CSE 473 – Introduction to Computer Networks *Jon Turner*

Exam 1 Solution

10/3/2012

1. (10 points). A user in St. Louis, connected to the internet via a 20 Mb/s (b=bits) connection retrieves a 250 KB (B=bytes) web page from a server in Seattle, where the page references 4 images of 1 MB each. Assume that the one way propagation delay is 25 ms.

   Approximately how long does it take for the page (including images) to appear on the user's screen, assuming non-persistent HTTP using a single connection at a time (for this part, you should ignore queueing delay and transmission delays at other links in the network)?

   5(100) ms + (2 + 4*8 Mb/(20 Mb/s) = 500 ms + 1.7 sec = 2.2 seconds*

   How long does it take if the connection uses persistent HTML (single connection)?

   100 ms + 50 ms + 1.7 sec = 1.85 seconds

   Suppose that the path from the server to the user passes through a 1 Gb/s link at a router R, and that the rate at which packets arrive at router R that must be sent on this link is 450,000 packets per second. If the average packet length is 2,000 bits, what is the average queueing delay at this link?

   I = (900 Mb/s)/(1 Gb/s) = 0.9, so average queue length = I/(1-I) = .9/.1 = 9 packets

   time to send a packet = (2000 bits)/(1000 bits per μs)

   *average delay = 9*2 μs = 18 μs*

2. (10 points). Suppose a server with IP address 1.2.3.4 executes the following lines of python.

```
sock = socket(AF_INET, SOCK_STREAM);
sock.bind(('1.2.3.4', 6789))
sock.listen(10)
connsock1, client1 = sock.accept()
connsock2, client2 = sock.accept()
```

Now, suppose a host with IP address 2.3.4.5 executes the following lines.

```
sockA = socket(AF_INET, SOCK_STREAM);
sockA.bind(('2.3.4.5', 23456))
sockA.connect(('1.2.3.4', 6789))
```

and a short while later, suppose another host with IP address 3.4.5.6 executes the following lines.

```
sockB = socket(AF_INET, SOCK_STREAM);
sockB.bind(('3.4.5.6', 34567))
sockB.connect(('1.2.3.4', 6789))
```

At this point, how many sockets are there at the server?

3

How many port numbers are being used at the server (by this program)?

1

What is the value of the variable, *client1*, at the server?

```
(("2.3.4.5",23456))
```

What is the value of the variable, *client2*?

```
(("3.4.5.6",34567))
```

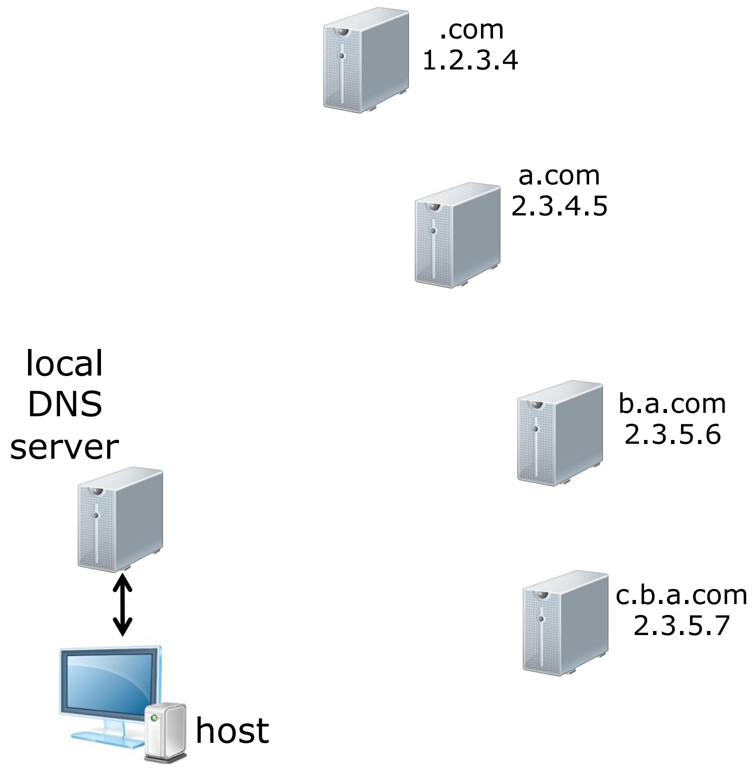
Give one line of python that causes the string "who hah" to be sent from the server to the second of the two clients. What is the maximum possible number of packets that TCP might use to deliver this string to the client?

```
connsock2.sendall("who hah")
```

This could require up to 7 packets.

