ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION **SUMMER SEMESTER, 2023-2024**

DURATION: 1 HOUR 30 MINUTES **FULL MARKS: 75**

CSE 4411: Data Communication and Networking

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 3 (three)** questions. Figures in the right margin indicate full marks of questions with corresponding COs and POs in parentheses.

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1. a) Suppose users share a 5 Mbps link. Each user requires 1 Mbps when transmitting but is idle 40 percent of the time. For the link, if the congestion is below 20%, it is considered working good enough. Given the scenario, when circuit switching is used, how many users can be supported? Also, when packet switching is used, how many users can be supported? Show full calculations. Assume that each users active/idle periods are independent of the others. 7 (CO1) (PO1)

Given,
$X \equiv$ Number of devices that are active at the same time
$P(X = k) = {}^{n}C_{k}(p)^{k}(1-p)^{n-k}$

Solution:

Circuit Switching

Since the total link capacity is 5 Mbps, the maximum number of users N_{circuit} that can be supported is

$$N_{\text{circuit}} = \left\lfloor \frac{5 \text{ Mbps}}{1 \text{ Mbps/user}} \right\rfloor = 5.$$

Hence, *with circuit switching*, we can support exactly $\boxed{5}$ users.

Packet Switching

In packet switching, each user sends packets when active at 1 Mbps, but is idle 40% of the time (active 60% of the time). We assume users become active independently.

Congestion Probability

The probability of congestion is

$$P(\text{congestion}) = P(X > 5) = 1 - P(X \leq 5) = 1 - \sum_{k=0}^{5} \binom{N}{k} (0.6)^{k} (0.4)^{N-k}.$$

We require

$$P(X > 5) < 0.20.$$

Equivalently,

$$\sum_{k=0}^{5} \binom{N}{k} (0.6)^{k} (0.4)^{N-k} > 0.80.$$

Numerical Evaluation

We check successive integer values of N until the congestion probability exceeds 20%. Below is a small table showing $P(X > 5)$ for $N = 5, 6, 7, 8$. (Can compute these binomial sums with a calculator)

Interpretation:

- $N = 5$: $P(X > 5) = 0$.
- $N = 6$: $P(X > 5) \approx 0.0467 < 0.20$.

- $N = 7$: $P(X > 5) \approx 0.1586 < 0.20$.
- $N = 8$: $P(X > 5) \approx 0.3154 > 0.20$.

Thus, the *largest* integer N satisfying $P(X > 5) < 0.20$ is

$$N = 7.$$

Rubric:

- 1 point for correct circuit switching answer
- 5 points for the correct congestion probability equation
- 1 point for correct numerical answer

b) Figure 1 presents a topology with some IP addresses and network addresses added at respective places. Based on the topology, answer the following questions: 5 + 3 + 2 (CO1) (PO1)

