Exam #2 for Computer Networks (CIS 6930) Spring 2000

>>> *SOLUTION* <<<

Welcome to Exam #2 in Computer Networks (CIS 6930). You have 75 minutes. Read each problem carefully. There are eight required problems (each worth 12.5 points). You may have with you a calculator, pencils, eraser, blank paper, lucky rabbit's foot, and one 8.5 x 11 inch "formula sheet". On this formula sheet you may have anything you want (definitions, formulas, etc.) as written, typed, or drawn by you. Photocopies or scans are not allowed on this sheet. Please submit your formula sheet with your exam. Please start each numbered problem on a new sheet of paper and do not write on the back of the sheets (I do not care about saving paper!). Submit everything in problem order. No sharing of calculators. Good luck and be sure to show your work.

Problem #1 (10 minutes)

Answer the following general questions regarding DLC protocols.

a) Sketch the timing diagram for stop-and-wait and "visually" derive the formula for link utilization (U).

```
See Figure 9.3 in text.  U = t_fr / (2 * t_pr + t_fr + 2*t_proc + t_ack)
```

b) Consider a 1-Mbps link of length 1000 kilometers (signal propagation is 5 nanoseconds/meter) and a sliding window protocol that uses go-back-N error recovery. Frame length is 125 bytes. The probability of a bit error is 1.0e-5 (and bit errors can be assumed to be independent and identically distributed). What is the minimum window size needed to achieve a utilization of 75% on this link? <u>If you do not have time to "crunch the numbers", at least show your set-up (e.g., so that Mathcad could solve it)</u>.

```
U_sw = (N*t_fr*(1 - p)) / ((1 - p - N*p)*(2*t_pr + t_fr))

t_pr = 0.005 sec
t_fr = 0.001 sec
p = 1 - (1 - 1.0e-5)^(125 * 8) = 0.010

0.75 = (N * 0.005*(1 - 0.010)) / ((1 - 0.010 - N*0.010)*(2*0.005 + 0.001))

Solving for N yields 1.623 which is a window size of 2 (window sizes must
be integer values).
```

Problem #2 (10 minutes)

Answer the following questions regarding bridging.

a) Describe what is a bridge and what it does. Be specific. If a figure will help, then draw one.

```
A bridge is a MAC-level filter.  For a bridge between two LANS, it forwards
only frames that are not addressed to stations known to be local to "this
side" LAN.
```

b) Give the algorithm for frame forwarding and table learning for a transparent bridge.

```
(1) receive a frame
(2) if ((DA in table) and (DA not local)) then not forward else forward
(3) if (SA in table) check/update direction
```

(4) if (SA not in table) add to table

c) How did a transparent bridge get its name (i.e., "transparent")?

A transparent bridge does not require any changes or actions on the part of the end-stations. Thus, the installation of a transparent bridge is "transparent" to the end-stations and this explains its name.

d) What is the spanning tree algorithm and why is it needed?

The Spanning Tree (ST) algorithm is a private algorithm between all bridges in a network. The ST algorithm identifies parallel bridges and disables parallel bridges in such a way the an acyclic tree of bridges is formed. The ST algorithm is needed to prevent loops in the bridged network where such loops would cause endlessly circulating frames (due to how the forwarding and table learning algorithm is implemented). The disabled parallel bridges are in an active standby state and can be put into active forwarding mode by the ST algorithm if the ST algorithm detects that an active bridge has failed.

Problem #3 (5 minutes)

In the figure below, assume that bridges #1, #2, and #3 are transparent bridges. Assume also that all stations have sent and received frames to/from all other stations. The MAC addresses for the stations are A, B, …, F. Give the bridge tables for all three bridges.

```
  Station |
   +---+  |                                 |         +----------+  |
   | A +--+                   +----------+  +---------+ Bridge 3 +--+
   +---+  +-------------------+ Bridge 2 +--+         +----------+  |  +---+
          |                   +----------+  |  +---+                +--+ F |
          |  +----------+  |                +--+ D |                |  +---+
          +--+ Bridge 1 +--+                |  +---+                |
   +---+  |  +----------+  |  +---+         |                    Ethernet
   | B +--+                +--+ C |         |  +---+
   +---+  |                |  +---+         +--+ E |
          |                |                |  +---+
       Ethernet         Ethernet         Ethernet
```

