

CPSC 441  
COMPUTER COMMUNICATIONS  
MIDTERM EXAM SOLUTION

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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 12 questions, and 7 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!

----- Fold here for privacy (optional) -----

Student Name: \_\_\_\_\_

Student ID: \_\_\_\_\_

Score: \_\_\_\_\_ / 50 = \_\_\_\_\_ %

## Multiple Choice

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

- 1 1. Negative ACKnowledgements (NAKs) are not needed in a Reliable Data Transfer (RDT) protocol if:
  - (a) sequence numbers are being used
  - (b) timeouts and retransmissions are being used**
  - (c) checksums are being used
  - (d) wireless is being used
  - (e) tennis balls are being used
  
- 1 2. The primary difference between UDP and TCP is:
  - (a) TCP is a reliable byte stream protocol, while UDP is not
  - (b) TCP is connection-oriented, while UDP is connection-less
  - (c) TCP uses sequence numbers, while UDP does not
  - (d) TCP enforces flow control, while UDP has no flow control
  - (e) all of the above**
  
- 1 3. The first version of TCP with “Slow Start” and “Congestion Avoidance” was:
  - (a) TCP Tahoe**
  - (b) TCP Reno
  - (c) TCP NewReno
  - (d) TCP Vegas
  - (e) TCP SACK
  
- 1 4. In TCP NewReno, the acknowledgements serve as:
  - (a) an error control mechanism
  - (b) a flow control mechanism
  - (c) a congestion control mechanism
  - (d) all of the above**
  - (e) none of the above

- 1 5. In a virtual circuit network, routing decisions are made:
- (a) once per packet
  - (b) once per call**
  - (c) once per hour
  - (d) once per day
  - (e) once per congestion episode (i.e., packet loss event)
- 1 6. In a datagram network, packet reordering is handled:
- (a) at the ingress router
  - (b) at the egress router
  - (c) with clever buffer management in routers
  - (d) at the end systems**
  - (e) none of the above
- 1 7. The Internet Protocol (IPv4) is an example of a:
- (a) connection-less network layer protocol**
  - (b) connection-oriented network layer protocol
  - (c) connection-less transport layer protocol
  - (d) connection-oriented transport layer protocol
  - (e) none of the above
- 1 8. Version 6 of the Internet Protocol (IPv6) improves upon IPv4 by:
- (a) expanding the IP address space
  - (b) providing better support for mobility
  - (c) providing better support for Quality of Service
  - (d) all of the above**
  - (e) none of the above

## Networking Concepts and Definitions

12 9. For each of the following pairs of terms, **define** each term, and **clarify** the key difference(s) between the two terms. Be clear and concise.

(a) (4 marks) “flow control” and “congestion control”

Flow control: speed matching between a single sender and a single receiver. Needed in transport-layer protocol. Typically done with sliding window.

Congestion control: network-wide control problem, involving multiple senders and multiple receivers. Typically at network layer. Manages core network to prevent saturation of resources, with excessive delay or loss of packets.

(b) (4 marks) “go-back-N” and “selective repeat”

These are both loss recovery mechanisms for pipelined RDT protocols.

Go-Back-N: When loss occurs, retransmit all outstanding unACKed segments. Simple. Uses cumulative ACKs. No buffering needed for out of order segments. Inefficient, in that it may retransmit many segments unnecessarily.

Selective Repeat: Efficient, but more complicated. Retransmits only missing segments. Needs to buffer out of order segs. Needs individual ACKs/timers.

(c) (4 marks) “Transport Level Endpoint (TLE)” and “TCP Control Block (TCB)”

TLE: generic transport-level concept. Identifies endpoint for end-to-end (process to process) communication. Involves host and port number. Used in multiplexing and demultiplexing pkts within a host.

TCB: specific TCP concept. Connection state record that stores TCP state information (e.g., TLE info, sequence number, ack number, window size, cwnd, ssthresh, RTT, RT0, negotiated options, etc).

## Reliable Data Transfer Protocols

10 10. In the RDT protocols discussed in class, we progressively relaxed several assumptions about our (initially perfect) network layer (NL), and added more and more functionality in the RDT protocol to make it work properly.

- (a) (5 marks) Give ONE example of a type of NL error that broke one of our elementary protocols. What was the problem that arose? What was the solution to this type of error? How did it work? What state information was involved? Where did the state information reside, and why?

Example 1: Receiver not always ready to receive, and might miss segments.

Solution: flow control (e.g., Stop and Wait).

Explicit ACKs to indicate successful delivery, and grant permission for more data to be sent. State is carried in ACK segments (control info), via NL, to update the Finite State Machine (FSM) at the sending endpoint.

- (b) (5 marks) Give ONE MORE example, distinct from the one above, of a type of NL error that broke one of our simple protocols. What was the problem that arose? What was the solution to this type of error? How did it work? What state information was involved? Where did the state information reside, and why?

Example 2: Network corrupts data segments, but not ACKs.