3. (10 points). The figure below shows a host, its local DNS server, three additional DNS servers and a web server (c.b.a.com). The tables at left represent the DNS caches for the local server and the host. Suppose the user at the host enters `c.b.a.comfoo.html` into a web browser.

name	address
.com	1.2.3.4
b.a.com	2.3.5.6
c.b.a.com	***2.3.5.7***



name	address
c.b.a.com	***2.3.5.7***

List all packets sent, leading up to the first packet sent from the host to the web server. For each packet, identify the sender, the receiver and give a brief description of the packet (for example, "query on name x.y.z" or "response IP=9.8.7.6"). Assume that the local server uses recursive query processing, but all others use iterative query processing. Show all changes to the contents of the DNS caches at the end of the sequence.

host to localDNS query on name c.b.a.com

localDNS to b.a.com query on name c.b.a.com

b.a.com to localDNS response IP=2.3.5.7

localDNS to host response IP=2.3.5.7

4. (10 points) Consider a packet with a total length of 250 bytes (including IPv4 header, with no options) and an id field equal to 17, sent from a host *A* to a host *B*, passing through routers *X* and *Y*. Assume that the subnet where host *A* is connected has an MTU of 500 bytes, the subnet where host *B* is connected has an MTU of 80 bytes and the subnet between *X* and *Y* has an MTU of 120 bytes. Assuming that the "don't fragment" flag is not set, how many fragments does router *X* divide the packet into? What is the length of each fragment?

   The payload has 230 bytes and each packet in the subnet joining X and Y has room for a 100 byte payload, but since 100 is not divisible by 8, we'll have 96 bytes in the initial fragments. So, there are 3 fragments with payload sizes of 96, 96 and 38 giving packet sizes of 116, 116 and 58.

   Complete the diagram below so that it represents the first two fragments forwarded by router *Y* (*not X*). Fill in all the blanks.

...		
id=***17***	MF=***1***	offset=***0***
...		
payload length=***56***		

...		
id=***17***	MF=***1***	offset=***7***
...		
payload length=***40***		

   Suppose host *A* sends a 50 byte packet with the "don't fragment" flag set. Explain what happens to this packet at each of the two routers.

   This packet is shorter than the MTU of all subnets, so it will be delivered to B without any fragmentation.

5. (10 points). The table at right represents a forwarding table for an IP router (for simplicity, we are using 8 bit addresses).

prefix	next hop	
	output	address
101*	2	1010 1111
0100*	4	0100 0110
0010 0*	6	-
1010 1*	7	-
0101 0*	5	0101 0011
1011 00*	3	1011 0000
0101 11*	1	0101 1100
0010 01*	9	-

If a packet arrives with destination address 1010 0110, what output is it sent to, and what is the IP address of the next network-level component to receive the packet?

output 2, address 1010 1111

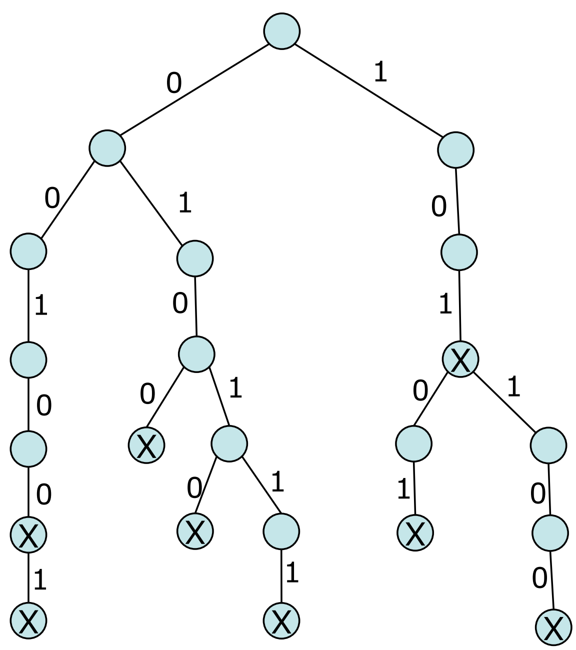
If a packet arrives with destination address 0010 0110, what output is it sent to, and what is the IP address of the next network-level component to receive the packet?