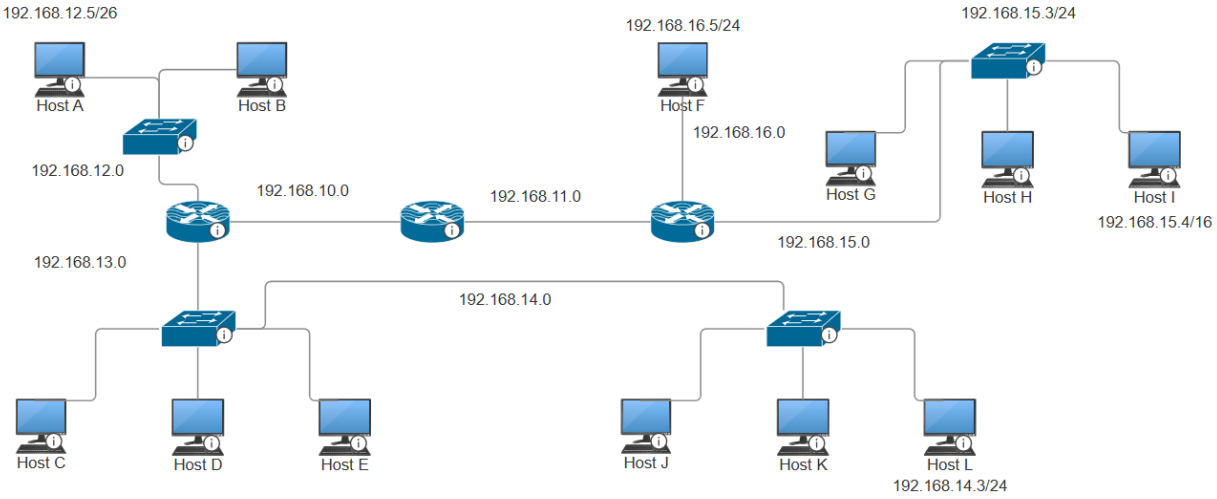


Figure 1: Topology for Question 1.b

i. Are all the IP addresses and network addresses assigned correctly? If not, correct the error(s). You don't need to draw the diagram

Solution:

- Host A IP - 192.168.12.5/24
- Switch shouldn't have any IP
- There shouldn't be any network between two switches
- Host I IP - 192.168.15.4/24
- Host L IP should be in the network 192.168.13.0

  Rubric:

  - 1 point for each correction

ii. What is the number of total networks present in the corrected topology?

Solution:

Six

Rubric:

- 3 points for correct answer

iii. If Host A sends data to Host I, how many times will routing happen?

Solution:

Three, one at each router

Rubric:

- 2 points for correct answer

c) Consider a router that interconnects three subnets: Subnet 1, Subnet 2, and Subnet 3. Suppose all of the interfaces in each of these three subnets are required to have the prefix 223.1.17 with subnet mask 24. Also suppose that Subnet 1 is required to support at least 60 interfaces, Subnet 2 is to support at least 90 interfaces, and Subnet 3 is to support at least 12 interfaces. Provide three network addresses (of the form a.b.c.d/x) that satisfy these constraints. 6 (CO3) (PO2)

Solution:

subnet 1 - 223.1.17.128/26
subnet 2 - 223.1.17.0/25
subnet 3 - 223.1.17.192/28

Rubric:

- 2 points for each correct network address

2. a) Consider the string of ASCII characters given in Code Snippet 1 that were captured by Wireshark when the browser sent an HTTP GET message (i.e., this is the actual content of an HTTP GET message). The characters <cr><lf> are carriage return and line-feed characters. $2 \times 3 + 7$ (CO2) (PO2)

```
1 GET /cs453/index.html HTTP/1.1<cr><lf>Host: gaia.cs.umass.edu<cr><lf>
2 User-Agent: Mozilla/5.0 (Windows;U; Windows NT 5.1; en-US; rv:1.7.2)
     Gecko/20040804 Netscape/7.2 (ax) <cr><lf>
3 Accept:ext/xml, application/xml, application/xhtml+xml,text/html;q
     =0.9,text/plain;q=0.8,image/png,*/*;q=0.5<cr><lf>
4 Accept-Language: en-us,en;q=0.5<cr><lf>
5 Accept-Encoding: zip,deflate<cr><lf>Accept-Charset: ISO-8859-1,utf-8;
     q=0.7,*;q=0.7<cr><lf>
6 Keep-Alive: 300<cr><lf>
7 Connection:keep-alive<cr><lf>
8 <cr><lf>
```

