

# Computer Networks CSCI 4211

## Homework 1 Solution

### 1. Short Questions and Answers: (24 points; 20 minutes)

(Two or three sentences would generally suffice.)

#### a. (4 points) Name one key advantage of packet switching.

Packet switching allows more efficient usage of network resources (e.g., bandwidth) for bursty data applications, by taking advantage of statistical multiplexing of resources.

#### b. (4 points) Using one or two sentences, define what is a protocol.

A protocol defines the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or reception of a message or other events.

#### c. (4 points) Using one or two sentences, describe what is transmission delay?

The transmission delay is the amount of time required to push (that is, transmit) all of the bits in a packet onto the link. This can be calculated by dividing the length of the packet ( $L$  bits) by the transmission rate ( $R$ ) of the link.

#### d. (4 points) Using one or two sentences, describe what is propagation delay?

The amount of time required for the bits to propagate down the link is propagation delay.

#### e. (4 points) Using a couple of sentences, discuss why we need both source and destination port numbers in transport layer protocols such as TCP or UDP.

Since there can be multiple processes using the network stack, port numbers are used along with IP addresses (which are used for differentiating machines) to distinguish different pairs of communicating processes on two machines.

f. (4 points) Name one or two major advantages of a layered network architecture.

Layering in network architecture increases the flexibility, maintainability and scalability of the system. It hides the underlying complexity from the upper layers and increases the level of abstraction. Also layering allows for decoupling of different components which is extremely beneficial.

## 2. Statistical Multiplexing: Circuit Switching vs. Packet Switching (26 points; 25 minutes)

Do Problem P8, Chapter 1 (page 71) in the textbook (the 7th edition).

In case you do not have the current version of the textbook, the problem is reproduced below for you.

Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in Section 1.3.)

(a) (8 points) When circuit switching is used, how many users can be supported?

Total Bandwidth available = 3Mbps = 3000Kbps

One user requirement = 150Kbps

So total users that can be supported =  $\frac{3000Kbps}{150Kbps} = 20$  Users

(b) (5 points) For the remainder of this problem, suppose that packet switching is used. Find the probability a given user is transmitting.

Probability = 0.1

(c) (8 points) Suppose there are 120 users. Find the probability that at any given time, exactly  $n$  users are transmitting simultaneously. (Hint: Think Binomial distribution – Instructor's Note: writing down a formula suffices!)

$$\text{Probability} = \binom{120}{n} p^n (1-p)^{120-n}$$

(d) (5 points) Find the probability that there are 21 or more users transmitting simultaneously.

$$\text{Probability} = 1 - \sum_{n=0}^{20} \binom{120}{n} p^n (1-p)^{120-n}$$

### 3. Network delay for circuit switching vs. packet switching (25 points; 20 minutes)

Minneapolis and New York are two end hosts on the Internet. Consider the following topology, link capacity and other specifications:

- New York, the destination host, is 5 hops away from Minneapolis, the source, i.e. there are 4 intermediate routers: Minneapolis – R1 – R2 – R3 – R4 – New York.
- The distance between any two adjacent nodes is 250 kilometers (km).
- The signal propagation speed is  $2.5 \times 10^5$  km per second.
- The message size is 2 Mbits ( $1\text{M} = 10^6$  )
- The maximum packet size is 100 Kbits ( $1\text{K} = 10^3$  ). The header size is negligible. Note for packet switching the message should be divided to packets, each of which cannot exceed the maximum packet size.
- The transmission speed of each link is 100Mbps.
- The circuit setup time is 0.5 second for the case of circuit switching.
- The processing time for routing & forwarding decision at each node can be ignored.

Please answer the following questions. (Note please make sure to illustrate your calculations clearly; you may receive partial credits even if your final answer is incorrect.)

(a) (10 points) The end to end delay in delivering the message using circuit switching.

The transmission delay is given by  $t_0 = \frac{2\text{Mbits}}{100\text{Mbps}} = 0.02$

The propagation delay is given by  $t_1 = \frac{5 \times 250\text{km}}{2.5 \times 10^8 \text{ m/s}} = .005\text{s}$ .

The circuit setup time is 0.5s

Hence the end to end delay is 0.525s.

(b) (10 points) The end to end delay in delivering the message using packet switching.

Since the message size is 2 Mbits and the maximum packet size is 100 Kbits there will be a total of 20 packets that need to be transmitted.

For the first packet the end to end delay will be propagation plus transmission delay (we are not considering queuing delay etc).

Total Time (first packet) =  $5 * \frac{L}{R} + 5 * \text{Prop Delay}$

$$= 5 * \frac{100 \text{ kbits}}{100 \text{ Mbps}} + 5 * \frac{250 \text{ kms}}{2.5 \times 10^8 \text{ m/s}}$$
$$= 0.005 \text{ s} + 0.005 \text{ s} = 0.01 \text{ s}$$

Transmission Delay ( for the 19 packets) =  $19 * \frac{L}{R}$

$$= 19 * \frac{100 \text{ kbits}}{100 \text{ Mbps}}$$
$$= 0.019 \text{ s}$$

$$\text{Total end to end delay} = 0.01 \text{ s} + 0.019 \text{ s}$$
$$= 0.029 \text{ s}$$

(c) (5 points) Will the delays calculated in parts (a) and (b) alter if Minneapolis was the destination and New York the source? Justify your answer.

If the source and destination are reversed there is no difference as the path and delays are symmetric.

#### 4. Name Resolution, DNS and DHT (10 points + 15 bonus points; 15 minutes)

a. (10 points) Do Problem P7, Chapter 2 (page 175) in the textbook (the 7th edition).

