

### 1. Ethernet Timing

This problem is about the Ethernet/IEEE 802.3 access protocol. To be definite, suppose that if a host detects a transmission while it is transmitting a frame, then: (i) if the host has already transmitted the 64-bit preamble, the host stops transmitting the frame and sends a 32-bit jamming sequence; (ii) else the host finishes transmitting the 64-bit preamble and then sends a 32-bit jamming sequence. Suppose the packets are 512 bits long, which is the minimum length allowed. Hosts A and B are the only active hosts on a 10 Mbps Ethernet and the propagation time between them is  $25 \mu\text{s}$ , or 250 bit durations. Suppose A begins transmitting a frame at time  $t = 0$ , and just before the beginning of the frame reaches B, B begins sending a frame, and then almost immediately B detects a collision. NOTE: For simplicity, please ignore the  $9.6 \mu\text{s}$  inter-frame wait time in the Ethernet protocol.

- Does A finish transmitting the frame before it detects that there was a collision? Explain.
- What time does A finish sending the jamming signal? What time does B finish sending the jamming signal?
- What time does A hear an idle channel again? What time does B first hear an idle channel again?
- Suppose each host next decides to retransmit immediately after hearing the channel idle. After the resulting (second) collision: When does A next hear the channel idle? When does B next hear the channel idle?
- Suppose after the second collision, A decides to wait 512 bit durations to retransmit (if it hears silence after that long) and B decides to retransmit immediately after hearing a silent channel. Is the transmission of host B successful?

### 2. Multiple Access

Suppose nodes  $A$  and  $B$  are ready to send a packet at the same time a third node ends transmission on a 10 Mbps Ethernet. In the  $i$ th round after  $i - 1$  collisions have already occurred, the two nodes wait  $0, 1, \dots, 2^{i-1} - 1$  slots until the next attempt, all  $2^{i-1}$  choices having equal probability.

- Find the probability  $q_i$  of a collision in the  $i$ th round, given that there are collisions in the previous  $i - 1$  rounds (i.e.  $q_1 = 1, q_2 = 1/2$ ), for all  $i \geq 1$ .
- Find the probability  $p_i$  that exactly  $i$  rounds are needed for the first success, and compute  $p_1, p_2, \dots, p_4$ .
- Now assume that after the first collision, node  $A$  “wins” the backoff and transmits successfully. After it is finished, both nodes try to transmit again ( $A$  has an infinite amount of traffic to send), causing a collision. After this collision, the  $A$ ’s collision counter is at 1 and  $B$ ’s is at 2. Compute the probability that  $A$  wins again.
- Given that  $A$  “won” the first round, compute the probability that  $A$  captures the network for the next 5 frames.

### 3. Token Ring Networks

In a token ring network, a station is allowed to hold the token for some period of time, the *token holding time*, THT. Let RingLatency denote the time it takes the token to make one complete rotation around the network when none of the stations have any data to send.

- In terms of THT and RingLatency, express the efficiency of the network when only one station is active. Assume early release for the next few questions.
- What setting of THT would be optimal for a network that only had one station active (with data to send) at a time?
- In the case where  $N$  stations are active, give an upper bound on the token rotation time, TRT, for the network.

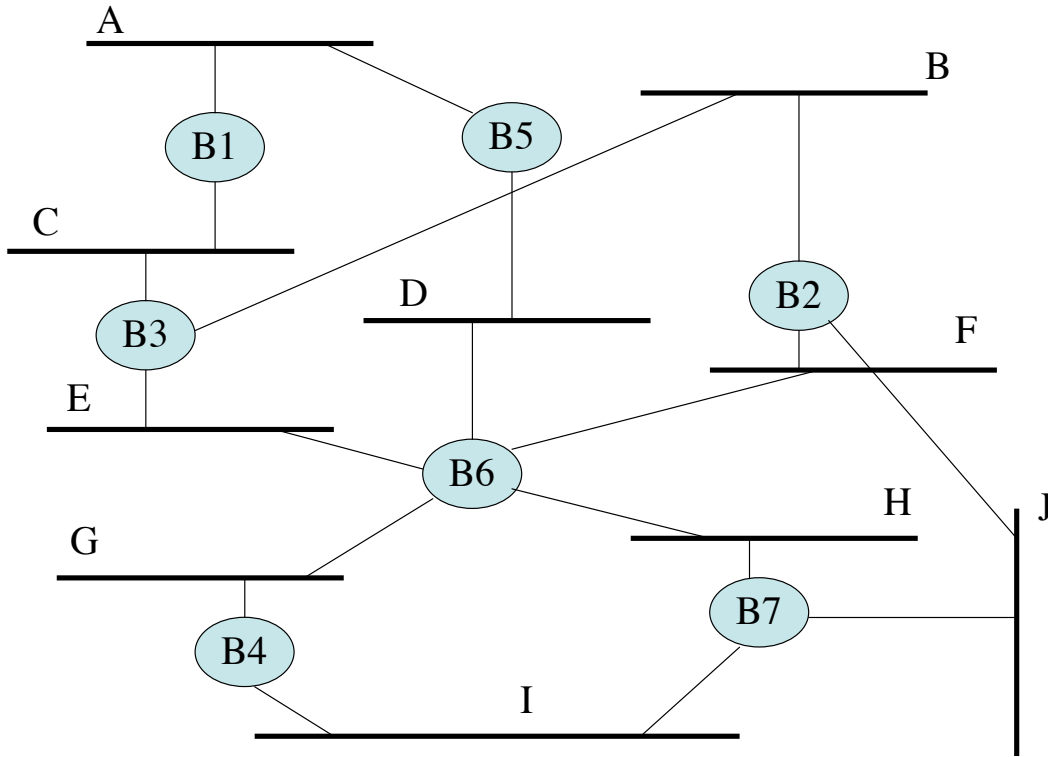


Figure 1: Bridged Network Configuration

- (d) Let  $N = 100$ ,  $\text{THT} = 1000 \mu\text{s}$ , and  $\text{RingLatency} = 200\mu\text{s}$ . Compute the efficiency of this network if all  $N$  nodes are active and are using early release.
- (e) Compute the efficiency of the above network if delayed release is used.

#### 4. Bridges

Consider the network configuration in Figure 1 for this question.

- (a) What ports would be *not* selected by the spanning tree algorithm? (The ID of each bridge is its number, i.e.  $B1$  has ID 1.) List ports as pairs (bridge, network), i.e.  $(B1,A)$ .
- (b) To simplify thinking about the spanning tree problem, suppose that communication among bridges happens in rounds. In each round, a bridge will forward the configuration message it received from the root in the previous round to all its other links, or, if it had not received this message, become root and send a new configuration message.  
Suppose that bridge  $B1$  fails at round 0 (i.e. it sent out its last message in round -1). How long will it take for the network of bridges to form a new tree?
- (c) List the ports that are not selected by the new spanning tree.