CPSC 441
COMPUTER NETWORKS

MIDTERM EXAM SOLUTION

Department of Computer Science
University of Calgary
Professor: Carey Williamson

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This is a CLOSED BOOK exam. Textbooks, notes, laptops, personal digital assistants, tablets, and cellular phones are NOT allowed. However, **calculators are permitted**.

It is a 50 minute exam, with a total of 50 marks. There are 13 questions, and 8 pages (including this cover page). Please read each question carefully, and write your answers legibly in the space provided. You may do the questions in any order you wish, but please USE YOUR TIME WISELY.

When you are finished, please hand in your exam paper and sign out. Good luck!

Student Name: ____________________

Score: ________ / 50 = ______ %

—————————— Optional Privacy Fold Here ——————————-

Student ID: ____________________

Multiple Choice

Choose the best answer for each of the following 8 questions, for a total of 8 marks.

1 1. The “telnet” application on the early Internet was used for:

(a) remote login

(b) file transfer

(c) electronic mail

(d) network news

(e) time synchronization

1 2. In the early days of the Internet, home Internet access was provided by:

(a) dial-up modem over twisted-pair telephone lines

(b) cable modems over coaxial cables

(c) IEEE 802.11 wireless networks (WiFi)

(d) Fiber To The Home (FTTH)

(e) all of the above

1 3. BitTorrent is an example of a network application that uses:

(a) the client-server paradigm and TCP

(b) the client-server paradigm and UDP

(c) the peer-to-peer paradigm and TCP

(d) the peer-to-peer paradigm and UDP

(e) none of the above

1 4. Which of the following is NOT a valid resource record type in DNS?

(a) A

(b) AA

(c) AAAA

(d) NS

(e) MX

1 5. In a UDP-based server, some typical system calls used are:

(a) `send()` and `recv()` (in that order)

(b) `recv()` and `send()` (in that order)

(c) `sendto()` and `recvfrom()` (in that order)

(d) `recvfrom()` and `sendto()` (in that order)

(e) `bind()` and `connect()` (in that order)

1 6. In TCP, acknowledgements (ACKs) are used for:

(a) error control

(b) flow control

(c) congestion control

(d) all of the above

(e) none of the above

1 7. In the "Congestion Avoidance" (CA) phase of TCP congestion control, the congestion window size `cwnd`:

(a) increases multiplicatively

(b) increases linearly

(c) remains constant

(d) decreases linearly

(e) decreases multiplicatively

1 8. One of the novel features of TCP Vegas is:

(a) loss-based congestion control

(b) delay-based congestion control

(c) hybrid congestion control (delay and/or loss)

(d) congestion-based congestion control

(e) none of the above

Internet Protocol Stack

8 9. In class, we discussed the 5-layer Internet protocol stack. Use your knowledge of the Internet protocol stack to answer the following questions:

(a) (4 marks) What is *encapsulation*? Explain it by describing the basic steps involved at each layer of the protocol stack.

```
- happens at originating end system (host)
- traverses DOWN the protocol stack, adding a new header of
control information at each layer (AL message --> TL segment
 --> NL datagram --> DL frame --> PL bits)
- physical layer transmits bits onto the transmission medium
```

(b) (4 marks) What is *decapsulation*? Explain it by describing the basic steps involved at each layer of the protocol stack.

```
- happens at destination end system (host)
- physical layer bits arrive from the transmission medium
- traverses UP the protocol stack, checking and removing
header information at each layer (PL-->DL-->NL-->TL-->AL)
```

Networking Delays

5 10. Suppose that a point-to-point link exists between a router at the University of Calgary and a router at the University of Alberta in Edmonton, which is 320 kilometers away.

(a) (2 marks) Assuming that signals propagate at approximately 2 x 10^8 meters per second, what is the propagation delay for a single bit to travel from Calgary to Edmonton? Recall that propagation delay $t_{prop} = \frac{distance}{speed}$. Show your work.

```
         320 x 10**3 m
tprop = --------------- = 1.6 x 10**-3 s = 0.0016 seconds
         2 x 10**8 m/s
```

(b) (3 marks) Assuming that the link transmission rate R is 1 Gbps (1x10^9 bits per second), how many 1000-byte packets would be needed to completely fill the link in one direction from Calgary to Edmonton? Recall that $t_{trans} = \frac{L}{R}$, where L is the packet size (in bits). Show your work.

```
          1000 B * 8 bits/B
ttrans = ------------------- = 8 x 10**-6 s = 0.000008 seconds
            1 x 10**9 b/s

        1.6 x 10**-3 sec
ans = ------------------- = 200 packets
         8 x 10**-6 sec
```

Networking Concepts and Definitions

9 11. For each of the following pairs of technical terms, **define** each term, and **clarify** the key difference(s) between the two terms. Be clear and concise. If in doubt about your definition, feel free to supplement with a relevant example.

