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 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!

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. Historically, the "big three" applications in the early days of the Internet were:

(a) remote login, World Wide Web, and illegal file sharing

(b) remote login, file transfer, and gopher

(c) secure shell, video streaming, and electronic mail

(d) file transfer, remote login, and electronic mail

(e) file transfer, Twitter, and Facebook

1 2. The Domain Name Service (DNS) is an example of a:

(a) transaction-oriented application-layer protocol

(b) session-oriented application-layer protocol

(c) transaction-oriented transport-layer protocol

(d) session-oriented transport-layer protocol

(e) all of the above

1 3. The Simple Mail Transfer Protocol (SMTP) is an example of a:

(a) transaction-oriented application-layer protocol

(b) session-oriented application-layer protocol

(c) transaction-oriented transport-layer protocol

(d) session-oriented transport-layer protocol

(e) all of the above

1 4. The primary advantage of a persistent HTTP connection is:

(a) a larger version number (1.1) than non-persistent HTTP (1.0)

(b) additional RTT's when obtaining multiple Web objects from the same Web server

(c) re-using an existing TCP connection for a Web transfer when it is possible to do so

(d) eliminating the need for state information at the application layer

(e) extra funding support from Google

1 5. The transmission time for a 1200-byte packet on a classic 10 Mbps (Megabits per second) Ethernet LAN would be approximately:

(a) 1 millisecond

(b) 2 milliseconds

(c) 10 milliseconds

(d) 20 milliseconds

(e) 50 milliseconds

1 6. The one-way propagation delay for a single bit of information traveling at the speed of light (3 x 10^8 meters per second) over a fiber-optic cable from Vancouver to Halifax (6000 kilometers) would be approximately:

(a) 1 millisecond

(b) 2 milliseconds

(c) 10 milliseconds

(d) 20 milliseconds

(e) 50 milliseconds

1 7. The underlying control principle in TCP's congestion avoidance algorithm is:

(a) Additive Increase, Multiplicative Decrease

(b) Exponential Increase, Multiplicative Decrease

(c) Additive Increase, Exponential Increase

(d) Additive Decrease, Multiplicative Increase

(e) Additive Increase, Additive Decrease

1 8. In general, the throughput achieved by TCP for a file transfer is:

(a) inversely proportional to the average window size used during the transfer

(b) inversely proportional to the round trip time of the network path

(c) inversely proportional to the TCP segment size used for the transfer

(d) inversely proportional to the file size

(e) all of the above

Internet Protocol Stack

10 9. Use your knowledge of the Internet's TCP/IP protocol stack to complete the following fill-in-the-blank sentences and paragraphs. (20 blanks to fill in, each worth 0.5 marks)

The Internet Protocol Stack has __five___ layers.

The top-most layer is called the ___Application_______ layer.
The logical units of data exchanged at this layer are called ____messages_____.
Two examples of protocols at this layer are ___HTTP__________ and ____SMTP_______.

The next lower layer is called the ____Transport_______ layer.
The logical units of data exchanged here are called ____segments_________.
Two services provided at this layer are __end-to-end comm___ and __muxing/demuxing___.
On the Internet, the two protocols to choose from at this layer are
______TCP_____________ and _______UDP___________.

Layer 3 of the Internet Protocol Stack is called the Network Layer.
It deals with logical data units called ____datagrams_____________.
The most prominent protocol at this layer on the Internet is ________IP__________.

Immediately beneath the Network Layer is the _____Datalink_____________ layer.
It deals with logical data units called _____frames_________,
which are exchanged on a hop-by-hop basis over network links.
One example of a widely-used protocol at this layer is ____Ethernet/WiFi______.

The lowest layer of the Internet Protocol Stack is the ____Physical______ layer.
The most basic unit of data exchange at this layer is called a ___bit__________.
Two examples of transmission media commonly used at this layer
include ___twisted pair/coaxial cable____ and ___optical fiber__________.

Networking Concepts and Definitions

12 10. 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.

(a) (3 marks) "connection-oriented" and "connectionless"

CO: stateful protocol design
Explicit setup phase (handshake) prior to data exchange
Explicit teardown phase to close
Suitable for any amount of data

CL: stateless protocol design
No setup phase required before exchanging data
No closing handshake needed
Suitable for small amounts of data

This choice of protocol design applies at every layer of the protocol stack!

