CSE 677: Solutions to Homework 1

2. **(6 points)** A client is fetching a base html file with k referenced objects ($k \geq 0$) from an Internet server. Let the RTT be r. Assume that the transmission/reception time for each file and referenced objects, if any, is d. Further, the only transmission/reception bottleneck in the network is the access link through which the client is connected to the Internet. In terms of r, k, and d, compute the following delay for the following scenarios:

   (a) non-persistent HTTP with parallel TCP connections. (no limit on the number of parallel connections)
   $2r + d$, if k is 0
   $2r + d + 2r + d \times k$, otherwise

   (b) non-persistent HTTP with no parallel TCP connections.
   $2r + d + (2r + d) \times k$

   (c) persistent HTTP with pipelining.
   $2r + d$, if $k = 0$
   $2r + d + r + d \times k$, otherwise

   (d) persistent HTTP without pipelining.
   $2r + d + (r + d) \times k$

3. **(4 points)** Suppose two hosts, A and B, are separated by 10,000 kilometers and are connected by a direct link of $R = 1$ Mbps. Suppose the propagation speed over the link is $2.5 \times 10^8 meters/sec$. What is the width (in meters) of a bit? (1Mbps = 10^6 bits per second)

   Answer: $\frac{2.5 \times 10^8 m/s}{10^6 bits/sec} = 250 m/bit$

4. **(5 points)** Suppose N packets arrive at a rate of S packets/second (with uniform spacing between packets) to a link at which no packets are currently being transmitted or queued. Each packet is of length L and the link has transmission rate R, where $R = S/2$. What is the average queuing delay for the N packets? Assume that the node has an infinite size packet buffer. (Hint: The first packet has a delay of 0. When the second packet arrives part of first packet has already been transmitted. First, compute the delay for each packet.)

   Answer: As R packets are being transmitted every second, the transmission delay for each packet is $1/R$. The average queuing delay is

$$\frac{1}{N}(0 + \frac{1}{2R} + \frac{2}{2R} + \frac{3}{2R} ..... + \frac{(N-1)}{2R}) = \frac{1}{2RN}(1 + 2 + ...(N-1)) = \frac{1}{2RN}\frac{(N-1)N}{2} = \frac{(N-1)}{4R}$$

5. **(7 points)** Consider sending a large amount of data over a lossy link. Each bit can be independently in error with a probability of b. Packets with any bit (data or header) in error is dropped by the receiver. Each packet contains an h bit header. The raw capacity of the link is C bits per second.

   (a) (2 points) What is the probability that a packet gets dropped at the receiver?

$$1 - (1 - b)^{h+d}$$

(b) (2 points) Compute the throughput over the link. Throughput is defined as the maximum number of data bits received per second by the application. Assume that the sender is sending packets back-to-back.

$$\frac{d}{d+h}(1-b)^{h+d}C$$

(c) (3 points) Assume $h = 100$, and $b = 10^{-5}$. What is the value of d that maximizes the throughput over the link?

By plugging in the values of h and b in the above expression, differentiating it and then equating it to 0 we get

$$\frac{d}{d+100}(1-10^{-5})^{100+d}ln(1-10^{-5}) + (1-10^{-5})^{100+d}\frac{1}{(d+100)^2} = 0$$

After cancelling some terms, this becomes a quadratic equation in d:

$$d^2 ln(1-10^{-5}) + 100 ln(1-10^{-5})d + 100 = 0$$

Solving it we get

$$d = \frac{-100 \pm \sqrt{10000 - \frac{400}{ln(1-10^{-5})}}}{2}$$

The non-negative value is 3112.66. As the number of bits has to be an integer, we observe that the throughput is higher for 3113 than 3112. So 3113 bits is the answer.

6. **(2 points)** Read about the WiMAX and WiFi technologies. What are the key differences between the two technologies? Do you think these technologies will co-exist in the future or will one of them replace the other? Comment with reasons.

Answer:

WiFi has been around for many years now, and is primarily used for short range ($\tilde{1}$00 m) and high data rate (up to $\tilde{5}$4 Mbps) communication. Users in a hotspot can expect to get several tens of Mbps on average provided the backbone connection to the Internet can support that data rate.

WiMAX on the other hand is targetted for wide-range (e.g, city-wide) coverage. Like the cellular towers they can provide coverage up to several miles with data rates that can be as high as several tens of Mbps. A deployment in Baltimore, MD provides roughtly 2-3 Mbps on average while driving.

Some other differences:

(a) Coverage area Generally, because using licensed frequency and higher transmission power than WiFi, the coverage range of a WiMAX can be up to 10 kilometers. WiFi covers a small area such as offices, cafeterias and school, and works as a traditional LAN.

(b) Licensed and unlicensed frequency band WiFi uses unlicensed frequency bands, whereas WiMAX uses both licensed and unlicensed bands.

Due to the differences in the coverage range and data rates, they are targetting two different markets. These technologies may co-exist in the future. WiFi will continue to provide high data services in hotspots and WiMAX may provide ubiquitous data services.

7. **(8 points)** Read the man pages for nslookup(1M). If you are not very familiar with UNIX man pages, start with **man man**. For parts (b), (c) and (d), also describe the commands you use to obtain the answers.

(a) **(2 points)** Read the man page for **resolv.conf**. Explain the contents of the **/etc/resolv.conf** file on the *stdsun* machine. What is the advantage of having multiple name servers as opposed to a single name server listed in this file?
Answer:
/etc/resolv.conf is the resolver configuration file that contains the local domain name and a list of IP addresses of name servers available to a host. The advantage of having multiple name servers is that should one of the name servers is not available a client can still access to another name server.

(b) **(2 points)** What are the canonical names of the machine **www.cnn.com** and **www.yahoo.com**.
Answer:
Command: nslookup -type=CNAME www.cnn.com
Command: nslookup -type=CNAME www.yahoo.com
There is no canonical name of www.cnn.com, and fp3.wg1.b.yahoo.com is the canonical name of www.yahoo.com.

(c) **(2 points)** What is the name and the IP address of the machine on which the email server for the following recipients is running: **prasun@cse.ohio-state.edu** and **edspace@nasa.gov**? (If there are several mail server machines, provide information on only one).
Answer:
Command: nslookup -type=MX cse.ohio-state.edu
Command: nslookup -type=MX nasa.gov
You will see a list of servers and their IP addresses. Any of the mail exchanges is a mail server.

(d) **(2 points)**What are the names and IP addresses of the authoritative name servers for the following machines: **www.cs.duke.edu** and **setiathome.ssl.berkeley.edu**?
Answer:
Command: nslookup -type=SOA www.cs.duke.edu
Command: nslookup duke.cs.duke.edu
Command: nslookup -type=SOA setiathome.ssl.berkeley.edu
Command: nslookup ns1.ssl.berkeley.edu
For www.cs.duke.edu, the authoritative name server is duke.cs.duke.edu and its IP address is 152.3.140.1. For setiathome.ssl.berkeley.edu, the authoritative name server is ns1.ssl.berkeley.edu and its IP address is 128.32.12.7 or 128.32.147.7.