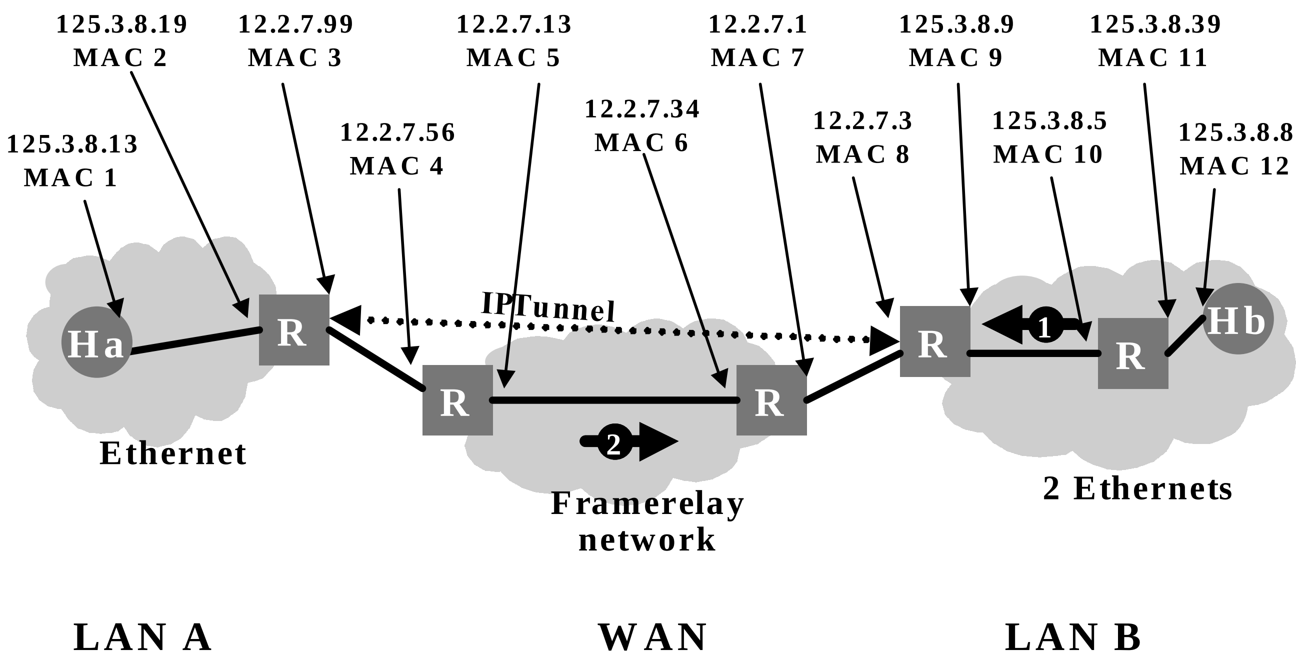
```
Destination Network         IP address of Router          Interface
-------------------         --------------------          ---------
128.2.10.0/23                  128.2.11.203                 hme0
224.0.0.0/8                    128.2.11.203                 hme0
127.0.0.1/32                   127.0.0.1                    lo0
```

   Suppose you want to browse some Internet sites, and you know you need to use the gateway 128.2.10.254. What command will you use to modify the forwarding table? What will be the forwarding table after you do the modification?

   Answer: Use the command: route add default 128.2.10.254 After you do this, the table will look like this:

```
Destination Network         IP address of Router          Interface
-------------------         --------------------          ---------
128.2.10.0/23                  128.2.11.203                 hme0
224.0.0.0/8                    128.2.11.203                 hme0
127.0.0.1/32                   127.0.0.1                    lo0
Default                        128.2.10.254                 hme0
```

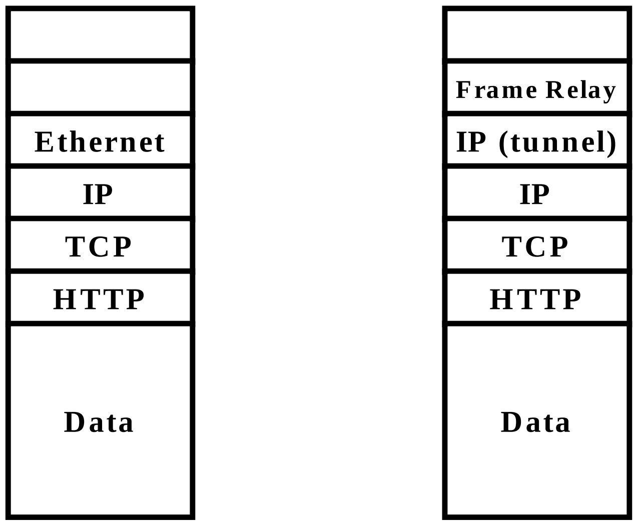
7 Headers under Tunneling



A corporation has two local area networks connected over a wide area network using an IP tunnel, as is shown in the picture above. The two edge routers that connect the LANs to the WAN forward any packets destined for the other LAN through the tunnel. Tunneling is used so that the corporation can more easily use non-standard protocol features in its corporate network. The first LAN is a simple Ethernet while the second LAN consists of two Ethernets connected by an internal router. Part of the WAN runs through a framerelay network. In the figure, R stands for Router and H for Host. The framerelay switches are not shown in the picture, and Ethernet hubs and switches are also not shown.

