CSE 123A Midterm Exam

July 19, 2006

Name: __________________________           Email: _________________________

Be sure to read questions carefully and answer all parts. Use complete sentences and explain your answers. One word responses will not be given credit. If you use any specific terms or acronyms, give a brief description of what they mean. You should be able to answer the questions in a few sentences or less. There is no need to write an essay. Remember to flip the pages over (there are questions on the back of most pages.) Good luck!

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<thead>
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<td>Question 4</td>
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<td>Question 5</td>
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</tbody>
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1) Layering and Coding

a) Why do we construct network protocols in layers? Are there any disadvantages to using layers? (6 points)

_We construct protocols in layers because of encapsulation_ (functionality inside each layer is entirely self contained) and _modularity_ (can replace a layer without impacting other layers). Layers also introduce an intermediate layer that provides a unique abstraction for various network technologies.

_One disadvantage to using layers is that some information can be hidden in the abstractions, which can lead to inefficient implementations._

b) Identify the OSI reference model layer for each of the following concepts. (4 points)

- **CSMA/CD**  
  _Layer 2 (data-link)_
- **Manchester encoding**  
  _Layer 1 (physical)_
- **Internet Protocol**  
  _Layer 3 (network)_
- **HTTP**  
  _Layer 7 (application)_

c) What is signal coding (or signaling)? If all clocks were exactly synchronized at all times, would this simplify signal coding algorithms? Why or why not? (10 points)

_Signal coding (or signaling) takes binary data and encodes it into a signal that can travel on physical links. Put simply, signaling is the process of transforming digital data to and from an analog representation._

_If all clocks were synchronized, we wouldn’t have to worry about clock drift between the sender and receiver, which would greatly simplify clock recovery. However, other problems (like baseline wander) would still be present._
2) Framing and Error Detection

a) Briefly describe sentinel framing, length-based framing, and clock-based framing. (6 points)

Sentinel framing uses special “sentinel” characters (STX, ETX) to indicate the start and end of each frame.

Length-based framing specifies the length of the frame in the beginning of the header, so the receiver knows exactly how much data to read.

Clock-based framing creates a continuous stream of fixed length frames. Sender and receiver must have synchronized clocks. All frames fit into a specific time interval (e.g., 125 usec).

b) What is the biggest challenge associated with length-based framing? In other words, what type of error is most detrimental? (7 points)

The biggest challenge of length-based framing is dealing with corrupt length fields in the header of the frames. If the length field gets corrupted, the receiver does not know how to interpret the frames, and it is difficult for the sender and receiver to recover from this type of error.

c) In class, we discussed several different ways to do error detection at the data-link layer. Briefly describe one specific technique or algorithm commonly used for error detection in framing. (7 points)

There are several valid answers including CRC, Internet checksum, simple parity, 2D parity, and voting. As long as you correctly identified and described one of these, you received credit.
3) Media Access

a) What key improvement did Ethernet make over Aloha? (4 points)

*Ethernet uses CSMA/CD.* CSMA/CD (Carrier Sense Multiple Access with Collision Detection) allows hosts to test whether or not a line is idle before sending (CSMA) and then detect collisions (CD). Aloha hosts did not have this capability. Aloha had guaranteed collisions, which made it very inefficient.

b) What are the advantages and disadvantages of using token rings instead of Ethernet? (6 points)

*Advantages:* No contention (and therefore no collisions), bounded access delay, support for fair, reserved, and priority access to network

*Disadvantages:* Complexity, reliability, scalability

c) Compare how exponential backoff is used in CSMA/CD versus CSMA/CA. Briefly describe how the exponential backoff algorithm works. (10 points)

*CSMA/CD uses exponential backoff after a collision is detected.* It is used in Ethernet. If a collision occurs after 2 hosts try to transmit, hosts wait some time (determined by exp backoff) and then try transmitting again.

*CSMA/CA uses exponential backoff before a collision occurs (in an attempt to avoid collisions completely).* It is used in wireless (802.11). When a collision is inferred, hosts wait for some number of idle timeslots (determined by exp backoff) to pass before trying to send.

Exponential backoff:
- First time: wait 0 or 1 min frame times at random, retry
- Second time: wait 0, 1, 2, or 3 times
- Nth time (N<=10): wait 0, 1, ..., 2^N-1 times
- Max wait 1023 frames, give up after 16 attempts
4) Hubs and Bridges

a) Will a network built using learning bridges that perform selective forwarding achieve higher aggregate throughput than the same network built using hubs? Why or why not? (8 points)

Yes, the network will achieve higher aggregate throughput using bridges. Bridges create separate collisions domains that allow different network segments to transmit on their own LANs in parallel which increases the aggregate throughput of the network. Also, selective forwarding potentially minimizes the number of network segments that must carry a given packet, again increasing aggregate throughput.

b) Consider the network of learning bridges shown in the following figure.

Assuming all forwarding tables are initially empty, show the forwarding table in each of the bridges after the following sequential transmissions:

- A sends to C
- D sends to A
- F sends to E
Fill in a table for each bridge after each transmission (on the next page), each with two columns: destination (hosts) and ports (numbers), showing how the bridge would forward traffic. (12 points)

1. After A sends to C:

<table>
<thead>
<tr>
<th>Bridge B1</th>
<th>Bridge B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Port number</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
</tr>
</tbody>
</table>

2. After D sends to A:

<table>
<thead>
<tr>
<th>Bridge B1</th>
<th>Bridge B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Port number</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
</tr>
</tbody>
</table>

3. After F sends to E:

<table>
<thead>
<tr>
<th>Bridge B1</th>
<th>Bridge B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Port number</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
</tr>
</tbody>
</table>
5) Internetworking and Reliability

a) How do routers (or gateways) differ from hubs and bridges? Identify two problems associated with hubs and bridges that routers overcome. (10 points)

Routers (layer 3) connect separate physical networks to create a single logical network. Two of the main problems or limitations associated with hubs and bridges include:

- Homogeneous link layer (routers support heterogeneous link layers)
- Limited scalability due to broadcast traffic (routers keep track of network topology so they know where to forward packets)

(There are others that received at least partial credit including buffer management and queuing. These are the main two however.)

b) Explain why the bandwidth-delay product is important in the context of stop-and-wait ARQ algorithms. (5 points)

This question was a bit open ended. I was just looking for some general discussion that related the bandwidth-delay product to ARQ algorithms, particularly the stop-and-wait algorithms. The bandwidth-delay product represents the volume of the link or pipe. In stop-and-wait ARQ algorithms, one packet is “in flight” at a time. (The sender sends one packet, waits for an acknowledgement, and then sends another packet.) Since the bandwidth-delay product tells us how much data can actually fit in the pipe, this value is actually a measure of the performance limitations associated with stop-and-wait algorithms. Other ARQ algorithms (sliding window, for example) are able to keep the pipe full, which makes them must more efficient than stop-and-wait.

c) The general strategy of using acknowledgements and timeouts to implement reliable delivery is called ARQ. Discuss the tradeoffs associated with picking “good” timeouts (not too long and not too short). (5 points)

Timeouts that are too short cause unnecessary retransmissions, which lead to network congestion.

Timeouts that are too long cause lengthy delays since it takes a long time for a retransmission to occur. They also make poor use of available bandwidth.