Computer Networks
Exercise 1

Problem 1

A router receives packet P and determines the outbound link to which the packet should be forwarded. When P arrives, one other packet is **1/3** done being transmitted on this outbound link and **15** other packets are waiting to be transmitted on this outbound link (in a queue). Packets are transmitted in order of arrival. Suppose all the packets are **1500** bytes and the transmission rate is **2** Mbps (2M bits per second). What is the queuing delay for the packet P? That is, how much time does it take until P is at the head of the queue? Justify your answer.

There are $15 + 2/3$ packets that are waiting to be transmitted in this outbound link, which means $15\frac{2}{3} * 1500 * 8 = 188,000\ bits$.

The transmission rate is $2\ Mbps$, so the queuing delay for the packet P is $188,000\ bits\ /2,000,000\ sec\ = 94\ ms$.

Formally:

$R = 2Mbps = 2,000,000\ bps$

$L = 15\frac{2}{3} * 1500 * 8 = 188,000\ bits$

Queueing delay = $L/R = 188,000/2,000,000 = 94\ ms$.

Problem 2

Suppose two hosts, A and B, are separated by **100,000** kilometers, and are connected by a direct link of R = **1** Mbps. Suppose the propagation speed over the link is **2.5*10^8** meters/sec.

a. What is the propagation delay?
b. Consider sending a file of 532,000 bits from host A to B. Suppose the file is sent continuously as one big message. What is the maximum number of bits that will be in the link at any given time?
c. What is the width (in meters) of a bit in the link (when there is a maximum number of bits in the link)?
d. How the width of a bit will be effected if we increase the distance between A and B?
e. How the width of a bit will be effected if we increase the propagation speed?
f. How the width of a bit will be effected if we increase R?

Justify your answers.

a. The length of physical link is $100,000\ km = 10^8\ m$, and the propagation speed is $2.5 * 10^8\ m/sec$, so the propagation delay is $10^8/(2.5 * 10^8) = 0.4\ sec$.
   Formally:
   $d = 100,000\ km = 10^8\ m$
   $s = 2.5 * 10^8\ m/sec$
   Propagation delay = $d/s = 10^8/(2.5 * 10^8) = 0.4\ sec$.

b. There are 0.4 seconds to transfer bits on the link, so the maximum number of bits that is possible in the link is $1\ Mbps * 0.4\ sec = 1,000,000 * 0.4 = 400,000\ bits$.

c. The width of a bit in the link is the speed of the bit divided by the transmission rate. $s/R = 2.5 * 10^8/1\ M = 250\ m$.

d. The width of a bit, given by the formula s/R, remains unaffected by changes in the distance between A and B. The width of a bit is determined by the speed of the bit s and the transmission rate R, and it does not depend on the length of the link.

e. The width of a bit, given by the formula s/R, is directly proportional to the propagation speed s, so if we increase s, the width of a bit will also be increased.
   If the speed of a bit increases, the bit will cover a greater distance in the same amount of time, so the width of the bit will increase.