We want to look in more detail at the headers of packets being exchanged by a web browser executing on the client host Ha in LAN A and the web server Hb executing in LAN B.

a) Please show the type and the order of the headers of the packets being exchanged by the web browser and server for the two locations marked on the network picture. When showing the "type" of header, be specific (e.g., Don't just write 'transport', but rather indicate 'TCP' or 'UDP'. Don't just write 'datalink', but rather indicate 'Frame Relay', or 'Ethernet' or something else). Include all headers of the following protocol layers: network layer, application layer, datalink layer, and transport layer. Use the packet outlines shown below, ie. fill in the header types in the right box. Note that there may be more boxes than you need. The top of each packet outline corresponds to the first byte in the packet while the bottom corresponds to the last byte.



Packet 1: B -> A **Packet 2: A -> B**

b) For the packet traveling in LAN B from LAN B to LAN A, identify the primary fields of the protocol headers. Primary fields means source and destination port numbers of transport protocols, source and destination IP addresses for network headers, and the datalink addresses or connection identifiers for the datalink layer. There is no need to fill in anything for application headers. Use the IP and datalink address information shown in the figure. The URL that the browser is trying to retrieve is "http://www.internalsupercom/index.html". If you do not have enough information to specify a field, fill in an "X" and briefly explain. If a field does not exist, fill in "-" and explain briefly.

Hdr Type	**Src**	**Dest**
Ethernet	MAC 10	MAC 9
IP	125.3.8.8	125.3.8.13
TCP	80	X
HTTP		
Data		

The source port in the TCP header is 80, since that is the default port used by HTTP (the application). The destination port is unknown. It was assigned by the operating system of host Ha when it opened the connection to the server.

c) The same question for packets traveling from LAN A to LAN B through the framerelay network.

Hdr Type	**Src**	**Dest**
Frame Relay	-	X
IP (tunnel)	12.2.7.99	12.2.7.3
IP	125.3.8.13	125.3.8.8
TCP	X	80
HTTP		
Data		

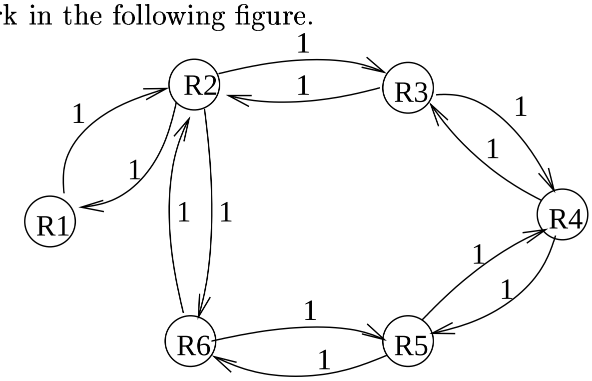
Because the two packets belong to the same connection, the IP and TCP headers for packets 1 and 2 are similar. The difference is that the source and destination fields are flipped.

The second IP header is for the tunnel. The source and destination IP addresses are for the entry and exit point of the tunnel.

Communication in frame relay is based on virtual connections. This means that the destination field will hold a connection identifier (unknown) and that there is no source field.

8 Distance-Vector

In this problem, you will be looking at the operation of a distance vector algorithm in the context of the network in the following figure.



Assume that all routers boot at the same time, at time unit 0. Assume that steps are synchronous. Step 1 consists of discovering your distance to all your neighbors. Each subsequent step consists of each router sending an update to all its neighbors and receiving a routing update from all its neighbors.

a) Show the contents of each router's routing table at the end of step 2 by filling in the tables below. The routing table for R1 has been filled out as an example. Each routing table entry consists of a destination address, next hop router and estimated cost for the path to that router.

R1

Dest.	Next Hop	Metric
R2	R2	1
R6	R2	2
R3	R2	2

R2

Dest.	Next Hop	Metric
R1	R1	1
R6	R6	1
R3	R3	1
R5	R6	2
R4	R3	2

R3

Dest.	Next Hop	Metric
R2	R2	1
R4	R4	1
R1	R2	2
R5	R4	2
R6	R2	2

b) How many steps does it take for the algorithm to converge? Please explain.

The algorithm will converge in 3 steps because the longest shortest path between any two nodes in the network is 3 hops.

c) If router R3 crashes at the end of time unit 17 and is rebooted at the end of time unit 18, at the end of what time unit, will it have a complete routing table, i.e. one that contains routing information on how to reach all other routers? Please explain.

R3 will have a complete routing table at time 19 since its neighbors have complete routing tables and it will take only 1 iteration for R3 to receive these tables.

d) Imagine that the network administrator decides that she wants to forward more traffic along the link from R2 to R6. To do that, she changes the link cost of this link to -20. Will that achieve her intent? Please explain.

This will not work. Going around the loop $R2 \rightarrow R6 \rightarrow R5 \rightarrow R4 \rightarrow R3 \rightarrow R2$ decreases the cost metric of this path at each iteration. The algorithm computing the shortest path to each destination will get into an infinite loop.