

CPSC 441
COMPUTER NETWORKS
MIDTERM EXAM

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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 = _____ %

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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.

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

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 2×10^8 meters per second, what is the propagation delay for a single bit to travel from Calgary to Edmonton? Recall that propagation delay $t_{prop} = \frac{\text{distance}}{\text{speed}}$. Show your work.

 - (b) (3 marks) Assuming that the link transmission rate R is 1 Gbps (1×10^9 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.

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”

(b) (3 marks) “persistent HTTP connection” and “non-persistent HTTP connection”

(c) (3 marks) “flow control” and “congestion control”

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

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?

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

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

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

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

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

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

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

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

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

*** 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 |