1 Wireless

1. Consider five wireless stations: A, B, C, D, and E. Station A can communicate with all other stations. B can communicate with A, C and E. C can communicate with A, B and D. D can communicate with A, C and E. E can communicate with A, D and B.

(a) When A is sending to B, what other communications are possible?
(b) When B is sending to A, what other communications are possible?
(c) When B is sending to C, what other communications are possible?

2. The topology in Figure 1 consists of 6 wireless nodes, A through F, illustrated by the corresponding dots. The circle around each node illustrates its transmission range. For example, A’s transmission area is shown by the shaded circle. The transmissions of two nodes interfere if and only if they transmit at the same time and their transmission areas overlap.

(a) For the transmission from A to B, list the potential hidden terminals from A and the exposed terminals.

(b) Assume you are using an RTS/CTS protocol to reduce the hidden/exposed terminal problems.
   i. Explain what prevents a hidden terminal from interfering with a sender.
ii. Explain how a terminal infers that it is exposed and can thus send to another destination.

iii. An exposed terminal in an RTS/CTS protocol may still be unsuccessful in sending. Explain how this is possible.

2 Spanning Tree Algorithm

1. Consider the network shown in Figure 2, where the letters A to J represent LANs and the circles B1 to B7 represent switches.

![Figure 2: Network for spanning tree algorithm](image)

(a) Indicate which ports are not selected by the spanning tree algorithm.

(b) Assume that switch B1 suffers catastrophic failure. Indicate which ports are not selected by the spanning tree algorithm after the recovery process when a new tree has been formed.

2. Consider hosts A, C, E and switches S1 to S6 with empty forwarding tables initially, connected as Figure 3 shows. The address of Sx is 00:00:00:00:00:0x.

(a) Which links are removed after the completion of the spanning tree? Mark the removed link(s) directly on Figure 3. Use the lowest switch address to break ties.

(b) Fill in the forwarding table at each switch after each transmission. Assume that each transmission starts after the previous has finished and the forwarding tables have been updated. In the forwarding table at each node, identify the port by the unique LAN segment (e.g., La, Lc) reachable using that port or the label of the link (e.g., ℓ_{12}, ℓ_{23}) that is connected to that port. In each cell, write only the forwarding information that gets updated and not the whole forwarding table.
3 Data transmission

1. How much bandwidth is needed to send computer screen images through an optical fiber? Assume the screen is 1920x1080 pixels, and each pixel carries 24 bits. The framerate is 60 images per second.

2. A direct Swiss flight between Zürich and New York takes 8h54m. You get on this flight, and take with you a 4 terabyte hard drive. Assume 4 terabytes is 32 terabits (3.2 \cdot 10^{13} \text{ bits}). Once you land in New York:
   (a) What was the data transmission rate (in Gigabits/s)?
   (b) What was the propagation delay?
   (c) How long would it take to transfer the same amount of data on a typical home fiber connection (assume a data transfer rate of 100 megabits/s)?
   (d) Since the flight time is constant for any amount of data (1 byte or 100 terabytes), up to how much data does it make sense to transfer over the fiber connection?

3. Suppose a 100 Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is 385,000 km and data travels over the link at the speed of light (3 \cdot 10^8 \text{ m/s})
   (a) Calculate the minimum delay for the link.
   (b) Calculate the bandwidth-delay product for the link.
(c) A camera on the lunar base takes pictures of Earth and saves them in digital format to disk. Suppose Mission Control on Earth wishes to download the most current image (25 MB). What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?