

American University of Beirut
Faculty of Engineering and Architecture
Electrical and Computer Engineering Department

EECE 450 – Computer Networks
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Spring 2008

Midterm Exam: Solution
Monday April 14, 2008

Midterm Guidelines:

- The duration of the exam is 90 minutes.
- The exam consists of 4 problems.
- The exam consists of 8 pages.
- There are a total of 100 points to be achieved.
- The exam is closed book.
- Only non-programmable calculators are allowed as utility.
- Do not forget to write your name and ID on the question booklet.
- Please do not write with pencils.
- **Enjoy and Good Luck!**

Name: _____

ID Number: _____

I have neither given nor received aid on this exam. **Signature:** _____

Problem 1 (24 pts) (Short Questions)

- (a) In ADSL, the downstream bit rate is 8 Mbps whereas the upstream bit rate is 1 Mbps. What is the key factor in ADSL physical layer design/characteristics that results in this difference between upstream and downstream bit rate capabilities? 3 pts

Since the frequency bandwidth allocated for the downstream is larger than that allocated for the upstream, there is a difference between upstream and downstream bit rates.

- (b) Give an example of a user service that is loss tolerant but requires bandwidth and timing guarantees.

Voice over IP or video over IP are loss tolerant but require bandwidth and timing guarantees.

Give an example of an application service that allows no losses and requires bandwidth and timing guarantees. 4 pts

Encrypted voice, encrypted video, or realtime gaming require no losses, bandwidth and timing guarantees.

- (c) Does Web caching reduce the delay for all objects requested by a user or for only selected objects? Explain. 3 pts

The delay is reduced only for selected objects depending on what is stored in the cache.

- (d) Bob uses Hotmail to send a message to Alice who accesses her mail from her mail server using Hotmail as well. Discuss how the message gets from Bob to Alice and list the series of application layer protocols that are used to move the message between them. 4 pts

Bob uses HTTP to send the message to his mail server. Bob's mail server uses SMTP to send the mail to Alice's mail server. Alice retrieves her mail from Hotmail using HTTP.

- (e) Rank the following ARQ protocols in terms of their throughput efficiency (from lowest to highest): 1) Alternating Bit protocol, 2) Go-Back-N protocol, and 3) Selective Repeat protocol. 3 pts

Alternating Bit protocol, Go-Back-N protocol, Selective Repeat protocol

- (f) Suppose users share a 2 Mbps link. Each user requires 1 Mbps when transmitting, but each user transmits only 10% of the time. How many users can be supported when using circuit switching?

A maximum of 2 users could be supported $\frac{2\text{Mbps}}{1\text{Mbps}} = 2$

Would using packet switching instead of circuit switching increase or decrease the number of supported users? Explain. 4 pts

- *This depends on the target/allowed loss rate.*
- *If some loss can be tolerated, using packet switching increases the number of supported users.*

- (g) Suppose a process in Host C has a UDP socket with port number 3456. Suppose both Host A and Host B each send a UDP message to Host C with destination port number 3456. How will the process at Host C know that these two segments originated from two different hosts? 3 pts

It will know that from the IP addresses of the source hosts.

Problem 2 (18 pts) (*Segmentation and UDP*)

Assume Host A needs to transfer voice data of 1000 Bytes to Host B using an application layer protocol that runs over UDP over IP over Ethernet. For each voice message, the UDP protocol adds a header of length 8 bytes, the IP protocol adds a header of length 20 bytes, and the Ethernet protocol adds a header of length 24 bytes. The distance between Host A and Host B is 9 km and the propagation speed is 3×10^8 m/s. Assume that Host A and Host B are separated by two equidistant switches and that all links are 1 Gbps Ethernet links. Moreover, assume the processing delay per frame at each switch is $1 \mu\text{s}$ and that switches apply store-and-forward switching.