Code Snippet 1: HTTP GET message for 2.a

The Code Snippet 2 shows the reply sent from the server in response to the HTTP GET message in Code Snippet 1.

```
1 HTTP/1.1 200 OK<cr><lf>Date: Tue, 07 Mar 2008 12:39:45 GMT<cr><lf>
2 Server: Apache/2.0.52 (Fedora)<cr><lf>
3 Last-Modified: Sat, 10 Dec 2005 18:27:46 GMT<cr><lf>
```

```
Etag: "526c3-f22-a88a4c80"<cr><lf>
Accept-Ranges: bytes<cr><lf>
Content-Length:3874<cr><lf>
Keep-Alive: timeout=max=100<cr><lf>
Connection: Keep-Alive<cr><lf>
Content-Type: text/html; charset=ISO-8859-1<cr><lf><cr><lf>
<!doctype html public "-//w3c//dtd html 4.0 transitional//en"><lf><
   html><lf><head><lf>
<meta http-equiv="Content-Type" content="text/html; charset=iso
   -8859-1"><lf>
<meta name="GENERATOR" content="Mozilla/4.79 [en] (Windows NT 5.0; U)
    Netscape"><lf>
<title>CMPSCI 453 / 591 / NTU-ST550A Spring 2005 homepage</title><lf>
   </head><lf><html><lf>
<much more document text following here (not shown)
```

Code Snippet 2: HTTP RESPONSE message for 2.a

Answer the following questions based on the above text-boxes

i. Why is the browser type needed in an HTTP request message?

Solution:

The browser type is needed in an HTTP request message because the server may have to send a different types of the same object to different browsers

Rubric

- 2 point for the correct answer.

ii. What are the first 5 bytes of the document being returned?

Solution:

The first five bytes of the returned document are : <!doc

Rubric

- 2 point for the correct answer.

iii. Write the content of the body section of the given http request message.

Solution:

No body section for HTTP GET message

Rubric

- 2 point for the correct answer.

iv. We want to extend the standard HTTP protocol so that a client can send multiple resource requests in a single message. In this new variant called HTTP/1.49 the client uses a custom method named BATCH, and the request body is a JSON (application/json) array of resource paths. The server must process all of these paths and respond with a JSON-formatted result.

Now, let's take an example of a JSON request array -

```
[ "/users/123/profile",
"/posts?sort=newest&limit=10",
"/static/images/logo.png" ]
```

Using the example JSON array above, write out the full, raw HTTP request message exactly as it would appear on the wire. You may use arbitrary but plausible values for headers, just ensure the final request is logically consistent. You can also use /r and /n instead of <cr> and <lf> respectively.

Solution:

```
BATCH / HTTP/1.49\r\n
Host: api.example.com\r\n
User-Agent: xHTTP-Client/1.0\r\n
Accept: application/json\r\n
Content-Type: application/json\r\n
Content-Length:  eighty-nine\r\n
Connection: keep-alive\r\n
\r\n
[
  "/users/123/profile",
  "/posts?sort=newest&limit=10",
  "/static/images/logo.png"
]\r\n
```

Code Snippet 3: Solution

Rubric

- 1 point for correct method name
- 1 point for correct version name
- 1 point for correct accept field value
- 1 point for correct content-type
- 3 points for correct body field value

b) You have developed a website with the domain name - www.alliutians.com, which is a social media platform for only iutians. Now, to get monetory values from the website you have introduced ads from www.adx.com. To give each users unique and better browsing experience you give them ads which align with their browsing behavior. For the simplicity of the question, suppose ads from adx are used by many websites as well. 8 + 4 (CO2) (PO2)

i. With a diagram, explain how you can be successful in showing targeted ads. You can assume any random website the user visits is monetized by adx

Solution:

Similar to the diagram in the slides with given domain names

Rubric

- 4 for correct diagram
- 4 point for correct explanation

ii. To make your domain name work for everyone, you need to register your domain name by going to a DNS registrar. Suppose the IP address of your web server is 212.212.212.252, and the IP address of your authoritative server (dns.allditians.com) is 212.212.212.1. What will be the TLD server in this case, and what will be the entry in the TLD server to achieve the domain name resolution?