Bridge 1

addr	direc
A	<-
B	<-
C	->
D	<-
E	<-
F	<-

Bridge 2

addr	direc
A	<-
B	<-
C	<-
D	->
E	->
F	->

Bridge 3

addr	direc
A	<-
B	<-
C	<-
D	<-
E	<-
F	->

Problem #4 (10 minutes)

Answer the following questions regarding switch architectures.

a) What is Head of Line (HOL) blocking and what effects can it have on performance.

HOL blocking is the situation where packets in the input queue are blocked by the first (head) packet in the queue, which is blocked by some resource shortages. Note that only the first packet is blocked by resource shortage. Any packets after the first packet are blocked just due to the first packet. The HOL blocking happens in "input-buffer" switches (i.e., it can not happen in "output-buffer" switches). HOL blocking can greatly reduce the throughput of an input buffered switch.

b) Describe one solution to HOL blocking for an input-buffered switch.

One solution is to use virtual output queueing (at each port, there is an input queue mapped for each output port and incoming packets are placed in the appropriate input queue based on their intended destination output port). With virtual output queueing, an arbitration scheme is needed to schedule the packets. PIM and iSLIP are two examples of such switch arbitration schemes.

b) Given a 10-port switch with line speeds of 1-Gbps and 32-bit wide memory used as output buffers. What must the memory speed be? Is this feasible? Comment on the feasibility of using output buffering for high-speed switches.

The memory speed of the output buffer must be able to handle all 10 ports fowarding a packet to it at once. This would be (10 * 1000,000,000 bits per second) / 32 bits per cycle = 312.5 million cycles per second or 3.2 nanoseconds per cycle. This is at the threshold of what modern (very expensive) SRAM can handle. If the switch architecture was changed to input buffering only, the memory speed would be reduced to 32 nanoseconds per cycle, which is feasible with much less expensive DRAM. In general, output buffering is not feasible for high-speed switches for the reasons shown in the above analysis.

<u>Problem #5</u> (10 minutes)

Answer the following questions regarding IP.

a) Sketch the IP packet header and describe the purpose of the fragment offset field.

```
31                                 0
+---+---+---------+----------------+
|Ver|IHL| Type    | Total length   |
+---+---+---------+---+------------+
| Identifier      |Flg|Frag offset |
+---+-------------+---+------------+
|TTL| Protocol    | Hdr checksum   |
+---+-------------+----------------+
|        Source address            |
+----------------------------------+
|      Destination address         |
+----------------------------------+
|              Options             |
+----------------------------------+
```

```
The fragment offset field is used when an TCP segment must be fragmented by
the IP layer.  This field identifies the position in bytes of this
fragment.
```

b) What is a class B IP address? How many class B subnets can there be? How many hosts per class B subnet?

```
A class B address has 16 bits for host id and 14 bits (the initial 10 is
fixed) for net id.  Thus, there can be 2^14 netids = 16,384 and 2^16
hostids = 65,536.
```

c) Name two methods of making more efficient use of IP addresses.

```
Subnet masking and dynamic assignment of IP addresses (via DHCP) allow for
efficient use of IP addresses.
```

__Problem #6__ (10 minutes)

In the figure below, assume that the host MAC addresses are A, B, and C as shown. Assume that the MAC addresses of router ports (1 and 2 for each router) are U, V, …, Z as shown. Answer the following questions:

a) Show the packet headers (key fields only - namely the address fields) for a packet as it flow from host 1101 to host 3309. Show the same for a return packet from host 3309 to host 1101.

```
|<-- MAC --> <--- IP ----> (MAC is dest/source, IP is source/dest)
+-----+-----+------+------+---//
|  W  |  A  | 1101 | 3309 |        - On subnet 11
+-----+-----+------+------+---//

+-----+-----+------+------+---//
|  Y  |  X  | 1101 | 3309 |        - On subnet 22
+-----+-----+------+------+---//

+-----+-----+------+------+---//
|  C  |  Z  | 1101 | 3309 |        - On subnet 33
+-----+-----+------+------+---//

+-----+-----+------+------+---//
|  Z  |  C  | 3309 | 1101 |        - On subnet 33 (return packet)
+-----+-----+------+------+---//

+-----+-----+------+------+---//
|  V  |  Y  | 3309 | 1101 |        - On subnet 22 (return packet)
+-----+-----+------+------+---//

+-----+-----+------+------+---//
|  A  |  U  | 1101 | 1101 |        - On subnet 11 (return packet)
+-----+-----+------+------+---//
```

b) Give the ARP cache for Router 2, port 1 (assume that all hosts have communicated to all other hosts).

```
+----------+-----------+
|   IP     |   MAC     |
+----------+-----------+
```

1101	A
1102	B
22XX	W
33XX	W

```
         11 (netid)
   Host   |                                    22 (netid)
   +---+  |                     1            2   |
   | A +--+                   +--------------+   |
   +---+  +-------------------+ U Router 1 V +--+
    01    |                   +--------------+   |
          |   1            2                     |
          |  +--------------+                    |                  33 (netid)
          +--+ W Router 2 X +--------------------+                    |  +---+
   +---+  |  +--------------+                    |   1           2    +--+ C |
   | B +--+                                      |  +--------------+  |  +---+
   +---+  |                                      +--+ Y Router 3 Z +--+    09
    02    |                                      |  +--------------+  |
```

The current router tables are...

Table for router 1

netid	port
11	1

Table for router 2

netid	port
22	2
33	2

Table for router 3

netid	port
22	1
33	2

<u>Problem #7</u> (10 minutes)

Answer the following questions regarding TCP.

a) State two benefits (or reasons) to having the TCP timeout value exponentially backoff when a timeout occurs.

The backing-off of timeout 1) prevents the time-out from getting stuck at a too low value given that RTT estimates are not updated for time-out cases (due to uncertainty of which packet an ACK belongs to), and 2) reduces the rate at which a host transmits thus reducing congestion in the network.

b) Explain how old TCP implementations accounted for variability of RTT in computing a timeout value.
Explain how modern TCP implementations account for variability of RTT in computing a timeout value.

Old implementations mutlipled their RTT estimate by a constant, typically 2. Moderm implementations estimate both the mean and variability of RTT and add the estimated RTT variability to the estimated RTT mean to get a time-out value.

<u>Problem #8</u> (10 minutes)

Answer the following questions regarding ATM.

a) State at least three attributes of a “perfect transport” as discussed in class.

A perfect transport must be speed scalable, distance scalable, and be able to transport a wide range of traffic types (including real-time and eleastic data traffic).

b) Sketch an ATM cell and identify the fields in the cell header. Describe the purpose of the VPI and VCI fields (and describe why there are two fields, not just one, for identifying the virtual circuit).

```
<------ 5 bytes ------> <-- 48 bytes -->
+---+---+---+-----+---+-------//-------+
|GFC|VPI|VCI|PT/CLP|HEC|                |
+---+---+---+-----+---+-------//-------+
```

The VPI/VCI pair identify the virtual circuit for the current connection. Two separate fields are used to allow for switches to be built that switch only VPI, only VCI, and combined VPI/VCI.

c) What makes it difficult to implement ARP on an ATM network? What is one possible solution? What are the drawbacks to this solution?

ATM is a connection-oriented technology. There is no “easy way” to do a broadcast. ARP requires broadcast. One solution is to idenitfy an “ARP server” with which all stations register and all ARP requests are directly sent to (for resolution). Problems with this include the requirement to add registration functions to all IP hosts and the single point of failure of an ARP server.

d) What is the purpose of AAL-5 and what does it do? Be specific.

AAL-5 was designed for simple and efficient data transfer (e.g., of LAN traffic). At the sender, AAL5 adds a trailer to a packet (a PDU) and then segments it for sending-out as ATM cells. At the receiver, AAL5 re-assembles the PDU from the received cells and passes it up to the higher layers.