(a) Assume Host A sends the whole voice data to Host B as one message. Calculate the total time needed to transfer the whole voice data from Host A to Host B. Show your steps. 6 pts

- *The header is 52 Bytes. The data is a 1000 bytes.*
- *Message + Header = 1052Bytes*
- $T_{tx} = \frac{1052 \times 8}{10^9} = \frac{L}{R} = 8.4 \mu\text{sec}$
- $T_{prop} = \frac{9 \times 10^3}{3 \times 10^8} = 30 \mu\text{sec}$
- $T_{total} = 3 \cdot T_{tx} + T_{prop} + 2 \cdot T_{prop} = 25.2 + 2 + 30 = 57.2 \mu\text{sec}$

(b) Assume the application layer protocol divides the voice data into **two** equal-size messages that are sent directly one after the other. Calculate the total time needed to send the whole voice data from Host A to Host B. Show your steps clearly. 6 pts

- *The header is still 52 Bytes. The data in each message is 500 Bytes.*
- *Message + Header = 552Bytes*
- $T_{tx} = \frac{552 \times 8}{10^9} = \frac{L}{R} = 4.5 \mu\text{sec}$
- $T_{prop_{A \rightarrow S1}} = 10 \mu\text{sec}$.
- $T_{total} = 4 \cdot T_{tx} + 2T_{proc} + T_{prop} = 30 \mu\text{sec}$

(c) Taking the results of the previous two parts into account, list one advantage and one disadvantage of data segmentation. 3 pts

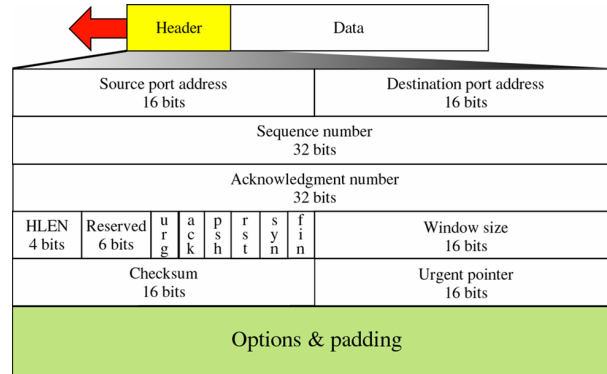
- *Advantage: More efficient.*
- *Disadvantage: More complex, more computational overhead.*

(d) Assume the voice data needs to be sent reliably, how can this be done knowing that UDP is used as the transport layer protocol? 3 pts

We could add reliability functionality at the application layer level. This could be done in the application layer headers.

Problem 3 (37 pts) (TCP)

TCP is used to transfer a 511 KB file from Host A to Host B over a 10 Mbps Ethernet link with an RTT of 100 ms. The maximum advertised window size is equal to 64 KB and TCP sends segments with an MSS of 1 KB. Assume the MSS contains the TCP header size of the TCP segment. The following is TCP's header structure:



(a) The TCP protocol is said to provide a connection-oriented reliable in-order byte stream service with flow control and congestion control. Which field(s) in the TCP header are needed for each of the following characteristics of the TCP protocol:

- Connection-oriented: *ack, syn, fin, rst*
- Reliable in-order delivery: *sequence number, ack number, ack*
- Flow control: *window size*

6 pts

(b) How many RTTs does it take until slow start opens the send window to 64 KB? Assume that the initial value of the window is set to one MSS? Justify your answer.

4 pts

It takes 6 RTTs.

(c) How many RTTs does it take to send the given file? Justify your answer.

4 pts

- *During the first 6 RTTs, 63KB are sent including headers. The data that has been sent is:*

$$511KB - 63KB + 0.126KB = L$$

- *$S = \#of\ segments\ required = \frac{L}{1KB-20B} = \frac{458881.024}{1004} = 457.05segments$*

- *$\#of\ RTTs = \lceil \frac{s}{64} \rceil = 8RTTs$*

- *Total Number of RTTs = 8 + 6 = 14RTTs*

(d) If the time to send the file is given by the number of required RTTs, what is the effective throughput for the transfer?

3 pts

$$T = \frac{511kB}{\#of\ RTTs \times 100} = \frac{523264}{1.4} = 373,360bps$$

(e) What percentage of the link bandwidth is utilized?