Solution:

In this scenario, the domain is alliutians.com, so the TLD server involved in the delegation will be one of the .com TLD nameservers.
There will be two new entries in the .com TLD zone. The entries would be:

1. alliutians.com IN NS dns.alliutians.com - Tells any resolver that for anything under alliutians.com, ask dns.alliutians.com.
2. dns.alliutians.com. IN A 212.212.212.1 - This is the glue record, so that when the .com server delegates to dns.alliutians.com, recursive resolvers immediately know its IP (212.212.212.1) rather than having to look it up in turn

Rubric:

- 1 point for correct TLD server name
- 1.5 points for each correct entry

3. a) UDP and TCP use 1s complement for their checksums. Suppose you have the following three 8-bit bytes: 01010011, 01100110, 01110100 — 5 + 5 (CO2) (PO2)

i. With the 1s complement scheme, how does the receiver detect errors? Explain with the given example

Solution:

First, let us compute the 1scomplement checksum over the three 8bit bytes:
We add them in 1scomplement (endaroundcarry) fashion, treating each as an 8bit word:

(1) Add $\text{Byte}_1 + \text{Byte}_2$:

$$01010011_2 \,(+)\, 01100110_2 \;=\; 10111001_2$$

(2) Now add that result to Byte_3:

$$10111001_2 \,(+)\, 01110100_2 \;=\; 00101110_2$$

Hence the 1scomplement sum of the three data bytes is

$$S = 00101110_2$$

The transmitter now forms the checksum by taking the bitwise (1scomplement) inversion of S:

$$\text{Checksum} \;=\; \overline{00101110_2} \;=\; 11010001_2$$

Therefore, the packet on the wire consists of

$$01010011, \quad 01100110, \quad 01110100, \quad 11010001.$$

The receiver recomputes the 1scomplement sum over all four 8bit words (the three data bytes plus the checksum) and checks whether the result is all 1s (i.e. 11111111_2). If it is, no error is detected; otherwise, an error is flagged. We already computed (in

the transmitter) that

$$D_1 + D_2 + D_3 \;=\; 00101110_2 \quad \text{(after endaroundcarry).}$$

Now the receiver adds that partial sum to the received checksum:

$$00101110_2 \;+\; 11010001_2 \;=\; 11111111_2 \text{ (all 1s, no further carry).}$$

Because the final 8bit result is 11111111_2, the receiver concludes no error detected. If any singlebit flips (or many multibit flips) had occurred in the data or checksum, the 1scomplement sum would generally not be all 1s, and the receiver would detect an inconsistency.

Rubric:

- 3 points for the correct checksum value
- 2 points for correct explanation of the process

ii. Is it possible that a 1-bit error will go undetected? How about a 2-bit error? Justify your answer with an appropriate example.

Solution:

No 1-bit error will go undetected, because if a 1-bit error is there, the sum can never be the same. But in case of 2-bit error, the sum can be the same - by modifying one 0 bit to 1, and another 1 bit to 0 in the appropriate position, the sum can be the same

Rubric:

- 1 point each for correct answer (Yes or No)
- 1 point each for correct justification
- 1 point for correct 2-bit error example

b) Host A and B are communicating over a TCP connection, and Host B has already received from A all bytes up through byte 126. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 80 and 40 bytes of data, respectively. In the first segment, the sequence number is 127, the source port number is 302, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A. $2 \times 3 + 4$ (CO2) (PO2)

i. In the second segment sent from Host A to B, what are the sequence number, source port number, and destination port number?

Solution:

The sequence number is 207, source port number is 302 and destination port number is 80.

Rubric:

- 1 point for correct sequence number
- .5 point each for correct port numbers

ii. If the first segment arrives before the second segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number, the source port number, and the destination port number?

Solution:

The acknowledgement number is 207, the source port number is 80 and the destination port number is 302.

Rubric:

- 1 point for correct acknowledgment number
- .5 point each for correct port numbers

iii. If the second segment arrives before the first segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number?