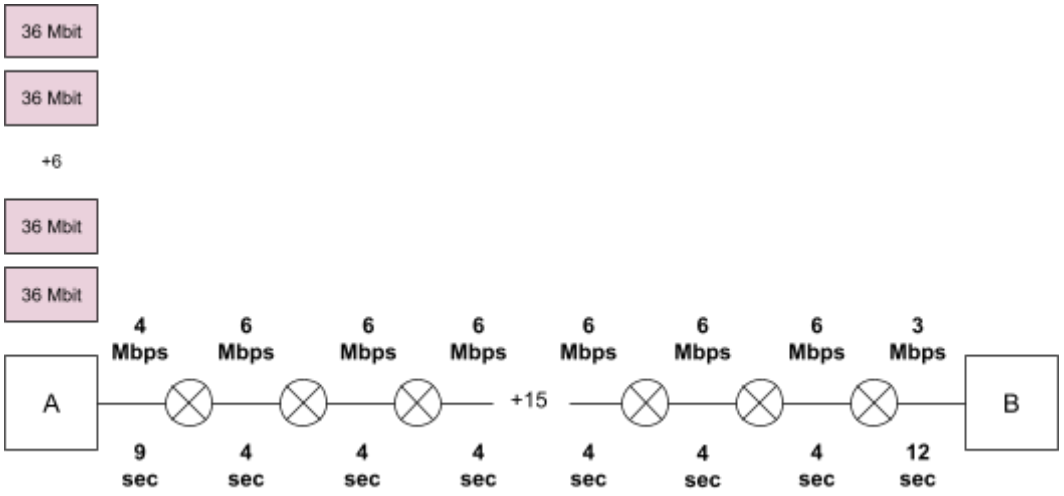
f. The width of a bit, given by the formula s/R, is inversely proportional to the transmission rate R, so if we increase R, the width of a bit will be decreased.
   If the transmission rate increases, bits are sent more frequently and each bit will cover a smaller distance in the link.

Problem 3

We wish to send a file of size **360** Mbit from source A to destination B. There are exactly **21** routers on the only existing route between A and B. All the links along the route between A and B support a transmission rate of **6** Mbps, except for the first link which supports a transmission rate of **4** Mbps, the last link which supports a transmission rate of **3** Mbps. Notice that the first link is the link between A and the first router and not the link between the first two routers! The last link is between the last router and B. The propagation speed between A and B is **2*10^8** meter/sec and the distance is **10,000** km (that is, **10^7** meter). We assume the file is divided into **10** equal-size packets for transmission (each of size **36** Mbit), all the routers implement store and forward techniques, and we are disregarding headers overhead. In addition, we assume that when a router is free, it can send a packet as soon as it gets the whole packet.
How much time in seconds will it take for the last bit of the file to reach host B?

Important: Notice that the transmission rate of the last link is **smaller** than that of the other links!

Justify your answer.



File size: $360\ Mbit$

Propagation speed s: $2 * 10^8\ m/sec$

Distance $d = 10^7\ m$

Transmission delay: L/R

First link: $36\ Mbit/4\ Mbps = 9\ sec$

Middle links: $36\ Mbit/6\ Mbps = 6\ sec$

Last link: $36\ Mbit/3\ Mbps = 12\ sec$

Propagation delay: $d/s = 10^7/2 * 10^8 = 0.05\ sec$

The delay until the last packet reaches the first router: $9 * 10 = 90\ sec$

The delay of the last router: $12 * 2\frac{1}{4} = 27\ sec$

The total time is: $90 + 6 * 20 + 27 + 12 + 0.05 = 249.05\ sec.$

Problem 4

Find the domain names (i.e., URL's) that are associated with the following IP addresses:

a. 66.161.11.20
b. 80.67.70.22
c. 67.15.82.48
d. 207.171.166.252

Shortly explain how you solved this problem.

a. webgod.linksys.com
b. www-8cc.akamai.com
c. www.skype.com
d. 166-252.amazon.com

To find the domain names, I used the **nslookup** command in the terminal.

```
➜  ~ nslookup 66.161.11.20
Server:         192.168.1.1
Address:        192.168.1.1#53

Non-authoritative answer:
20.11.161.66.in-addr.arpa       name = webgod.linksys.com.

Authoritative answers can be found from:

➜  ~ nslookup 80.67.70.22
Server:         192.168.1.1
Address:        192.168.1.1#53

Non-authoritative answer:
22.70.67.80.in-addr.arpa        name = www-8cc.akamai.com.

Authoritative answers can be found from:

➜  ~ nslookup 67.15.82.48
Server:         192.168.1.1
Address:        192.168.1.1#53

Non-authoritative answer:
48.82.15.67.in-addr.arpa        name = www.skype.com.

Authoritative answers can be found from:

➜  ~ nslookup 207.171.166.252
Server:         192.168.1.1
Address:        192.168.1.1#53

Non-authoritative answer:
252.166.171.207.in-addr.arpa    name = 166-252.amazon.com.

Authoritative answers can be found from:
```

Problem 5

Using only notepad please compose an HTML page, that includes:

1. The moving title in blue color: **Computer networks 2023: Exercise 1**
2. A fixed title in red color with your **full names**.
3. **Two** images centered, side by side, at the middle of the page (You may choose whatever picture you want.)
4. A link to the course website.
5. Another link to your favorite website.
6. A horizontal line.
7. An HTML Form containing: Sender, Receiver, Subject, Message Field, and Submit bottom.