3 pts

$$\% = \frac{0.373}{10} \times 100 = 37.3\%$$

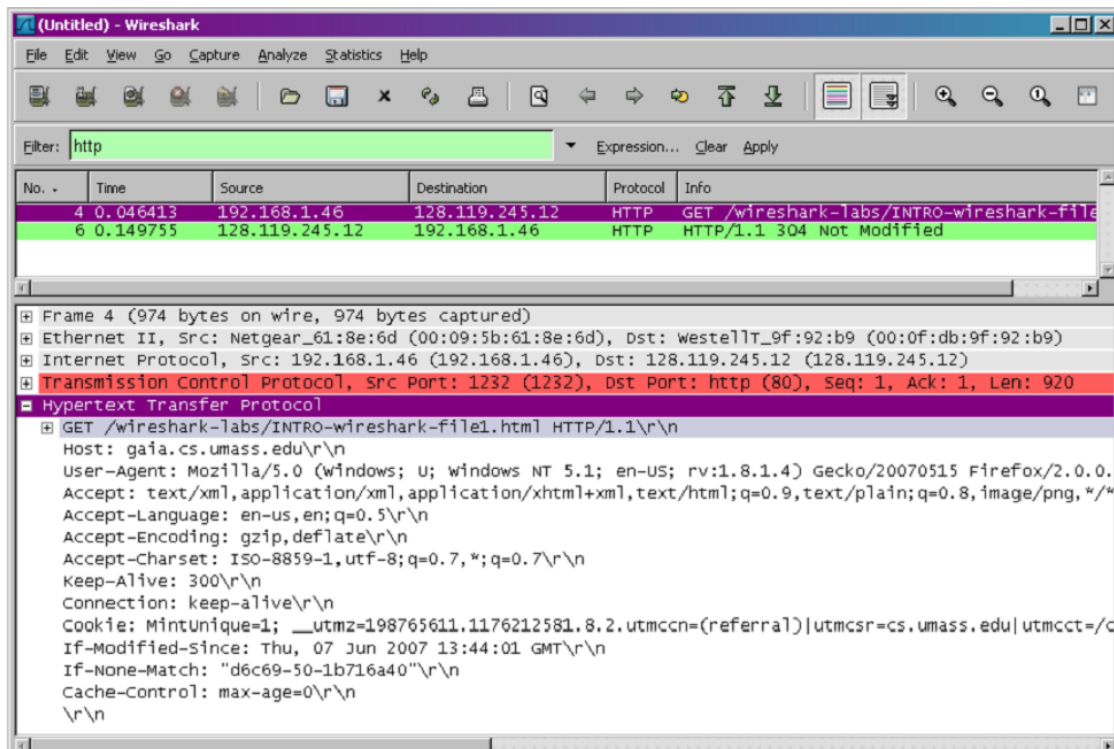
- (f) Why is the size of the TCP maximum advertised window typically equal to 64 KB? 4 pts
Since $2^{16} = 64kB$ where 16 refers to the number of available bits.
- (g) What is a possible extension that can be used to increase the size of the advertised window? 3 pts
Both the sender and receiver should agree that the window size is in multiples of 4 bytes. e.g we could perform scaling during connection setup.

Host A sends two TCP segments consecutively to Host B over a TCP connection. The first segment has sequence number 90 whereas the second segment has sequence number 110.

- (h) How much application data is transmitted in the **first** segment? 3 pts
The amount of application data is: $110 - 9 - 20B = 81$ bytes.
- (i) Suppose the first segment is lost but the second segment arrives at Host B. In the acknowledgement that Host B sends to Host A, what will be the acknowledgement number? 3 pts
The acknowledgement number will be 90.
- (j) How can Host A determine that a given segment is lost? List two ways. 4 pts
- *Via a timeout.*
 - *Via multiple repeated acks.*

Problem 4 (21 pts) (HTTP)

Given the following Wireshark snapshot taken during a web browsing session:



- (a) What is the URL that was entered into the browser? 3 pts
www.gaiia.cs.umass.edu/wireshark-labs/Intro-wireshark-file

- (b) What is the IP address of the web server? 1 pt
128.119.245.12
- (c) After the user enters the URL into the browser, how can it know the IP address of the web server? 3 pts
DNS
- (d) What version of HTTP is the browser running? 1 pt
HTTP/1.1
- (e) Does the browser request a non-persistent or a persistent connection? Justify your answer. 3 pts
The browser is requesting a persistent connection because of Connection keep-alive.
- (f) What is the port number used on the host where the browser is running? How is this port number normally selected? 3 pts
The port number is 1232. It is a temporary port allocated by the operating system.
- (g) Was the server able to successfully find the requested object or not? Justify your answer. 2 pts
Yes, because of the 304 Not Modified response
- (h) Did the server send the requested object or not? Justify your answer. 2 pts
No, it sent back a Not Modified response because a conditional GET was sent.
- (i) By the way, list two uses of cookies. 3 pts
- *Security/authentication*
 - *Online marketing/shopping*
 - *Personalized accounts*