Solution:

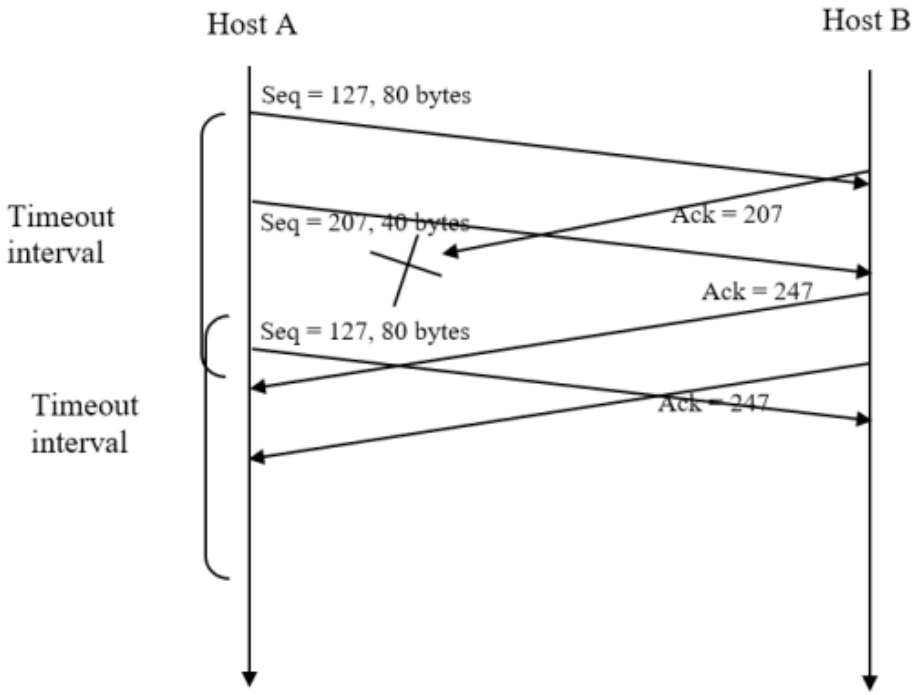
The acknowledgement number is 127, indicating that it is still waiting for bytes 127 and onwards.

Rubric:

- 2 points for correct acknowledgment number

iv. Suppose the two segments sent by A arrive in order at B. The first acknowledgment is lost and the second acknowledgment arrives after the first time-out interval. Draw a timing diagram, showing these segments and all other segments and acknowledgments sent. (Assume there is no additional packet loss.) For each segment in your figure, provide the sequence number and the number of bytes of data; for each acknowledgment that you add, provide the acknowledgment number.

Solution:



Rubric:

- .5 points for each correct portion of the diagram

c) What are the reasons for handshaking in TCP, and why do we use a three-way handshake instead of a two-way handshake? Justify your answer. 7 (CO2) (PO2)

Solution:

Purpose of the TCP Handshake Before any application data flows, TCP uses a handshake to:

- **Synchronize Sequence Numbers.** Each side chooses an initial sequence number (ISN). Exchanging SYN segments carrying these ISNs lets both peers agree where to start counting bytes.
- **Negotiate Connection Parameters.** Options such as Maximum Segment Size (MSS), window scaling, and selective acknowledgments are advertised during the handshake.
- **Prevent Old/Duplicate Connections.** Fresh, randomized ISNs and explicit acknowledgments ensure that delayed packets from a previous session cannot be misinterpreted as part of a new one.
- **Establish Bidirectional Reliability.** TCP is full duplex: both clientserver and serverclient paths must be verified before data transfer begins.

Why Not a TwoWay Handshake?
A simple two step handshake cannot guarantee:

- **Mutual Confirmation.** The client never knows if the server actually saw its SYN before data flow begins.
- **Sequence Number Acknowledgment.** One sides initial sequence number remains unacknowledged, risking misordering or overlap.
- **HalfOpen Resilience.** If the server crashes right after replying, the client proceeds under the false assumption that the connection is established.
- **Spoofing Protection.** Without a final ACK, an offpath attacker needs to guess only one sequence number to inject traffic.

Rubric:

- 3 points for correct handshaking reason
- 4 points for justifying 3-way handshake