cmsc 417 S05 Exam 2 SOLUTION name: ______________

- Total points 30. Total time 70 mins. 4 problems over 4 pages. **No book, no notes, no calculator.**
- Sign here ______________ to have your exam scores listed on web by last five digits of your UID.

1. [**6 pts**] Consider an error-detecting CRC with the generator 1101. The CRC bits follow the data bits in any transmission. The string of bits 1110110001 is received. Determine whether it is acceptable, and if so what is the data bit sequence.

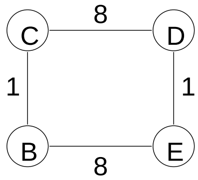
SOLUTION

```
 G = 110110
 So r=5

               1010111
     1101 ) 1110110001
            1101
             0111
             0000
              1111
              1101
               0100
               0000
                1000
                1101
                 1010
                 1101
                  1111
                  1101
                  0010  = Remainder


Not acceptable because remainder is not zero.
```

Grading:

- 4 points for the division, 1 point for decision.
- Max 2 points for appending "000" before dividing, for making decision based on dividend.
- Max 1 point for doing integer division (i.e., treating bit string as binary number)

2. [6 pts]



The above network uses the distance-vector routing algorithm. Assume the following:

- Links are bidirectional, and a link has the same cost in each direction.
- If several neighbors of a node can serve as the node's next hop to a destination, the node chooses the neighbor with the smaller id $(A<B<C<\cdots<Z)$.
- Nodes exchange their routing info once every second, in perfect synchrony and with negligible transmission delays. Specifically, at every time i, $i = 0, 1, 2, 3, \cdots$, each node sends its routing info, then receives routing info and updates its routing table; the update is completed by time $i + 0.1$.
- At time 0, the link costs are as shown above and the routing tables are stable. At time 0.5, the cost of the link from C to D becomes 2. There is no further change in the link costs.

a. Give the evolution of the routing table entry at nodes B, C, and D for destination E, at times 0.1, 1.1, 2.1, $\cdots$, until they stabilize. **Present your final answer in the format given below, where the entry for time 0.1 has already been filled. Do your rough work elsewhere.**

b. Point out when the table entries stabilize.

c. Point out when the next hops stabilize.

SOLUTION

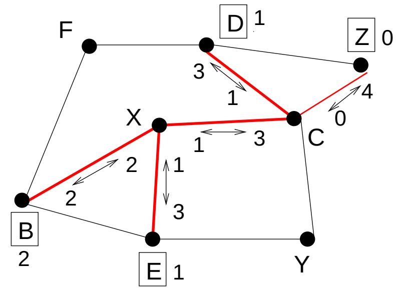
Time	At B, dist to E		At C, dist to E		At D, dist to E	
	via C	via E	via B	via D	via C	via E
0.1	10	8*	9*	9	17	1*
1.0	10	8*	9	3*	11	1*
1.1	4*	8	9	3*	5	1*
2.1	4*	8	5	3*	5	1*

`* indicates next hop.  Next hops stabilize at time 1.1.  Tables stabilize at time 2.1.`

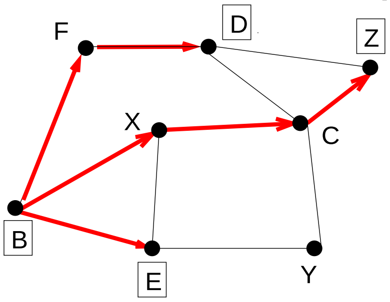
Grading: 2 points for the row at time 1.1. 2 points for the row at time 2.1. 1 point for next-hop stable time. 1 point for tables stable time.