(a) (3 marks) "hosts" and "switches"

```
- hosts are end systems at the edge of the Internet that run
network applications and implement the FULL Internet protocol stack
- switches are intermediate devices within the network core
that do store-and-forward processing of network packets (datagrams)
- switches implement only a partial protocol stack (PL/DL/NL)
```

(b) (3 marks) "persistent HTTP connection" and "non-persistent HTTP connection"

```
- non-persistent: a type of HTTP interaction that is transaction-oriented,
  obtaining only a single Web object over a TCP connection (e.g., HTTP/1.0)
- persistent: a type of HTTP interaction that is session-oriented,
obtaining multiple Web objects over the same TCP connection (e.g., HTTP/1.1)
- persistent is faster and has much less overhead (if same Web server)
```

(c) (3 marks) "flow control" and "congestion control"

```
- flow: speed matching between a single sender and single receiver,
so that sender does not transmit more data than RECEIVER can handle
- congestion: a network-wide control problem with many senders and
receivers; do not transmit more data than the NETWORK can handle
```

Reliable Data Transfer (RDT)

10 12. In class, we discussed several different RDT protocols, namely:

- USP: Unrestricted Simplex Protocol
- SAW: Stop and Wait
- PNA: Positive/Negative Acknowledgement
- PAR: Positive Ack with Retransmission
- OBSWP: One-Bit Sliding Window Protocol

(a) (2 marks) Which of these protocols would be the most appropriate for a perfect Network Layer (NL) that never delays, loses, or corrupts packets? Why?

```
USP: simplest and fastest, with least overhead, since there is
no need for data integrity checking, ACKs, timers, or retransmission
```

(b) (2 marks) Which of these protocols introduced "flow control" to do speed matching between the sender and the receiver? How was this feature provided?

```
SAW: ACKs were used to give permission for the next packet once the
previous one was received and delivered; at most 1 segment at a time
```

(c) (2 marks) Which of these protocols would be the most appropriate for a NL that can corrupt DATA packets and/or ACK packets? What additional mechanisms and/or state variables are required in this protocol?

```
PAR: need checksums, sequence numbers, timers, and retransmission
(PNA cannot handle corrupted ACKs or NAKs, so we need PAR for this)
```

(d) (2 marks) Which (if any) of these protocols supported full-duplex data transfer? What additional state variables were required for this?

```
OBSWP: need separate sequence numbers and expected sequence numbers
for each direction, plus timers at each end for sent data segments
```

(e) (2 marks) Despite having two possible sequence numbers (i.e., '0' and '1'), OBSWP allows *at most* one DATA segment in transit from Fred to George at any time. Why? What could possibly go wrong in this protocol if Fred was allowed to send both segments '0' and '1' in a pipelined fashion?

```
- the loss of certain ACKs could break this RDT protocol
- for example, if both segments 0 and 1 were sent, and both ACKs
were lost, then the retransmissions of 0 and 1 would be falsely
interpreted as new data with valid sequence numbers, resulting
in duplicate data delivery, and breaking the reliability of OBSWP
```

Transmission Control Protocol (TCP)

10 13. The attached page contains a Wireshark-like trace showing the network packets exchanged between two transport-level endpoints during a Web page download. Use your knowledge of TCP to answer as many of the following questions as you can.

(a) (1 mark) What is the IP address of the client that initiated the HTTP request?

`136.159.5.41`

(b) (1 mark) What source port number did the client use for this TCP connection?

`1048`

(c) (1 mark) What is the Initial Sequence Number (ISN) proposed by the client?

`135530`

(d) (1 mark) What is the ISN that the server used for this TCP connection?

`769762`

(e) (1 mark) What is the receive socket buffer size used by the client?

`32768`

(f) (1 mark) What is the Maximum Segment Size (MSS) used by the server?

`1460`

(g) (1 mark) Does the client use delayed-ACKs? (Yes or No)

`Yes`

(h) (1 mark) Who closed their end of the connection first: the client, or the server?

`Server`

(i) (1 mark) What was the total number of TCP data bytes sent by the server?

`10,645`

(j) (1 mark) How long did it take for this Web page download to complete?

`0.222 seconds`

*** THE END ***

Time	SrcIP	DestIP	Size	Port	Port	SeqNum	AckNum	Rwin	Flags
1632.186	136.159.5.41	306.16.30.95	44	1048	80	135530	0	32768	S
1632.189	306.16.30.95	136.159.5.41	44	80	1048	769762	135531	24820	SA
1632.190	136.159.5.41	306.16.30.95	40	1048	80	135531	769763	32768	A
1632.330	136.159.5.41	306.16.30.95	412	1048	80	135531	769763	32768	PA
1632.333	306.16.30.95	136.159.5.41	40	80	1048	769763	135903	24820	A
1632.335	306.16.30.95	136.159.5.41	330	80	1048	769763	135903	24820	PA
1632.340	306.16.30.95	136.159.5.41	1500	80	1048	770053	135903	24820	A
1632.342	306.16.30.95	136.159.5.41	1500	80	1048	771513	135903	24820	PA
1632.343	136.159.5.41	306.16.30.95	40	1048	80	135903	771513	31018	A
1632.350	306.16.30.95	136.159.5.41	1500	80	1048	772973	135903	24820	A
1632.353	306.16.30.95	136.159.5.41	1500	80	1048	774433	135903	24820	A
1632.353	136.159.5.41	306.16.30.95	40	1048	80	135903	774433	28098	A
1632.355	306.16.30.95	136.159.5.41	1500	80	1048	775893	135903	24820	A
1632.357	136.159.5.41	306.16.30.95	40	1048	80	135903	777353	25178	A
1632.359	306.16.30.95	136.159.5.41	932	80	1048	777353	135903	24820	A
1632.362	306.16.30.95	136.159.5.41	1500	80	1048	778245	135903	24820	A
1632.363	306.16.30.95	136.159.5.41	742	80	1048	779705	135903	24820	FPA
1632.364	136.159.5.41	306.16.30.95	40	1048	80	135903	779705	22826	A
1632.365	136.159.5.41	306.16.30.95	40	1048	80	135903	780408	22124	A
1632.381	136.159.5.41	306.16.30.95	40	1048	80	135903	780408	22124	A
1632.404	136.159.5.41	306.16.30.95	40	1048	80	135903	780408	27244	A
1632.408	136.159.5.41	306.16.30.95	40	1048	80	135903	780408	31340	FA