(b) (3 marks) "encapsulation" and "decapsulation"

Encap: traversing down the protocol stack on the sender, adding control info in the headers at each layer

Data units get larger as you go

Decap: traversing up the protocol stack at the receiver, removing headers and verifying correctness before delivering to layer above

Data units get smaller as you go

(c) (3 marks) "iterative DNS query" and "recursive DNS query"

I: a form of DNS query resolution in which the onus is on the initiator to perform successive queries at each different level of the DNS hierarchy
Multiple queries required by local DNS

R: a form of DNS query resolution in which one DNS server performs query on your behalf, like a nested RPC
Result returned and cached on DNS path
Single query required by local DNS

(d) (3 marks) "go-back-N" and "selective repeat"

GBN: simple error recovery mechanism for lost segs in pipelined protocol
Keeps one timer for oldest unacked seg
Upon loss, go back to left edge of W and resend ALL of the unacked segs
No buffering of out-of-order segs

SR: advanced error recovery mechanism for lost segs in pipelined protocol
Keeps one timer for each unacked seg
Upon loss, resend only the missing segs
Uses individual (selective) ACKs
Requires buffering for out-of-order segs

Reliable Data Transfer

10 11. In class, we discussed several versions of Reliable Data Transfer (RDT) protocols, and the mechanisms used to detect and recover from different types of errors that could occur in an unreliable network layer.

(a) (3 marks) One type of error is a **corrupted data segment**. What mechanism or mechanisms are needed in an RDT protocol to detect and recover from this type of error? How do they work?

```
- checksum calculated by S, included in header, verified by R
- NAK to indicate unsuccessful data (or timeout at sender)
- retransmission to resend fresh copy of corrupted/discarded segs
```

(b) (3 marks) A second type of error is a **duplicate data segment**. What mechanism or mechanisms are needed in an RDT protocol to detect this type of error? In particular, what state variables are needed, and where do they reside?

```
- sequence number at sender side FSM, and in each segment
- expected sequence number at receiver side FSM
- check arriving seqnum against expected to detect duplicates,
  and avoid delivering to AL more than once
- need to ACK all incoming data (even retransmissions!)
```

(c) (4 marks) A third type of error is a **lost data segment**. What mechanism or mechanisms are needed in an RDT protocol to detect and recover from this type of error? What additional state information is needed, and where does it reside?

```
- sequence numbers and expected sequence numbers as above
- R uses sequence numbers to detect gaps in data stream
- S uses timer to detect lack of ACK
- S estimates RTT to set reasonable RTO value
- timeout at S triggers retransmission of lost segment
```

Transmission Control Protocol (TCP)

10 12. The diagram below illustrates the generic segment structure used by the Transmission Control Protocol (TCP). Use your knowledge of TCP to answer the following questions.

<table>
<tr><td colspan="2">Source Port</td><td>Destination Port</td></tr>
<tr><td colspan="3">Sequence Number</td></tr>
<tr><td colspan="3">Acknowledgement Number</td></tr>
<tr><td>Length</td><td>Flags</td><td>Window</td></tr>
<tr><td colspan="2">Checksum</td><td>Urgent Pointer</td></tr>
<tr><td colspan="3">Options (optional)</td></tr>
<tr><td colspan="3">DATA (optional)</td></tr>
</table>

(a) (1 mark) What is the default size (in bytes) for a TCP segment header?

```
20 bytes
```

(b) (2 marks) What is a Transport Level Endpoint (TLE)? Which field or fields are used to help convey this information?

```
TLE: combination of IP address and port to identify comm endpoint (socket)
Source port (16 bits) and Destination port (16 bits)
```

(c) (3 marks) Which field or fields are used in TCP's 3-way handshake to open a new connection? What information is conveyed during the handshake, and how?

```
SYN flag and a randomly-chosen Initial Sequence Number (ISN) X
3-way handshake: (1) SYN from C to S carrying ISN X; (2) SYN ACK from S to C
that ACKs X+1 and proposes ISN Y; (3) ACK from C to S that ACKs Y+1
```

(d) (2 marks) What is the purpose of the **Window** field? How is it used?

```
Flow control. The receiver advertises the maximum number of bytes that
it is willing to receive, based on its currently available buffer space
```

(e) (1 mark) What **Flags** field bit is used to abort a TCP connection that has encountered an unrecoverable error?

```
R (reset)
```

(f) (1 mark) Which header fields (if any) are used by TCP's congestion control algorithms?

```
None. (cwnd and ssthresh are state variables at endpoints, not in headers!)
```

*** THE END ***