15-441: Computer Networks
Assignment 1

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1 Theoretical Transmission Limits

For the following, compute the maximum throughput of the given media and encoding, in bits per second. Show any work used to calculate the throughput.

1. 20KHz band, binary encoding.
2. 50KHz band, S/N is 3000.
3. Phone connection with frequency range between 300 and 3000Hz. S/N is 30dB.
4. Cable Internet providers like Comcast usually offer much higher maximum download speeds than maximum upload speeds. Explain why Shannon's theorem might predict this discrepancy, despite the bandwidth being the same both ways.

2 Transmission Speeds and HTTP

A web browser is accessing a website that is 1KB in size. The website also contains 15 pictures, each 10KB in size. The usual mode for downloading the content is for the browser and server to follow the following protocol:

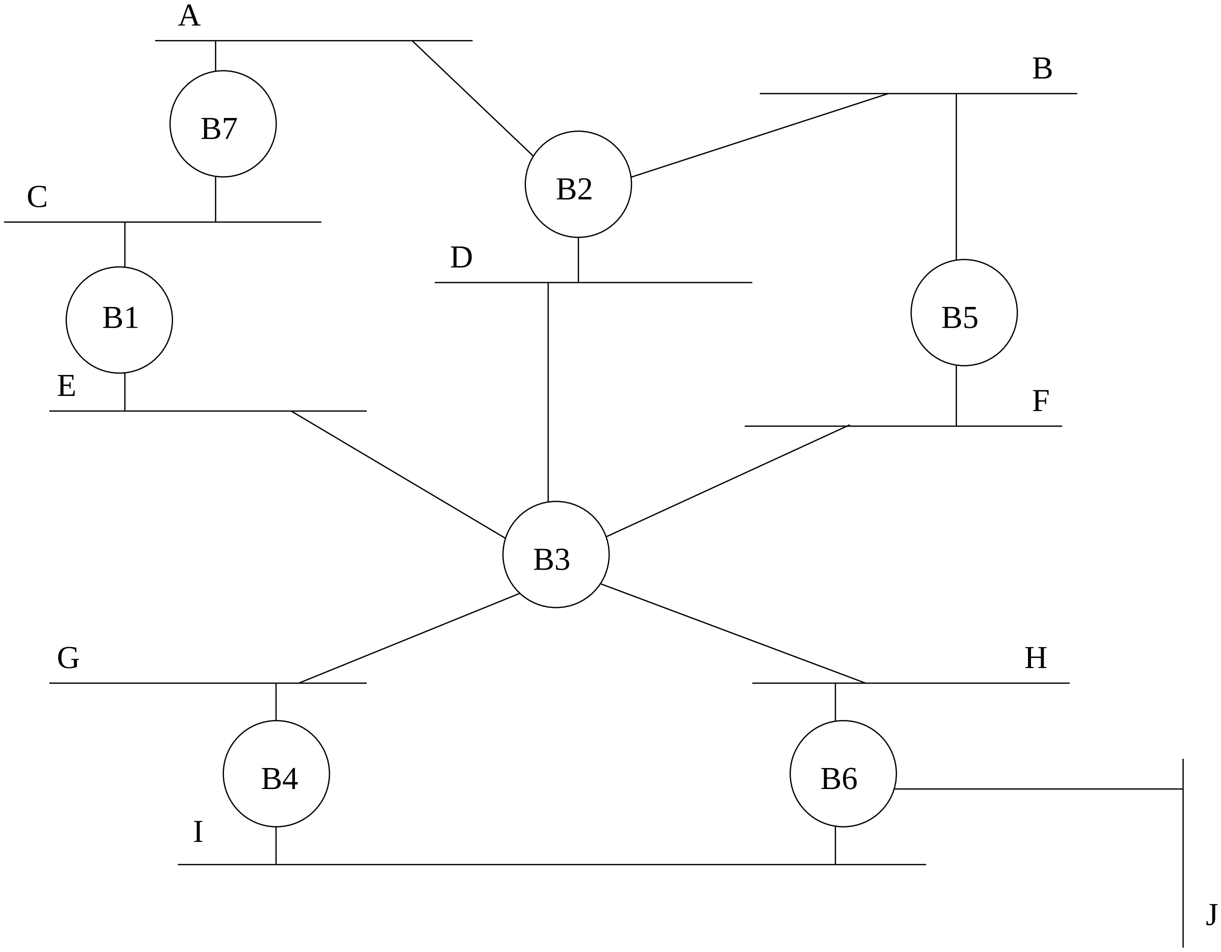
- Client connects with server, taking 1 RTT.
- Client sends GET request to server.
- Server responds with data.
- Client disconnects from server, taking 1 RTT.

