cmsc 417-F04 Exam 2 SOLUTION name: ____________

Total points 30. Total time 70 mins. 4 problems over 4 pages. No book, no notes, no calculator.

1. [6 pts] Consider an error-detecting CRC with the generator 110110. The CRC bits follow the data bits in any transmission. Compute the transmitted bit sequence for the data bit sequence 111110111.

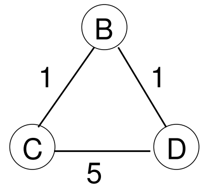
SOLUTION

```
 G = 110110
 So r=5

               101110100
  110110 ) 11111011100000
           110110
            010001
            000000
             100011
             110110
              101011
              110110
               111010
               110110
                011000
                000000
                 110000
                 110110
                    11000  = Remainder


Tx sequence (= data followed by remainder) =  11111011111000
```

Grading:

- 4 points for the division, 2 points for the transmitted sequence.
- Max 2 points for not appending “00000” before dividing.
- Max 3 points for transmitting dividend instead of remainder.

2. [10 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 *smallest* 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 between B and D becomes 8. There is no further change in the link costs.

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

SOLUTION

Time	At B, dist to D via C	At B, dist to D via D	At C, dist to D via B	At C, dist to D via D
0.1	3	1*	2*	5
1.0	3*	8	2*	5
1.1	3*	8	4*	5
2.1	5*	8	4*	5
3.1	5*	8	6	5*
4.1	6*	8	6	5*
5.1	6*	8	7	5*
6.1	6*	8	7	5*

`*' indicates minimum entry

System stabilizes at time 5.1

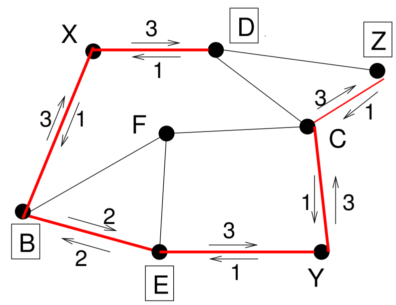
Grading:

- Lose 3 points for invalid initial entry for B (e.g., starting with distance to D via C equal to 6).
- Max 2 points for stating that stable by time 2.1.
- Lose 1 point if everything correct but stabilization time.
- Lose 2 points if everything correct but started at 2.1 instead of 1.1.
- Lose 2 points if everything correct but one line.

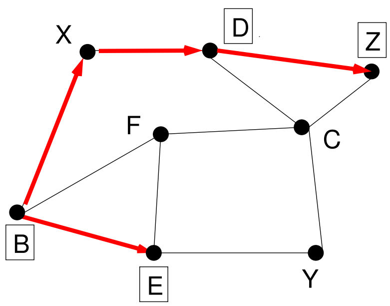
3. [10 pts] In this problem, every router is a multicast router; links are bidirectional; unicast routing is done on shortest-hop paths with ties resolved by choosing the next hop with *largest* id (where Z> $\cdots$ >C>B>A); nodes B, D, E, Z constitute a multicast group; each node in the group generates a flow of 1 packet/second to be delivered to all other nodes in the group. **Do your rough work elsewhere.**

SOLUTION

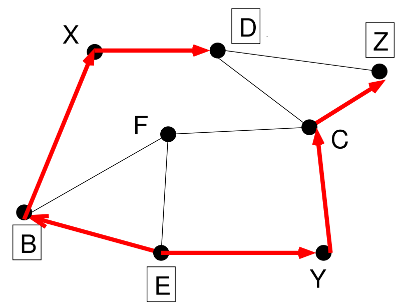
a. Assume a center-based shared multicast tree with center node E and join requests sent on unicast routes. Indicate on the figure the multicast tree and the aggregate flow on each link in each direction.



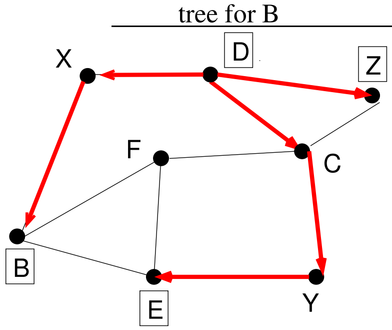
b. Assume that RPF (with pruning) is used to build source-specific routing trees. Indicate in the figures below the appropriate multicast trees.



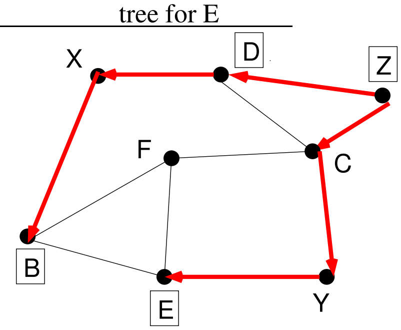
tree for B



tree for E

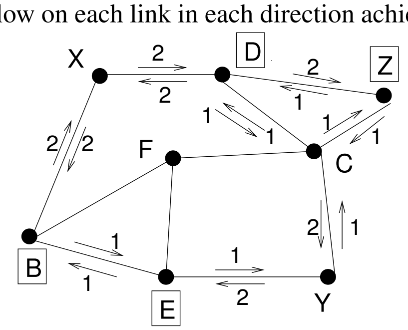


tree for D



tree for Z

c. Indicate in the figure the aggregate flow on each link in each direction achieved in part b.



Grading:

- Part a: 2 points for spanning tree. 2 points for aggregate flows.
- Part b: 1 point for each spanning tree.
- Part c: 2 points for aggregate flows.
- Lose 3 points overall if you resolved ties by using next hop of smallest id (instead of largest id).

4. [4 pts] $2N$ nodes share a wireless medium using slotted ALOHA with the following twist. The $2N$ nodes are divided into two groups of N nodes each. Each node in group 1 transmits with a probability p in each slot. Each node in group 2 transmits with a probability $2p$ in each slot. Assume that $p < 0.5$ and that every node always has packets to send.

a. Obtain the throughput (i.e., average number of packets successfully transmitted per slot). Your answer should be a formula in N and p.

b. Obtain the value of p for which group 2 gets three times the throughput of group 1. Your answer should be a number.

SOLUTION

Part a

Prob[successful transmission in a slot]
$=$ Prob[exactly one node transmits]
$=$ Prob[(exactly one group 1 node transmits AND no group 2 node transmits)
OR (exactly one group 2 node transmits AND no group 1 node transmits)]
$= N\,p\,(1-p)^{N-1}\,(1-2p)^{N} \quad + \quad N\,2p\,(1-2p)^{N-1}\,(1-p)^{N}$
$= N\,p\,(1-p)^{N-1}\,(1-2p)^{N-1}\,[\,(1-2p)\,+\,2(1-p)\,]$
$= N\,p\,(1-p)^{N-1}\,(1-2p)^{N-1}\,[\,3-4p\,]$

Part b From expression for part a, we want $3(1-2p) = 2(1-p)$ which simplifies to $3-6p = 2-2p$, or $p = 1/4$

Grading:

- Part a: 2 points. 1 point for expression of the form $Np(1-p)^{N-1} + N2p(1-2p)^{N-1}$.
- Part b: 2 points (all or nothing).