Department of Electrical Engineering and Computer Science

MASSACHVSETTS INSTITVTE OF TECHNOLOGY

6.263 Data Communications Networks: Fall 2005

Midterm Solutions

Nov. 8, 2005

1. [35 points]: Routing & MST.

A. Answer True or False. Points will be subtracted for incorrect answers. You do not need to explain your answer. (5 points for each)

(a) In a distance vector protocol that finds paths that minimize hop count, the reverse and forward paths may have different length, measured in number of hops. Assume all links are bidirectional.

A: False.

(b) In BGP, the forward and reverse path may have different length (in terms of number of AS hops).

A: True.

(c) In an undirected graph, the shortest path between two nodes lies on some minimum spanning tree.

A: False.

(d) If the edges in a graph have different weights, then the minimum spanning tree is unique.

A: True.

B. BGP resembles a distance vector protocol, except that BGP uses an AS PATH instead of a simple hop count. Consider a modification to BGP that replaces the AS PATH by the number of AS hops. Assume that the BGP routes have converged, and answer the following.

(a) Assume that the BGP policies ignore customer-provider relationships and prefer the route with the smallest number of hops. Can the resulting routes have loops? Explain.

A: No, it doesn't have loops. In this case, BGP reduces to a distance vector protocol.

(b) Assume BGP policies may ignore customer-provider relationships and have no constraints over the preferences they make. Can the resulting routes have loops? Explain.

A: Yes. Take two ASs that are connected to each other and to the destination AS0. AS1 prefers to go to AS0 via AS2, and AS2 prefers to go to destination via AS1.

C. Suppose you are given weighted undirected graph G and its minimum spanning tree T. Give an algorithm that finds the second minimum spanning tree , i.e., your algorithm should find the spanning tree of G with smallest total weight except of T. Note that the minimum spanning tree and the second minimum spanning tree differ by exactly one edge. But which edge? This is what your algorithm has to figure out.You might find it useful to look at the example below.

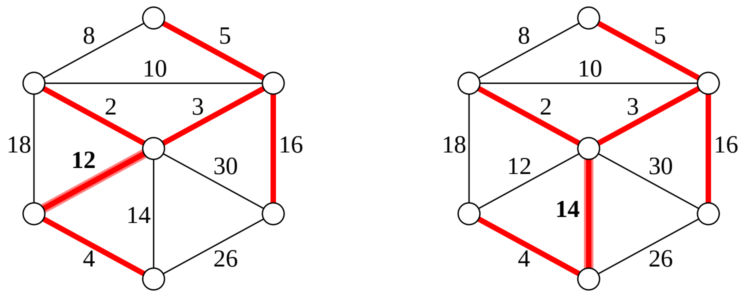

Figure 1: Example MST and the second MST.

A: Set $\Delta|T| = \infty$.
Set $E_{new} = -1$, and $E_{old} = -1$.
For every edge e that is not on the tree, do:

- Add the edge to the tree, creating a cycle.
- find k the maximum weight edge in the cycle such that $k \neq e$.
- remove k
- compute the change in the tree weight $\delta = weight(e) - weight(k)$.
- if $\delta < \Delta|T|$ then $\Delta|T| = \delta$ and $E_{new} = e$ and $E_{old} = k$.

The new tree is the one that results in from replacing E_{old} by E_{new}.

2. [15 points]: Wireless. Provide short answers for the following questions. Don't write more than 1-3 sentences for each answer.

Assume all nodes are using 802.11 MAC. The radio range is fixed. Also the radio range is slightly longer than the inter-node distance i.e., each node can reach only its left and right neighbors. Assume currently node A is sending a data packet (as opposed to an ACK, an RTS, or a CTS) to node B. Node C wants to send a packet to node D.

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A-->B  C  D
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A. Assume node C (and only C) ignores the 802.11 MAC and sends the packet, would C's packet arrive safely at D? Would A's packet arrive safely at B? Explain.

A: C's packet will arrive safely at D, while A's packet is unlikely to arrive safely at B.

B. Assume the same situation as above. If all nodes are using the 802.11 MAC, then C will wait until the end of A's transmission plus DIFS. When C uses 802.11, how does it know exactly when A's transmission end?

A: C knows how long to wait from the NAV vector in the CTS sent by B.

C. Ben who is currently taking 6.263 is doing a project about 802.11. He runs an experiment in which A sends to B as fast as possible.

A-->B

Ben notices that it happens in his experiment that B receives multiple copies of each packet. When he investigates this issue, he finds that the MAC at node A sometimes retransmits a packet to B even when node B has received the packet. Explain to Ben the likely reason of such behavior (assuming that node A is not broken).

A: The wireless link is asymmetric. It has a high delivery rate from A to B and low delivery rate from B to A. Thus, B's ACKs are getting lost.

3. [25 points]: Consider a M/G/1 queue with the following modification. If, at the instant when a customer leaves, only one other customer remains in the system, that last customer is taken with the departing customer, thus emptying the queue. In effect, the service time for that free-riding customer is 0. The arrival rate is λ and we denote by X the service time for the users who do not free-ride.

Suppose that X has an arbitrary distribution with a well-defined Laplace transform $X^*(s)$. Provide a set difference equations sufficient to express the transform for the number of customers in the queue in terms of λ and $X^*(s)$.

A:

$$Q_{n+1} = Q_n - \Delta_{Q_n} + V_{n+1}$$

where Q and V are defined as in class and $\Delta_k = k$ for $k = 0, 1, 2$ and $\Delta_k = 1$ otherwise.

4. [25 points]: Consider a M/G/1 queue with arrival rate λ and service time X with bimodal distribution: $X = 1$ with probability 0.5 and $X = 2$ with probability 0.5. Give the distribution for the residual service time witnessed by a randomly arriving customer.

A:

$f_R(r) = (1 - \rho)\delta(r) + f_{R'}(r)$

where

$f_{R'}(r) = \begin{cases} \frac{2\rho}{3} \text{ for } 0 \leq r \leq 1 \\ \frac{\rho}{3} \text{ for } 1 \leq r \leq 2 \end{cases}$

and $\rho = \frac{3\lambda}{2}$.