## FINAL

# EE/TE4367 Telecommunications Switching \& Transmission SPRING 2007, Prof. Murat Torlak 

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## Problem 1. General, 25 points

(a) List two fundamental approaches to transferring information over a packet switching network.
(b) A packet contains three major fields: $\qquad$ , $\qquad$ , and
$\qquad$ . (Fill up the blanks)
(c) The internet is composed of many networks that communicate with each other using $\qquad$ . (Fill up the blank)
(d) Modulation can be classified into two categories. Name them and give a digital modulation example for each category.
(e) The open systems interconnection (OSI) reference model divides the basic communication functions required for computers to communicate into the seven layers. Name at least four of the seven layers.

## Problem 2. Digital Communications (25 points)

Consider a digital communication system using BPSK signaling at a transmission rate of 4800 bps.
(a) Find the probability of bit error of BPSK when $E_{b} / N_{0}=8 \mathrm{~dB}$ in AWGN channel. Note that you can use the following approximation for probability of error

$$
P_{b}=Q\left(\sqrt{\frac{2 E_{b}}{N_{0}}}\right) \approx e^{-E_{b} / N_{0}}
$$

(b) The transmitted energy of BPSK signaling is $E_{b}=A^{2} T_{b} / 2$, where $T_{b}$ is the bit interval and $A$ is the signal amplitude. Determine the signal amplitude required to achieve an error probability of $10^{-6}$ if the two-sided noise power spectral density $N_{0} / 2=0.5 \times 10^{-10}$ watts $/ \mathrm{Hz}$. You can use the approximation in part (a).
(c) Suppose that you need to increase the data rate to 38.4 kbps using the same bandwidth as BPSK signaling. You can achieve this increase using M-PSK signaling without needing to increase the transmission bandwidth. M can be determined as the number of points in the M-PSK constellation and can be
increased until the data rate becomes 38.4 kbps while the bandwidth remains the same. Determine the number of points M in the new constellation.

## Problem 3. Cellular Communications ( 25 points)

A cellular network operates hexagonal cells with $\mathrm{R}=2 \mathrm{~km}$ radius with $\gamma=3$.
(a) Determine the cluster size if the system can tolerate an SIR of 15 dB . Find a possible i and j pair for this cluster size.
(b) Determine the distance between the nearest co-channel cells in this system for the cluster size found in part (a).

## Problem 4. Packet Switching ( 25 points)

An audiovisual application running on Workstation A uses packet switching to transmit speech and video over the following network connection to Workstation B.


The network connection is established using packet switching. We consider using a packet format which contains 640 bits of speech and video message. Each packet has a 40 byte header. Size of other fields in the packet is negligible.
(a) Find out what percentage of each packet is header overhead.
(b) Draw a time diagram and identify all the components of the end-to-end delay. Keep it in mind that a packet cannot be sent until it has been filled and that a packet cannot be relayed until it is completely received (that is, store and forward). Assume no bit errors.
(c) Evaluate all the delay components for which you have been given sufficient information. Consider both choices of packet length. Assume that the signal propagates at a speed of $1 \mathrm{~km} / 5$ miroseconds. Consider two cases of backbone network speed: 45 Mbps and 1.5 Mbps as indicated in the diagram above.