In case you do not have the current version of the textbook, the problem is reproduced below for you.

Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that  $n$  DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT (round-trip-time) of  $\text{RTT}_1, \dots, \text{RTT}_n$ . Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let  $\text{RTT}_0$  denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object how much time elapses from when the client clicks on the link until the client receives the object?

Initially your web browser will contact the DNS server and when it gets the IP address of the required URL, it will fetch the object from the IP address.

So time required to find IP address =  $RTT_1 + RTT_2 + \dots + RTT_n$

Time required for fetching object =  $RTT_0$

Time for TCP handshake =  $RTT_0$

$$\text{Total Time} = 2RTT_0 + \sum_{i=1}^n RTT_i$$

b. (Optional: 15 points) Briefly discuss the pros and cons of using dynamic hash table (DHT) techniques to implement the domain name system instead of the hierarchically distributed mechanism used in today's DNS.

Some of the benefits of using a dynamic hash table (DHT) are the following

- 1) Because of decentralization the reliability and redundancy of the system increase.
- 2) No single server will become a bottleneck or chokepoint because of the decentralization.
- 3) Since the authority is distributed, no single entity can cause the system to fail. Thus, taking the system down becomes immensely more difficult, as it becomes more robust.

Some disadvantages are the following:

- 1) Individual domains lose autonomy in managing their namespace.
- 2) Hierarchical semantics of name lookup are lost.
- 3) Since the authority is distributed among the various nodes, authorization and authentication of various operations becomes an issue.
- 4) Without good redundancy mechanisms, loss of a single server may mean loss of part of the namespace.

5. Wireshark Hands-on Practice: HTTP (15 points total; 15-20 minutes) (Approximate time excludes Wireshark setup time, learning the basics of how to use Wireshark, etc.)

1. Is your browser running HTTP version 1.0 or 1.1? What version of HTTP is the server running?

HTTP 1.1

2. What is the IP address of your computer and that of the web server?

My IP 10.155.6.2

Server IP 160.94.22.158

The IP of the server is always the same for everyone but the IP address of your computer will vary and it may be a private IP as well.

3. How many HTTP GET request messages were sent by your browser?

Two

(Here one GET request is for the html and the other is for the favicon icon. By default, most common web browsers (except SeaMonkey) issue a GET request for the icon but in some cases this may not hold so if you have only one GET request it is also correct.)

4. How many data-containing TCP segments were needed to carry this single HTTP response?

2 TCP segments

5. What is the status code and phrase associated with the response to the HTTP GET request?

Code 200 Response OK

The image shows a Wireshark packet capture of an HTTP transaction. The packet list at the top shows four packets:

No.	Time	Source	Destination	Protocol	Length	Info
2054	3.495369	10.155.6.2	160.94.22.158	HTTP	515	GET /classes/Fall-2017/csci4211/Assignments/HTTP-2.htm HTTP/1.1
2057	3.499708	160.94.22.158	10.155.6.2	HTTP	1145	HTTP/1.1 200 OK (text/html)
2060	4.445146	10.155.6.2	160.94.22.158	HTTP	494	GET /favicon.ico HTTP/1.1
2061	4.451359	160.94.22.158	10.155.6.2	HTTP	341	HTTP/1.1 200 OK

The packet details pane for packet 2057 shows the following structure:

- Frame 2057: 1145 bytes on wire (9160 bits), 1145 bytes captured (9160 bits) on interface 0
- Ethernet II, Src: Cisco\_92:61:40 (7c:ad:74:92:61:40), Dst: Apple\_8b:98:19 (70:56:81:8b:98:19)
- Internet Protocol Version 4, Src: 160.94.22.158, Dst: 10.155.6.2
- Transmission Control Protocol, Src Port: 80, Dst Port: 52831, Seq: 1375, Ack: 450, Len: 1079
- 2 Reassembled TCP Segments (2453 bytes): #2056(1374), #2057(1079)
- Hypertext Transfer Protocol
- Line-based text data: text/html

The packet bytes pane shows the raw data of the response, which is a 200 OK status code followed by the HTML content.

## 6. TCP Connection Management (14 points total. Approx. 20 minutes)

The following figure shows the control messages sent among the client and the server under normal operations using the three-way handshake protocol. (Note: in SYNACK(y,x) and ACK(x,y), the first number is the sequence number of the message, the second number is the acknowledgment number, i.e., the sequence number of the message being acknowledged.)

a. (7 points) Consider the following scenario (see Figure 3) where the SYNACK(y,x) message sent by the server is lost during the transmission. What will happen at either the client or the server side?

Client Side: The client will be waiting for the SYNACK(y,x) message but since it was lost there will be a timeout and the the client will try again to do the three way handshake.

Server Side:

Since the client will not receive the SYNACK(y,x) message there will be no response from it and the server will timeout terminate the connection.

b. (7 points) Suppose that by now the connection in a. (where the client used the initial sequence no. x, and the server used the initial sequence no. y) has been closed. An old, duplicate message SYNACK(y,x) now pops up at the client side (see Figure 4). First, can this scenario happen at all? Second, in response to this SYNACK(y,x) message, what will the client do? Briefly explain your answers to both questions.

Yes this scenario can happen, suppose the client sent the server SYN(x) and the server responded with SYNACK(y,x) but the packet got delayed such that the client timed out and sent another SYN(x) packet to the server and after the data was exchanged the client terminated the connection but now the original SYNACK(y,x) packet has arrived.

Since the client has terminated the connection it will simply ignore the packet and not send anything to the server which will not notice anything.