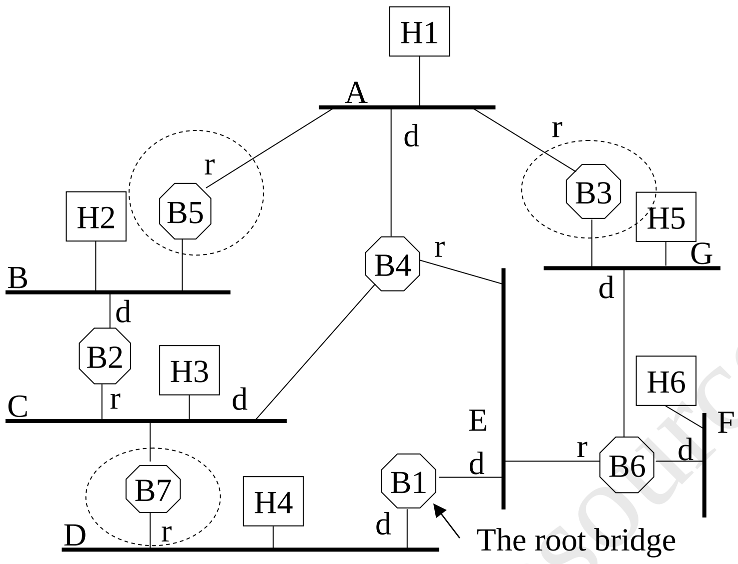
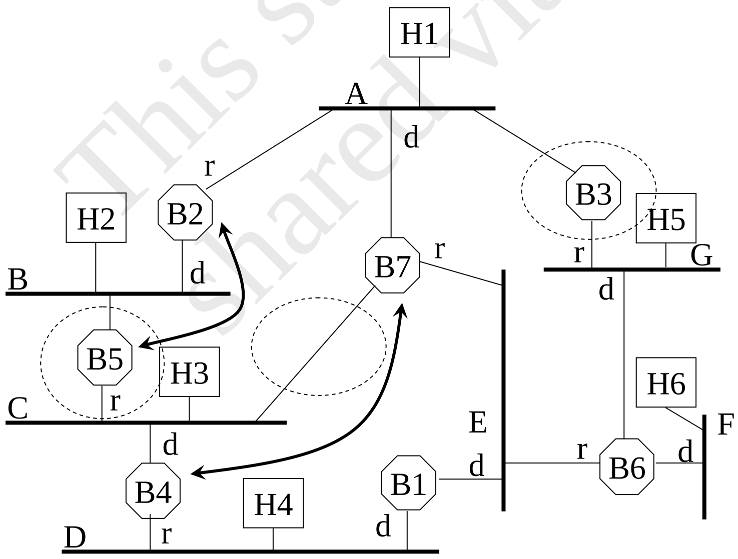
ECE 438/638: Computer Communications **Spring 2013**
Problem Set 6 Solutions

All problems carry equal weight.

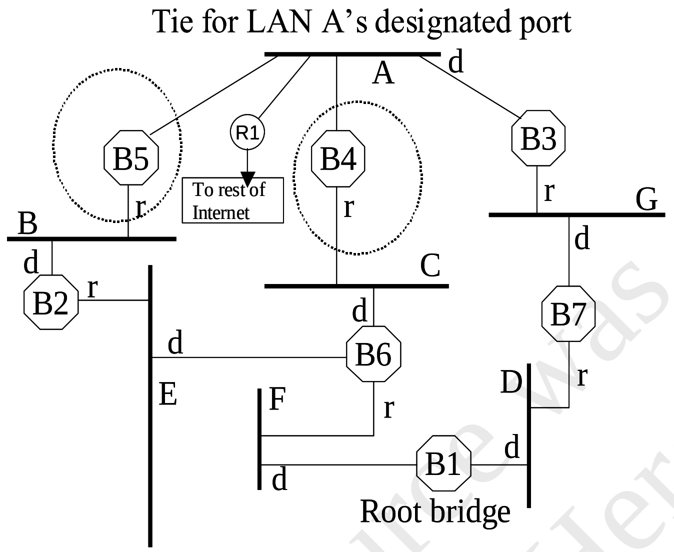
1. **Spanning Tree Algorithm for Intelligent Bridges**.
The resulting spanning tree is shown in the figure. Notice that the bridges B3, B5, and B7 do not forward *data* frames (but they do forward spanning tree control frames). Also notice there is a tie at bridge B3 for the root port, and there is a tie for which port is the designated port for both LAN's B and C.



