CS/ECE 438: Communication Networks — Fall 2007

Midterm Exam — Solutions

1. **(34 points) Short Answer**

   (a) **(2 points)** How many IP addresses are there in a /27 network?

   $$2^5 - 2 = 30$$

   two addresses for broadcast and network name.

   (b) **(2 points)** Which is more efficient, a Manchester encoding or a 4B/5B encoding?
   Manchester encoding is only 50% efficient whereas 4B/5B is 80% efficient.

   (c) **(2 points)** Why does the 802.11 wireless Ethernet protocol not use CSMA/CD?
   In wireless networks, it is impossible to detect collisions during transmissions because the receiver radio has to be turned off for the duration.

   (d) **(3 points)** What is the hidden terminal problem?
   If B can hear both A and C, but A and C cannot hear each other due to being out of range, A may start an interfering transmission to one already in progress from C to B, creating a collision at B that A cannot detect.

   Note: A may be transmitting to another node D, rather than C, and a collision would still occur at B.

   (e) **(3 points)** How does 802.11 solve it?
   The transmitting node sends a RTS and the receiving node sends a CTS before transmission, indicating the period that the channel will be busy. Nodes that can hear the receiver will hear the CTS and stay silent for that period of time.

   (f) **(12 points)** List one advantage and one disadvantage each for the following forwarding schemes:

      i. Datagram forwarding
      Advantages: Ability to re-route packets dynamically in case of failures.
      Can send traffic immediately.
      Disadvantages: Header requires full unique address.
      May not be possible to deliver packet
      Successive packets may not follow the same route
      Global address to path translations require significant storage.

      ii. Virtual Circuits
      Advantages: Header requires only a small VCID.
      Can reserve resources when setting up connection.

      Disadvantages: Need to wait 1 RTT per set up.
      Failure require the connection to be re-established.

      iii. Source Routing
      Advantages: Simple switches.
      Route under control of the source.

      Disadvantages: Hosts must know entire topology (and keep it up to date).
      Headers might become large.

(g) **(6 points)** List one advantage each for: Link State Routing, Distance Vector Routing.
Link state routing: Global view of the network allows for more optimizations, multiple path selection.
More robust to errors.
No count-to-infinity problem.
Distance-vector routing: Potentially smaller message traffic.
Less state maintained at nodes.
An updated link cost does not need to be broadcast to the entire network.

(h) **(4 points)** List two reasons for using a different routing schemes within an AS (intra-AS) and between AS'es (inter-AS).
Policy: different goals addressed by routing within the AS (e.g. performance) and between AS's (e.g. revenue maximization).
Performance: Can optimize traffic within the AS better because of more limited view and single administrative domains.
Scale: AS abstraction reduces table size and update traffic, as routing changes within an AS need not be propagated to other AS's.
Compatibility / innovation: Intra-AS schemes give AS's flexibility to choose different designs and experiment with new ones, whereas inter-AS scheme must be the same for all routers in the world.

2. **(6 points)** The USB protocol uses a CRC with the polynomial $x^5 + x^2 + 1$. Calculate the CRC of the bit string 1100011110110001

The polynomial $x^5 + x^2 + 1$ is equivalent to the bit string 100101.

```
100101 | 110001111011000100000
         100101
         ------
          101001
          100101
          ------
            110011
            100101
            ------
             101100
             100101
             ------
               100111
               100101
               ------
                   100001
                   100101
                   ------
                      100000
                      100101
                      ------
                         10100
```

3. **(6 points)** Consider 4 hosts on a single LAN with the following ARP tables:

10.0.0.1
MAC: 0:0:1

IP	MAC	T
10.0.0.3	0:0:3	5

10.0.0.2
MAC: 0:0:2

IP	MAC	T
10.0.0.4	0:0:4	7

10.0.0.3
MAC: 0:0:3

IP	MAC	T
10.0.0.1	0:0:1	5

10.0.0.4
MAC: 0:0:4

IP	MAC	T
10.0.0.2	0:0:2	7

The third column, T, represents the number of minutes since the ARP cache entry has been updated. Suppose 10.0.0.1 performs an ARP request for 10.0.0.4. After the request is complete, its table is:

10.0.0.1
MAC: 0:0:1

IP	MAC	T
10.0.0.3	0:0:3	6
10.0.0.4	0:0:4	0

Write the contents of the ARP tables for the other three hosts.

Host 10.0.0.4 will add an entry for 10.0.0.1 to its ARP cache, since it will likely need to communicate with 10.0.0.1.

Host 10.0.0.3 will snoop on the ARP request and update the T field for its entry for 10.0.0.1 to 0.

Host 10.0.0.2 will also hear the ARP request, but because it has no entry for 10.0.0.1, it will ignore the request. 10.0.0.2 will not *hear the ARP response, because ARP responses are unicast. So the tables will be:*

10.0.0.2
MAC: 0:0:2

IP	MAC	T
10.0.0.4	0:0:4	8

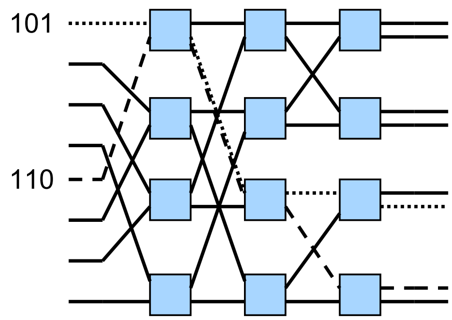
10.0.0.3
MAC: 0:0:3

IP	MAC	T
10.0.0.1	0:0:1	0

10.0.0.4
MAC: 0:0:4

IP	MAC	T
10.0.0.2	0:0:2	8
10.0.0.1	0:0:1	0

4. **(7 points)** Consider the following Banyan network:



(a) Draw the path taken by the packet 101 (shown) towards the output port

(b) Show (on the diagram) how another packet on another input, destined for a different output port, can collide with 101 inside the Banyan network

(c) What condition would prevent such a collision?