Assume that the RTT between the browser and the web server is exactly 100ms. Assume the size of the GET request is negligible. Calculate the total amount of time the browser takes to download the data under the following circumstances:

1. The bandwidth is 1.5Mbps, and the web browser accesses each item individually and with a separate connect / disconnect cycle.
2. The bandwidth is 1.5Mbps, and the web browser uses a Keep-Alive connection with the server, and only connects / disconnects with the server once. Each item is requested with one GET command after the previous has finished transmission.
3. The bandwidth is 1.5Mbps, and the web browser is able to pack multiple HTTP GET requests into one transmission. After downloading the HTML file, the browser then requests all 15 pictures.

3 Switching and Flow Control

Peterson and Davie, Exercise 3.13



Given the extended LAN shown above, indicate which ports are not selected by the spanning tree algorithm.

4 Ethernet

Peterson and Davie, Exercise 2.44

Let A and B be two stations attempting to transmit on an Ethernet. Each has a steady queue of frames ready to send; A's frames will be numbered A_1, A_2, and so on, and B's similarly. Let $T = 51.2\mu s$ be the exponential backoff base unit.

Suppose A and B simultaneously attempt to send frame 1, collide, and happend to choose backoff times of $0xT$ and $1xT$, respectively, meaning A wins the race and transmits A_1 while B waits. At the end of this transmission, B will attempt to retransmit B_1 while A will attempt to transmit A_2. These first attempts will collide, but now A backs off for either $0xT$ or $1xT$, while B backs off for time equal to one of $0xT, \ldots, 3xT$.

1. Give the probability that A wins this second backoff race immediately after the first collision, that is, A's first choice of backoff time $kx51.2$ is less than B's.
2. Suppose A wins this second backoff race. A transmits A_3, and when it is finished, A and B collide again as A tries to transmit A_4 and B tries once more to transmit B_1. Give the probability that A wins this third backoff race immediately after the first collision.
3. Give a reasonable lower bound for the probability that A wins all the remaining backoff races. Assume a maximum 16 retries for the remaining retransmission attempts.

4. What then happens to the frame B_1?

This scenario is known as the Ethernet *capture effect.*

5 Bit Packing

Peterson and Davie, Exercises 2.5 - 2.6

1. Assuming that we are using the HDLC protocol for bit stuffing, show the bit sequence transmitted over the link when the frame contains the following bit sequence:

   ```
   110101111101011111101011111110
   ```

   Mark the stuffed bits.

2. Suppose the following sequence of bits arrives over a link:

   ```
   1101011111010111110010111110110
   ```

   Show the resulting frame after any stuffed bits have been removed. Indicate any errors that might have been introduced into the frame.

3. Given an original data size of 60 bits, (a) what is the largest number of bits that may need to be transmitted, and (b) what is the smallest number of bits? Remember to include both begin and end frame markers.

6 Signal Encodings

Consider the following possible encodings:

1. Manchester encoding
2. NRZ
3. NRZI

Determine which encodings may have problems with long strings of 0s, long strings of 1s, or neither, and explain why they might be problematic. If an encoding is not problematic for either, explain why it is more robust against such messages.