You may want to use a table to better align your page. Please submit the page and the two images with your exercise. You are welcome to use the following link to help in completing HTML question: http://htmlgoodies.earthweb.com/primers/primer_1.html, http://www.w3schools.com/html/.
(This is the only place where we will deal with HTML in the course).

Attached is the index.html file and the images.

Problem 6

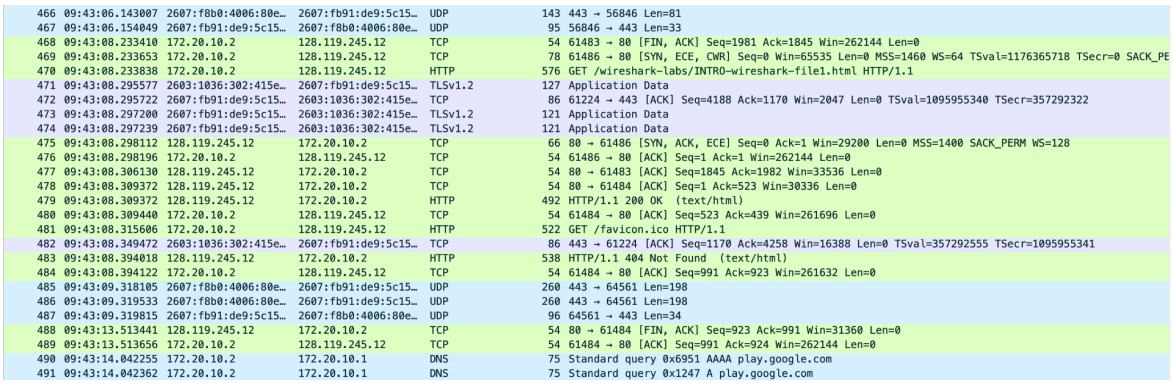
Enclosed please find the documents “Wireshark Lab: Getting Started” The goal of this first Lab is to introduce you to Wireshark.

At the end of the lab there are **4** simple questions that will demonstrate that you have been able to get Wireshark up and running. Answer these **4** questions. Where applicable, justify your answers using screen captures.

The goal of this first lab was primarily to introduce you to Wireshark. The following questions will demonstrate that you’ve been able to get Wireshark up and running, and have explored some of its capabilities. Answer the following questions, based on your Wireshark experimentation:

1. List the different protocols that appear in the protocol column in the unfiltered packet-listing window in step 7 above.
2. How long did it take from when the HTTP GET message was sent until the HTTP OK reply was received? (By default, the value of the Time column in the packet- listing window is the amount of time, in seconds, since Wireshark tracing began. To display the Time field in time-of-day format, select the Wireshark View pull down menu, then select Time Display Format, then select Time-of-day.)
3. What is the Internet address of the gaia.cs.umass.edu (also known as www-net.cs.umass.edu)? What is the Internet address of your computer?
4. Print the two HTTP messages displayed in step 9 above. To do so, select Print from the Wireshark File command menu, and select “Selected Packet Only” and “Print as displayed” and then click OK.