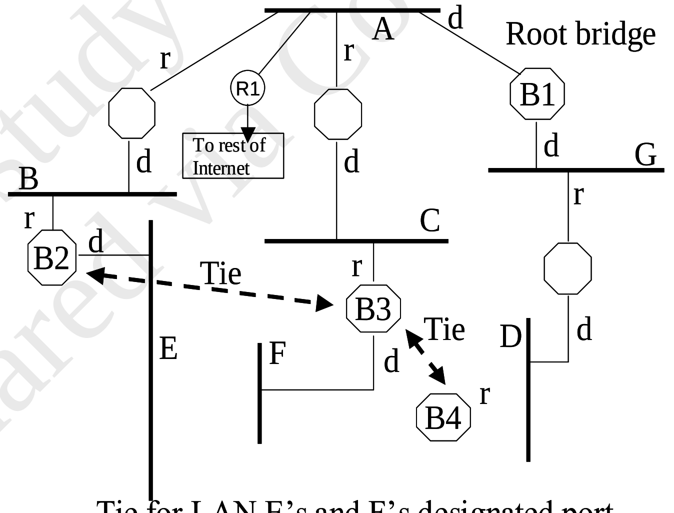
There are many solutions to the second part of the problem. One is to change B4 to B1 (making it the root) and carefully setting other bridge numbers. Another possible solution is shown in the figure below in which the root bridge is not changed. In particular, note that we need to be careful with the bridge between LAN's A and G (because of the tie), and the designated ports for LAN's B and C. In the final tree, bridges B3 and B5 do not forward data, and the link from B7 to LAN C is also removed from the spanning tree.



2. **Spanning Tree Algorithm for Intelligent Bridges**
The figure for part (a) is shown below. Note that there is a tie between B3 and B4 for the designated port for LAN A. In the final spanning tree B4 and B5 are removed from the spanning tree and do not forward data packets. Notice that all the traffic generated on LAN's B, C, D, E, and F will flow to LAN G on the way to the Internet. Thus, if each LAN generates traffic for the Internet at a rate of *R* bps, then the load carried by LAN G is 6*R*.

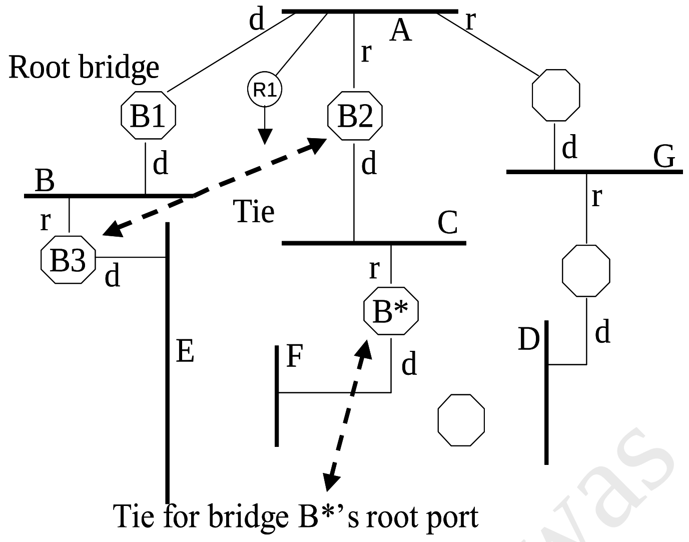


Part (b). To make a more efficient tree (with respect to forwarding traffic to the Internet) we should include bridges B3, B4, and B5 in the final tree. Also, we would like to have LAN's D, E, and F, each use a separate branch in the final tree. There are two possible solutions. For the first solution shown below, there is a tie for the designated port for LAN's E and F. So we must choose the bridge numbers for the three bridges involved in the tie in the order in the figure below (you could use different numbers but you must maintain the same ordering for these three bridges).



Tie for LAN E's and F's designated port

An alternative solution that results in the same flow for data packet traffic is show below. Notice here there is a tie for the root port for the bridge labeled B*. So we must choose the bridge numbers for the two bridges involved in the tie in the order in the figure below (you could use different numbers but you must maintain the same ordering for these two bridges). The id numbers for the other bridges is not important other than ensuring that each bridge has a unique id. With either solution the load on LAN's B, C, and G is 2*R*.



3. **Spanning Trees**. Chapter 3, number 21
   (a) If the bridge forwards all spanning-tree messages, then the remaining bridges see networks D, E, F, G, and H as a single network. The tree produced has B2 as root, and disables the following links:
      From B5 to A (the D side of B5 has a direct connection to B2)
      From B7 to B
      From B6 to either side
   (b) If B1 simple drops the messages, then as far as the spanning-tree algorithm is concerned the five networks D-H have no direct connection, and in fact the entire extended LAN is partitioned into two disjoint pieces A-F and G-J. Neither piece has any redundancy alone, so the separate spanning trees that are created leave all links active. Since bridge B1 still presumably is forwarded other message (i.e., data frames), all the original loops still exist.

