Midterm Exam (EECS 333) Introduction to Communication Networks

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2-2:50 pm, April 27, 2007

Requirements

• You have 50 minutes to complete the exam. Use your time strategically.
• This is a closed book closed notes exam. Work on your own.
• Some formulas and constants you may or may not need are listed in below.
• Make sure to provide justification for your answers. A correct numerical answer without justification may be considered wrong.
• If we cannot read it, we cannot grade it.

Some Formulas May or May not Be Useful

• A Poisson random variable $X$ with its mean value equal to $\lambda$ has the following probability mass function:
  $$P\{X = n\} = \frac{1}{n!}\lambda^n e^{-\lambda}.$$

• Shannon capacity of an additive white Gaussian channel of bandwidth $B$ is
  $$C = B \log_2\left(1 + \frac{P}{BN_0}\right) \text{ bits/s}$$

  where $P$ is the received signal power and $N_0$ is the noise power per unit bandwidth. Usually $P/(BN_0)$ is referred to as the signal-to-noise ratio (SNR).

Constants

• $\sqrt{2} \approx 1.41$. $\sqrt{3} \approx 1.73$. $e \approx 2.72$.
• $\ln 2 \approx 0.69$. $\ln 3 \approx 1.10$. $\ln 9 \approx 2.20$. $\ln 10 \approx 2.30$.
• $\log_2 10 = \ln 10 / \ln 2 \approx 3.32$. $\log_2 3 = \ln 3 / \ln 2 \approx 1.58$.
• The speed of light in copper is $2 \times 10^8$ meters per second.
Problem 1  (5 points)

Tick the correct answer(s) to each of the following questions. Choose all that apply.

1. The number of links in a fully connected non-directional network of \( N \) nodes is (a) \( N \); (b) \( N^2 \); (c) \( N^2 - N \); (d) \( N^2/2 - N/2 \); (e) \( N^N \); (f) \( 2^N \).

2. The IP (Internet Protocol) corresponds to which layer of the 7-layer OSI reference model? (a) Physical layer; (b) Data link layer; (c) Network layer; (d) Transport layer; (e) Session layer; (f) Representation layer; (g) Application layer.

3. Channelization strategies such as FDMA, TDMA and CDMA are more suitable (a) for burst traffic than for constant rate traffic; (b) for video streams than for paging; (c) for heavy traffic than for light traffic.

4. An error-control code with minimum Hamming distance of 11 is capable of (a) detecting 11 bits of error; (b) detecting 5 bits of error; (c) correcting 5 bits of error; (e) correcting 11 bits of error.

5. Consider the data link layer of a direct link between two stations. Flow control is used (a) for the two stations to share the resource fairly; (b) to prevent transmit window overflow; (c) to prevent a transmitter from overrunning a receiver’s buffer; (d) to transmit frames as quickly as possible whenever the link is free.

Problem 2  (4 points)

Suppose that a band-pass communication system has a 25 kHz bandwidth. Let the noise be additive and Gaussian distributed. If we want to send 62.5 kbps reliably through the channel. What is the minimum required signal-to-noise ratio?
Problem 3  (4 points)

Suppose Martin sends a 2000-bit frame using his laptop from the Tech to Norris Center through a straight copper wire at 100 Mbps. By the time the first bit of the frame arrives at Norris Center, has the last bit of the frame left Martin’s laptop or not?

Problem 4  (6 points)

The Transmission Control Protocol (TCP) is widely used in the Internet. A key function of TCP is congestion control, namely adjusting the transmission rate according to the round trip time inferred from the time it takes to receive the ACKs. This adjustment is carried out in real-time. In general, congestion causes delay in packet transmission. We will learn TCP later in this course, but by now you have enough knowledge about ARQ to answer the following questions.

1. What is the main advantage of Go-Back-N compared to Stop-and-Wait?

2. Generally speaking, how large should the transmit window size be in the Go-Back-N scheme? If you are not sure, then give the key factors which have an impact on the window size.

3. Suppose the transmission rate is adjusted by varying the size of the transmission window. Should we increase the window size or decrease the window size if the round trip time is observed to have increased? Justify your answer.
Problem 5  (6 points)

Consider a slotted Aloha system. Assume that the aggregate transmission attempts by the large number of users are modelled as a Poisson processes with average rate $G$ transmissions per slot.

1. What is the probability a transmission is successful on its first attempt?

2. What is the probability that it takes exactly $k$ attempts for a transmission to be successful?

3. What is the average number of transmission attempts needed for a packet to be successful?

4. Suppose the receivers are improved so that if no more than two users transmit in the same slot, both frames are received correctly. Collision takes place only if three or more frames are sent during the same slot. What is the throughput $S$ as a function of the load $G$?