output 9, address 0010 0110

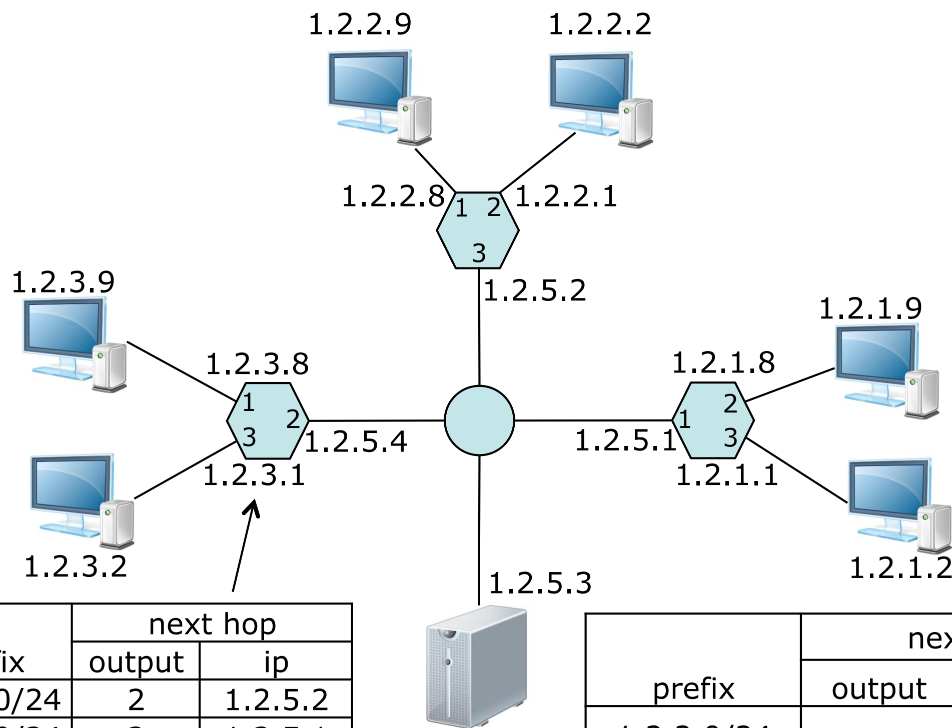
If a packet arrives with destination address 1011 0010, what output is it sent to, and what is the IP address of the next network-level component to receive the packet?

output 3, address 1011 0000

Draw a diagram of a binary trie that could be uses as a lookup data structure for the prefixes in the table. Mark each node that corresponds to a prefix in the table with an X.



6. (10 points). The diagram below shows a network with 3 routers (shown as hexagons) connected by an Ethernet switch. The routing table for the left-hand router is shown. Complete the routing table for the right-hand router, so that packets will be delivered appropriately (use no more than 5 route table entries).



prefix	next hop	
	output	ip
1.2.2.0/24	2	1.2.5.2
1.2.1.0/24	2	1.2.5.1
1.2.5.0/24	2	-
1.2.3.0/29	3	-
1.2.3.8/29	1	-

prefix	next hop	
	output	ip
1.2.2.0/24		
1.2.3.0/24		
1.2.5.0/24		
1.2.1.0/29		
1.2.1.8/29		

If a switch was inserted between the host with IP address 1.2.3.2 and its router, how many hosts could be *added* to that switch, without having to change the routing table entries? What IP addresses would those hosts use?

A /29 prefix contains 8 addresses. Since 2 are already in use, so this leaves addresses 1.2.3.0, 1.2.3.3, 1.2.3.4, 1.2.3.5, 1.2.3.6 and 1.2.3.7. So 6 hosts could be added.

This is actually not quite right, since there is a special rule for subnets. The first address in any subnet range (the address defined by all zeros) is generally interpreted as the "subnet address" and is not supposed to be used by any host. In addition, the last address in any subnet range (the address defined by all ones) is the "broadcast address" for the subnet and should not be assigned to a host. This rule effectively eliminates hosts 1.2.3.0 and 1.2.3.7, so technically, only 4 hosts can be added.

7. (15 points) In the figure in problem 6, suppose that the server, with IP address 1.2 5.3 is configured to use the right-hand router for its non-local traffic. Assume that the ARP tables for all hosts and routers are empty initially. List all packets that must be sent from one network-level component to another, in order to deliver a packet from the server to the host with IP address 1.2.2.9. For each packet, specify which component sends it and which receives it and give a brief description (for example – "left router to top router: ARP request for address xyz", or "server to top router: data packet").

    1. *Server broadcasts ARP request for address 1.2.5.1.*
    2. *Right-hand router responds with its MAC address.*
    3. *Server sends packet with destination address 1.2.2.9 to right-hand router (using MAC address).*
    4. *Right-hand router broadcasts ARP request for address 1.2.5.2.*
    5. *Top router responds with its MAC address.*
    6. *Right-hand router forwards packet with destination address 1.2.2.9 to top router.*
    7. *Top router broadcasts ARP request for address 1.2.2.9.*
    8. *Host with address 1.2.2.9 responds with its MAC address.*
    9. *Top router forwards packet with destination address 1.2.2.9 to destination host.*

    What packets must be sent when the server sends a second packet to the same host?

    In this case, steps 3, 6 and 9 from the above list are all that's required.