For (b), note that for a collision, it is necessary that the two packets occupy the same wire, rather than simply arrive at the same 2x2 switch. So if the packet 110 was instead 010, no collision would have happened.

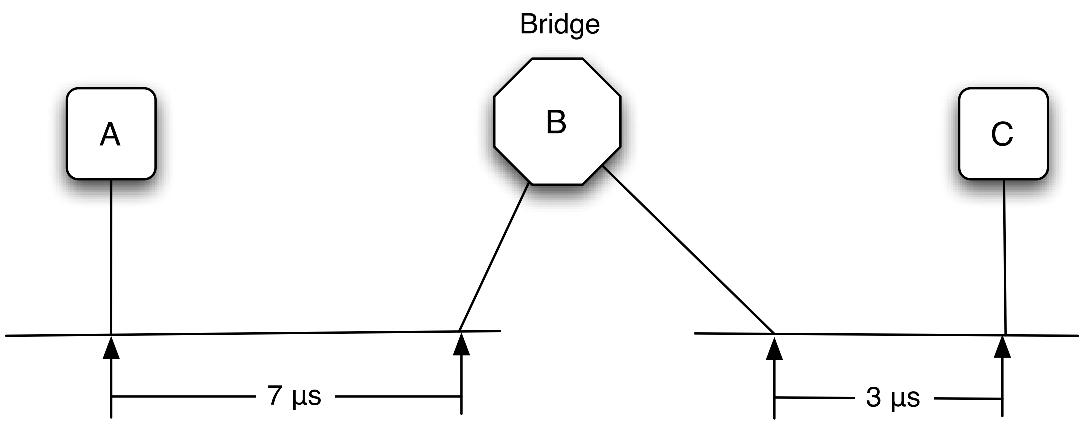
For (c), sorting the input packets in ascending order can be shown to prevent collisions. A Batcher network can perform the sorting.

5. **(10 points)** Consider a client connecting to a server, sending a request, and then reading back a response. Show the sequence of networking system calls that must occur on the client and the server for this to work, in the order that they must be executed. The calls you should use are: `accept`, `bind`, `close`, `connect`, `listen`, `read`, `socket`, `write`. You do not need to list the arguments to the calls.

Client	**Server**
`socket`	`socket`
	`bind`
	`listen`
`connect`	`accept`
`write`	`read`
`read`	`write`
`close`	`close`

Note: We didn't grade the ordering of calls between the client and the server because it is ill-defined. For example, `accept` may be called either before or after the `connect` call; whichever *is called first will simply block until the other one is called. (But if you call* `connect` *before* `listen` *is called, you will get a "connection refused" error.)*

6. **(12 points)** Consider hosts A and C connected by two Ethernet segments, with a bridge B in the middle. The segments are 10 Mbps and introduce a latency of 3 μs and 7 μs respectively.



A is transferring data to C by sending Ethernet frames with a 1500-byte payload. After sending a frame, it waits for an acknowledgment from C before sending the next one. The acknowledgment has a 10-byte payload.

(a) Recalling that an Ethernet frame includes an 8-byte preamble and a 14-byte header, calculate the effective bandwidth of the data transfer.

Recall that a bridge is a pass-through device that introduces almost no processing delay. So in this case, when A sends a bit, it arrives at C 10μs later. The time to send a whole packet is then:

$$\frac{(1500 + 14 + 8)bytes}{10Mbps} + 10\mu s = 1227.6\mu s$$

The time to send the acknowledgment is:

$$\frac{(10 + 14 + 8)bytes}{10Mbps} + 10\mu s = 35.6\mu s$$

Therefore, the effective bandwidth is:

$$\frac{1500bytes}{1227.6 + 35.6\mu s} \approx 9.5Mbps$$

(b) Calculate the effective bandwidth if B was replaced by a switch.

A switch will buffer a packet before sending it out. So the total transfer time of a packet from A to C is: transmission time at A + latency A to B + transmission time at B + latency B to C. To send the forward packet, it takes:

$$2\frac{(1500 + 14 + 8)bytes}{10Mbps} + 10\mu s = 2445.2\mu s$$

To send the ack, it takes:

$$2\frac{(10+14+8)bytes}{10Mbps} + 10\mu s = 61.2\mu s$$

The effective bandwidth is:

$$\frac{1500bytes}{2445.2 + 61.2\mu s} \approx 4.8Mbps$$

(c) Calculate the effective bandwidth if the switch was cut-through.

A cut-through switch acts nearly like a bridge in that it does not buffer packets. However, it needs to receive the full header before deciding which port to output on. Therefore, it adds a processing delay of $\frac{22bytes}{10Mbps} = 17.6\mu s$ *in each direction. The effective bandwidth is then:*

$$\frac{1500bytes}{1227.6 + 35.6 + 17.6 * 2\mu s} \approx 9.2Mbps$$