1. Some of the protocols that appear in the protocol column:
   HTTP, TCP, UDP, TLSv1.2, DNS.

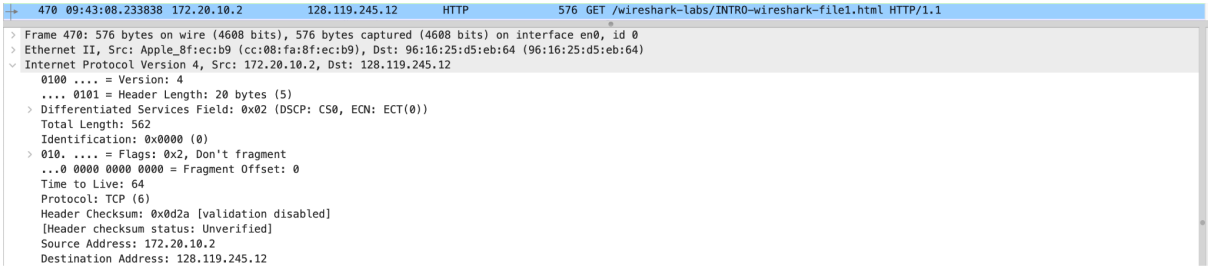


466	09:43:06.143007	2607:f8b0:4006:80e…	2607:fb91:de9:5c15…	UDP	143	443 → 56846 Len=81
467	09:43:06.154049	2607:fb91:de9:5c15…	2607:f8b0:4006:80e…	UDP	95	56846 → 443 Len=33
468	09:43:08.233410	172.20.10.2	128.119.245.12	TCP	54	61483 → 80 [FIN, ACK] Seq=1981 Ack=1845 Win=262144 Len=0
469	09:43:08.233653	172.20.10.2	128.119.245.12	TCP	78	61486 → 80 [SYN, ECE, CWR] Seq=0 Win=65535 Len=0 MSS=1460 WS=64 TSval=1176365718 TSecr=0 SACK_PE
470	09:43:08.233838	172.20.10.2	128.119.245.12	HTTP	576	GET /wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1
471	09:43:08.295577	2603:1036:302:415e…	2607:fb91:de9:5c15…	TLSv1.2	127	Application Data
472	09:43:08.295722	2607:fb91:de9:5c15…	2603:1036:302:415e…	TCP	86	61224 → 443 [ACK] Seq=4188 Ack=1170 Win=2047 Len=0 TSval=1095955340 TSecr=357292322
473	09:43:08.297200	2607:fb91:de9:5c15…	2603:1036:302:415e…	TLSv1.2	121	Application Data
474	09:43:08.297239	2607:fb91:de9:5c15…	2603:1036:302:415e…	TLSv1.2	121	Application Data
475	09:43:08.298112	128.119.245.12	172.20.10.2	TCP	66	80 → 61486 [SYN, ACK, ECE] Seq=0 Ack=1 Win=29200 Len=0 MSS=1400 SACK_PERM WS=128
476	09:43:08.298196	172.20.10.2	128.119.245.12	TCP	54	61486 → 80 [ACK] Seq=1 Ack=1 Win=262144 Len=0
477	09:43:08.306130	128.119.245.12	172.20.10.2	TCP	54	80 → 61483 [ACK] Seq=1845 Ack=1982 Win=33536 Len=0
478	09:43:08.309372	128.119.245.12	172.20.10.2	TCP	54	80 → 61484 [ACK] Seq=1 Ack=523 Win=30336 Len=0
479	09:43:08.309372	128.119.245.12	172.20.10.2	HTTP	492	HTTP/1.1 200 OK (text/html)
480	09:43:08.309440	172.20.10.2	128.119.245.12	TCP	54	61484 → 80 [ACK] Seq=523 Ack=439 Win=261696 Len=0
481	09:43:08.315606	172.20.10.2	128.119.245.12	HTTP	522	GET /favicon.ico HTTP/1.1
482	09:43:08.349472	2603:1036:302:415e…	2607:fb91:de9:5c15…	TCP	86	443 → 61224 [ACK] Seq=1170 Ack=4258 Win=16388 Len=0 TSval=357292555 TSecr=1095955341
483	09:43:08.394018	128.119.245.12	172.20.10.2	HTTP	538	HTTP/1.1 404 Not Found (text/html)
484	09:43:08.394122	172.20.10.2	128.119.245.12	TCP	54	61484 → 80 [ACK] Seq=991 Ack=923 Win=261632 Len=0
485	09:43:09.318105	2607:f8b0:4006:80e…	2607:fb91:de9:5c15…	UDP	260	443 → 64561 Len=198
486	09:43:09.319533	2607:f8b0:4006:80e…	2607:fb91:de9:5c15…	UDP	260	443 → 64561 Len=198
487	09:43:09.319815	2607:fb91:de9:5c15…	2607:f8b0:4006:80e…	UDP	96	64561 → 443 Len=34
488	09:43:13.513441	128.119.245.12	172.20.10.2	TCP	54	80 → 61484 [FIN, ACK] Seq=923 Ack=991 Win=31360 Len=0
489	09:43:13.513656	172.20.10.2	128.119.245.12	TCP	54	61484 → 80 [ACK] Seq=991 Ack=924 Win=262144 Len=0
490	09:43:14.042255	172.20.10.2	172.20.10.1	DNS	75	Standard query 0x6951 AAAA play.google.com
491	09:43:14.042362	172.20.10.2	172.20.10.1	DNS	75	Standard query 0x1247 A play.google.com

