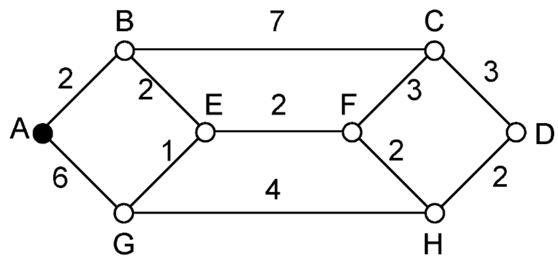
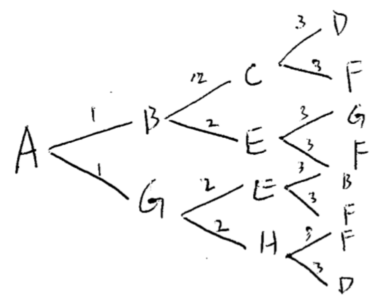
Problem 1

Consider the network of the following figure but ignore the weights on the lines. Suppose that it uses flooding as the routing algorithm. If a packet sent by A to D has a maximum hop count of 3, list all routes it will take. Also tell how many hops worth of bandwidth it consumes.



The path it will take is BCD and GHD because they are the only path within 3 hops. Since the packet can do at most 3 hops. the total hops can be listed below. Thus there are 14 hops total.



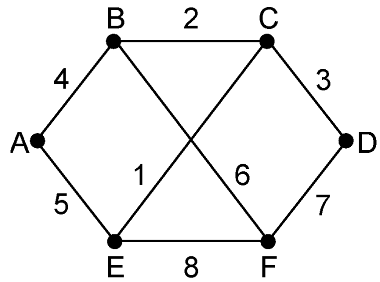
Problem 2

Give a simple heuristic for finding two paths through a network from a given source to a given destination that can survive the loss of any communication line (assuming two such paths exist). The routers are considered reliable enough, so it is not necessary to worry about the possiblity of router crashes.
Hint: Dijkstra's algorithm might be a good starting point.

Pick a route using the shortest path. Now remove all the arcs used in the path just found, and run the shortest path algorithm again. The second path will be able to survive the failure of any line in the first path, and vice versa. It is conceivable, though, that this heuristic may fail even though two line-disjoint paths exist. To solve it correctly, a max-flow algorithm should be used.

Problem 3

Consider the subnet in the following figure. Distance vector routing is used, and the following vectors just come into router C: from B: (5, 0, 8, 12, 6, 2); from D: (16, 12, 6, 0, 9, 10); and from E: (7, 6, 3, 9, 0, 4). The measured delays to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outing line to use and the expected delay.



Using the update approach discussed in class, the solution for C's routing table is (11 (B), 6 (B), 0 (C), 3 (D), 5 (E), 8 (B))

Problem 4

In the following packet buffer for router B of the previous figure, the Boolean OR of the two sets of ACF bits are 111 in every row. Is this just an accident here, or does it hold for all subnets under all circumferences?

			Send flags			ACK flags			
Source	Seq.	Age	A	C	F	A	C	F	Data
A	21	60	0	1	1	1	0	0	
F	21	60	1	1	0	0	0	1	
E	21	59	0	1	0	1	0	1	
C	20	60	1	0	1	0	1	0	
D	21	59	1	0	0	0	1	1	

It always holds. If a packet has arrived on a line, it must be acknowledged. If no packet has arrived on a line, it must be sent there. The cases 00 (has not arrived and will not be sent) and 11 (has arrived and will be sent back) are logically incorrect and thus do not exist.

Problem 5

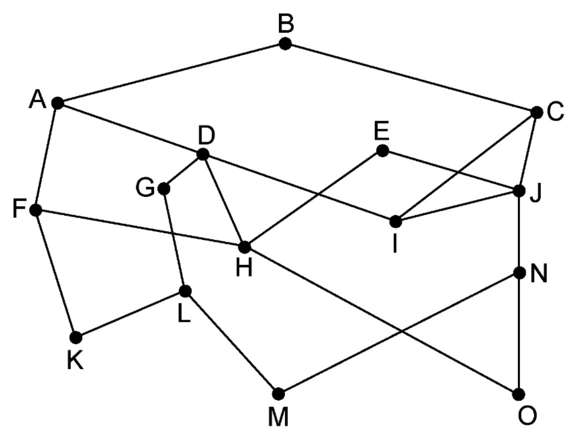
For hierarchical routing with 4800 routers, what region and cluster sizes should be chosen to minize the size of the routing table for a three-layer hierarchy? A good starting place is the hypothesis that a solution with k clusters of k regions of k routers is close to optimal, which means k is about the cube route of 4800 (around 16). Use trial and error to check out combincations where all three parameters are in the general vicinity of 16.

Use a convenient tool to search for three sizes with a product of at least 4800 (to be large enough to cover the entire network) and minimum sum (to have the smallest routing table). We found six solutions of clusters, regions and routers of sizes: (17, 17, 17), (16, 17, 18), (16, 16, 19), (15, 18, 18), (15, 17, 19), and (15, 16, 20). Of these (17, 17, 17) is the most straightforward choice. In all cases the table size is 51.

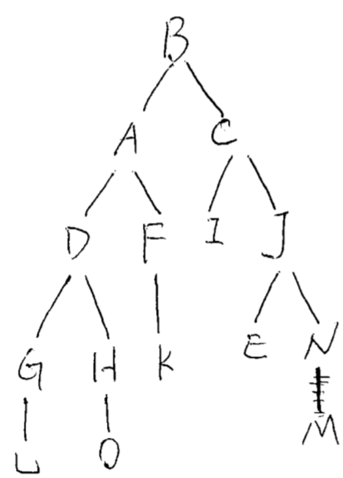
Problem 6

Looking at the subnet below, how many packets are generated by a broadcast from B, using

- reverse path forwarding
- the sink tree



- reverse path forwarding
  Assuming the routing tables follow the sink tree generated by the BFS of the graph.



Then the reverse path forwarding does the following forwarding B-A, B-C.
A-D, A-F. C-I, C-J.
D-G, D-H, D-I. F-H, F-K. I-D, I-J.
G-L. H-E, H-F, H-O. K-L.
L-K, L-M. O-N.
So there are 21 forwarding in this scenario.

- the sink tree If we use the tree from BFS, then there are 14 forwarding (i.e. number of edges).

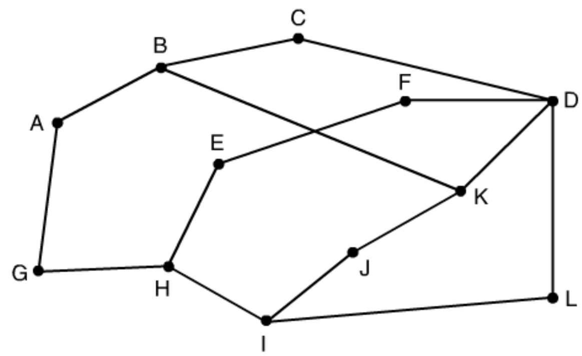
Problem 7

Consider Fig. 5-15(a) in our textbook. Image that once new line is added, between F and G, but the sink tree in Fig. 5-15(b) remains unchanged. What changes occur to Fig. 5-15(c)?

Node F currently has two descendants, A and D. It now acquires a third one, G, not circled because the packet that follows IFG is not on the sink tree. Node G acquires a second descendant, in addition to D, labeled F. This, too, is not circled as it does not come in on the sink tree.

Problem 8

Compute a multicast spanning tree for route C in the following subnet for a group with members at routes A, B, C, D, E, F, I, and K.



The tree is