Solution: checksum calculated on segment, and carried in header.

Protects the receiver from delivering bogus data.

Uses ACKs and NAKs to disambiguate successful delivery or not.

State info is carried in the header, and updates FSMs at endpoints.

## Transmission Control Protocol (TCP)

10 11. The output on the next page shows a tcpdump trace (similar to WireShark) of the network packets exchanged between two computers on a network. Use your knowledge of TCP and IP to answer the following ten questions.

- (a) (1 mark) What application-layer protocol is (likely) being used for this conversation?

HTTP/1.0 (TCP on port 80)

- (b) (1 mark) What is the IP address of the client?

192.168.1.9

- (c) (1 mark) What is the Round-Trip Time (RTT) between the client and the server?

0.002 seconds

- (d) (1 mark) How much application-layer payload is in the client's first data packet?  
 378 bytes (133606 - 133228)
- (e) (1 mark) What is the TCP Initial Sequence Number (ISN) proposed by the server?  
 3310607972
- (f) (1 mark) What is the Maximum Transmission Unit (MTU) size on this network?  
 1500 bytes
- (g) (1 mark) What is the Maximum Segment Size (MSS) used by the server's TCP?  
 1460 bytes (3310609722 - 3310608262)
- (h) (1 mark) In total, how many bytes of application-layer data does the server send?  
 6519 bytes (3310614492 - 3310607973)
- (i) (1 mark) Which end initiates the closing of this TCP connection: client or server?  
 server
- (j) (1 mark) In total, how long did this conversation last?  
 0.257 seconds (30.141 - 29.884)

Time(s)	SourceIP	DestinationIP	Size	TCP	SPort	DPort	SeqNum	AckNum	Window	Flags
29.884	192.168.1.9	136.159.5.17	44	TCP	1035	80	133227	0	win: 32768	S
29.886	136.159.5.17	192.168.1.9	44	TCP	80	1035	3310607972	133228	win: 24820	SA
29.888	192.168.1.9	136.159.5.17	40	TCP	1035	80	133228	3310607973	win: 32768	A
29.948	192.168.1.9	136.159.5.17	418	TCP	1035	80	133228	3310607973	win: 32768	PA
29.952	136.159.5.17	192.168.1.9	40	TCP	80	1035	3310607973	133606	win: 24820	A
29.955	136.159.5.17	192.168.1.9	329	TCP	80	1035	3310607973	133606	win: 24820	PA
29.959	136.159.5.17	192.168.1.9	1500	TCP	80	1035	3310608262	133606	win: 24820	A
29.960	136.159.5.17	192.168.1.9	1500	TCP	80	1035	3310609722	133606	win: 24820	PA
29.962	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310609722	win: 31019	A
29.970	136.159.5.17	192.168.1.9	1500	TCP	80	1035	3310611182	133606	win: 24820	A
29.972	136.159.5.17	192.168.1.9	1500	TCP	80	1035	3310612642	133606	win: 24820	A
29.972	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310612642	win: 28099	A
29.973	136.159.5.17	192.168.1.9	429	TCP	80	1035	3310614102	133606	win: 24820	FA
29.974	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310614492	win: 26250	A
30.072	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310614492	win: 26250	A
30.136	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310614492	win: 31370	A
30.141	192.168.1.9	136.159.5.17	40	TCP	1035	80	133606	3310614492	win: 0	F

## Internet Protocol (IP)

- 10 12. The diagram below shows the header format for an Internet Protocol (IP) datagram. Use your knowledge of IP and the diagram to answer the questions below.

Version	Type	Length	
Identification		Flags	Offset
TTL	Protocol	Checksum	
Source Address			
Destination Address			
Options			
DATA			

- (a) (1 mark) What is the typical size of the header for an IPv4 datagram?

20 bytes

- (b) (1 mark) How is the 16-bit IP checksum field calculated?

Sum all 16-bit words in the header, using modulo-2 arithmetic.

Take the 1's complement of this value and insert it into checksum field.

- (c) (2 marks) How is the TTL field used on the Internet? What purpose does it serve?

Time To Live: hop count limit for packets. Initialized by original sender to a value (like 20), and then decremented by 1 at each router traversed. If count reaches 0, discard packet. Prevents packets from living forever on the Internet, such as in a routing loop.

- (d) (2 marks) Which fields are needed for IP fragmentation? How does it work?

Identification, Flags, Offset. All fragments get same ID value, and different offsets to show their relative position in the original data. Flag field is used to indicate More Fragments for all but the last fragment of the datagram.

- (e) (2 marks) Which field is used for IP congestion control? How does it work?

The IP protocol does not provide congestion control on the Internet, so this issue has been left up to higher-layer protocols (e.g., TCP) to handle.

- (f) (2 marks) Among the remaining fields not yet discussed, which is your favourite, and why? What does it do, and how?

Many possible answers. Version field to distinguish IPv4 from IPv6.

Length field to indicate total datagram size. Data field to carry useful payload.

\*\*\* THE END \*\*\*