2. The HTTP GET message was sent at 09:43:08.233838, and the HTTP OK reply was received at 09:43:08.309372.
   It took 75,534 milliseconds.

470	09:43:08.233838	172.20.10.2	128.119.245.12	HTTP	576	GET /wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1
479	09:43:08.309372	128.119.245.12	172.20.10.2	HTTP	492	HTTP/1.1 200 OK (text/html)

3. The the Internet address of the gaia.cs.umass.edu website is 128.119.245.12 (this is the Destination Address).
   The Internet address of my computer is 172.20.10.2 (this is the Source Address).



4. The printed messages:

```
No.     Time               Source                Destination           Protocol Length Info
    470 09:43:08.233838    172.20.10.2           128.119.245.12        HTTP     576    GET /
wireshark-labs/INTRO-wireshark-file1.html HTTP/1.1
Frame 470: 576 bytes on wire (4608 bits), 576 bytes captured (4608 bits) on interface en0, id 0
Ethernet II, Src: Apple_8f:ec:b9 (cc:08:fa:8f:ec:b9), Dst: 96:16:25:d5:eb:64 (96:16:25:d5:eb:64)
Internet Protocol Version 4, Src: 172.20.10.2, Dst: 128.119.245.12
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
    Differentiated Services Field: 0x02 (DSCP: CS0, ECN: ECT(0))
    Total Length: 562
    Identification: 0x0000 (0)
    010. .... = Flags: 0x2, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0x0d2a [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 172.20.10.2
    Destination Address: 128.119.245.12
Transmission Control Protocol, Src Port: 61484, Dst Port: 80, Seq: 1, Ack: 1, Len: 522
Hypertext Transfer Protocol
No.     Time               Source                Destination           Protocol Length Info
    481 09:43:08.315606    172.20.10.2           128.119.245.12        HTTP     522    GET /
favicon.ico HTTP/1.1
Frame 481: 522 bytes on wire (4176 bits), 522 bytes captured (4176 bits) on interface en0, id 0
Ethernet II, Src: Apple_8f:ec:b9 (cc:08:fa:8f:ec:b9), Dst: 96:16:25:d5:eb:64 (96:16:25:d5:eb:64)
Internet Protocol Version 4, Src: 172.20.10.2, Dst: 128.119.245.12
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
    Differentiated Services Field: 0x02 (DSCP: CS0, ECN: ECT(0))
    Total Length: 508
    Identification: 0x0000 (0)
    010. .... = Flags: 0x2, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0x0d60 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 172.20.10.2
    Destination Address: 128.119.245.12
Transmission Control Protocol, Src Port: 61484, Dst Port: 80, Seq: 523, Ack: 439, Len: 468
Hypertext Transfer Protocol
```