3. [12 pts] In this problem, every router is a multicast router; links are bidirectional; unicast routing is done on shortest-hop paths with ties resolved by choosing the next hop with smallest id (A<B<C< ⋯ <Z); nodes B, D, E, Z constitute a multicast group; B generates 2 packets/second, D and E each generate 1 packet/second, and Z does not generate any packet. Each packet has to be delivered to all other nodes in the group. **Do your rough work elsewhere.**

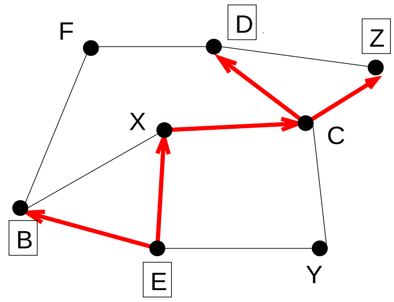
a. Assume a center-based shared multicast tree with center node C and join requests sent on unicast routes. Indicate on the figure the multicast tree and the aggregate flow on each link in each direction.
[Grading: 2 points for tree, 2 for flows]



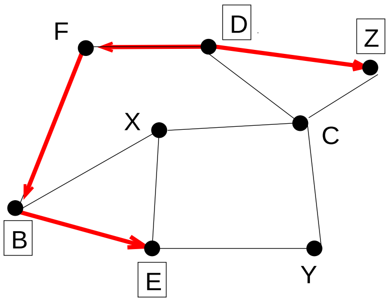
b. Assume that RPF (with pruning) is used to build source-specific routing trees. Indicate in the figures below the appropriate multicast trees.
[Grading: 1.5 points for each tree]



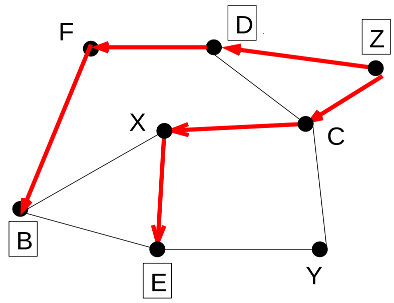
tree for B



tree for E

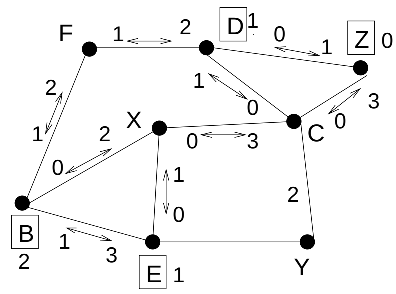


tree for D



tree for Z

c. Indicate in the figure below the aggregate flow on each link in each direction achieved in part b.
[Grading: 2 points]



4. [6 pts] Consider the following multiple access scheme that combines TDMA and slotted ALOHA. There are 30 users, separated into two groups, one of 4 users and the other of 26 users. Even time slots (i.e., 0, 2, 4, ...) are reserved for the 4-user group. Odd time slots (i.e., 1, 3, 5, ...) are reserved for the 26-user group. Contention within each group is resolved by the slotted ALOHA protocol (e.g., when a user in the 26-user group wants to send, it waits for an odd slot and then transmits with a probability p).

Determine the throughput (in packets/slot) of the system, assuming that every user always has something to send and in each group the users use the optimal probability. Your answer can be in terms of fractions.

SOLUTION

For slotted-ALOHA of N nodes, the throughput is $Np[(1-p)^{N-1}]$, where p is the transmission probability. The optimal p is $1/N$, resulting in throughput of $(1-p)^{N-1}$.

The 4-user group and even slots form a 4-node slotted-ALOHA system. Thus its max throughput is achieved when $p = 1/4$, and equals $1 - (1/4))^3$, which equals $(3/4)^3$, which equals 27/64.

The 26-user group and odd slots form a 26-node slotted-ALOHA system. Thus its max throughput is achieved when $p = (1/26)$, and equals $(1 - (1/26))^{25}$, which practially equals $1/e$.

Thus the overall throughput is $(1/2)[(27/64) + (1/e)]$.

Grading: 2 points for obtaining the expression $1 - (1/4))^3$. 2 points for obtaining the expression $(1 - (1/26))^{25}$. 2 points for combining them and getting the final answer.