4. **IP Fragmentation**. (a) Leaving 20 bytes for the IP header, the MTU of 900 bytes on the first network allows an IP packet with 880 bytes to be carried. Because 880 is a multiple of 8, the size does not need to be adjusted to account for the 8 byte boundary constraint. Thus, the original IP packet is broken into two IP packets on the first subnetwork.

M	offset in bytes	offset in 8-byte units	bytes data	Total size of IP packet
1	0	0	880	900
0	880	110	320	340

(b) In the second subnetwork the first of the two fragments is fragmented again. Thus, the three IP packets carried in the second subnetwork have sizes given in the table. The size 576 is used because it is the smallest multiple of 8 less than or equal to 580 (i.e., 600-20).

M	Offset in bytes	offset in 8-byte units	bytes data
1	0	0	576
1	576	72	304
0	880	110	320

(c) The destination host receives the same packets carried by the second subnetwork. Reassembly is done at the destination only, so the answer for part (c) is identical to the answer to part (b).

5. IP **Fragmentation**. Chapter 3, number 34
The IPv4 header allocates only 13 bits to the Offset field, but a packet's length can be up to 2^{16} bytes since the length field is 16 bits. In order to support fragmentation of a maximum-sized packet, we must count offsets in multiples of $2^{16-13} = 2^3$ bytes.

The only concerns with counting fragmentation offsets in 8-byte units are that we would waste space on a network with MTU = 8n + 7 (for some integer n), or that alignment on 8-byte boundaries would prove inconvenient. 8-byte chunks are small enough that neither of these is a significant concern.

6. IP **Fragmentation**. Chapter 3, number 41
IPv4 effectively requires that, if reassembly is to be done at the downstream router, then it be done at the link layer, and will be transparent to IPv4. IP-layer fragmentation is only done when such link-layer fragmentation isn't practical, in which case IP-layer reassembly might be expected to be even less practical, given how busy routers tend to be. See RFC791, page 23.

IPv6 uses link-layer fragmentation exclusively; experience had by then established reasonable MTU values, and also illuminated the performance problems of IPv4-style fragmentation. (TCP path-MTU discovery is also mandatory, which means the sender knows just how large TCP segments can be to avoid fragmentation.)

Whether or not link-layer fragmentation is feasible appears to depend on the nature of the link; neither version of IP therefore requires it.

7. **Subnetting**. Chapter 3, number 55
Apply each subnet mask and if the corresponding subnet number matches the SubnetNumber column, then use the entry in Next-Hop. (In these tables there is always a unique match.)

(a) Applying the subnet mask 255.255.255.128, we get 128.96.39.0. Use interface0 as the next hop.
(b) Applying subnet mask 255.255.255.128, we get 128.96.40.0. Use R2 as the next hop.
(c) All subnet masks give 128.96.40.128 as the subnet number. Since there is no match, use the default entry. Next hop is R4.
(d) Next hop is R3.
(e) None of the subnet number entries match, hence use default router R4.

8. **Subnet** design. Chapter 3, number 68
(a) Giving each department a single subnet, the nominal subnet sizes are 2^7, 2^6 , 2^5 , 2^5 respectively; we obtain these by rounding up to the nearest power of 2. A possible arrangement of subnet numbers is as follows. Subnet numbers are in binary and represent an initial segment of the bits of the last byte of the IP address; anything to the right of the / represents host bits. The / thus represents the subnet mask. Any individual bit can, by symmetry, be flipped throughout; there are thus several possible bit assignments.

		Subnet number	Subnet mask	
A	0/	200.1.1.0	255.255.255.128	one subnet bit, with value 0; seven host bits
B	10/	200.1.1.128	255.255.255.192	
C	110/	200.1.1.192	255.255.255.224	
D	111/	200.1.1.224	255.255.255.224	

The essential requirement is that any two distinct subnet numbers remain distinct when the longer one is truncated to the length of the shorter.

(b) We have two choices: either assign multiple subnets to single departments, or abandon subnets and buy one or more bridges. Here is a solution giving A two subnets, of sizes 64 and 32; every other department gets a single subnet of size the next highest power of 2:

		Subnet number	Subnet mask	host id's
A	01/	200.1.1.64	255.255.255.192	64-127
	001/	200.1.1.32	255.255.255.224	32-63
B	10/	200.1.1.128	255.255.255.192	128-191
C	000/	200.1.1.0	255.255.255.224	0-31
D	11/	200.1.1.192	255.255.255.192	192-255