KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

COE 540 –Computer Networks
Nov 25th, 2011 – Midterm Exam

Student Name:
Student Number:
Exam Time: 90 mins

- Do not open the exam book until instructed
- The use of programmable calculators and cell phone calculators is not allowed – only basic calculators are permitted
- Answer all questions
- All steps must be shown
- Any assumptions made must be clearly stated

Question No.	Max Points	
1	40	
2	50	
3	30	

Total: 120

Q.1) (40 points) On the subject of probability theory and queueing

a) **(20 points)** ATM cells arrive to a communications buffer with exponential interarrival times of mean 1 millisecond. Let the interarrival time random variable be denoted by *T*.

(1) **(5 points)** Write the probability density function (PDF) for the interarrival time random variable.

(2) **(5 points)** If our interest is the number of ATM cells arriving in *t* seconds, what probability mass function (PMF) characterizes this random variable? (state the name and write an expression for the PMF).

(3) **(5 points)** What is the mean number of cells arriving in 15 ms?

(4) **(5 points)** What is the probability of no ATM cell arriving in a period of 50 milliseconds?

b) (20 points) Assume traffic is arriving at the input port of a router according to a Poisson arrival process of rate λ = 100 packets/sec. If the traffic distribution is as follows:

30% of packets are 512 Bytes long,

50% of packets are 1024 Bytes long,

20% of packets are 4096 Bytes long

If the transmit speed of the router output port is 1.5 Mb/s

(1) **(5 points)** What is the average packet transmit time?

(2) **(5 points)** What fraction of time will the router buffer be empty?

(3) **(5 points)** What is the average packet waiting time before transmit?

(4) **(5 points)** What is the average buffer size in the router?

Hint: the P-K mean value formula is $E[W] = \frac{\lambda E[\tau^2]}{2(1-\rho)}$.

Q.2) (50 points) On the subject of data link and ARQ protocols

a) **(20 point)** Assume a sliding window protocol is used on a link that connects node A to Nod B through a geostationary satellite relay station. Let the sliding window size, W, be 7 and the frame length, L, equal to 1500 Bytes. Ignoring the ACK and processing times it is required to:

(1) Plot the utilization of the link AB as a function of the bit rate R offered by the service provider.
(2) What is the maximum possible throughput link AB in frames per second.

Assume a geostationary orbit for the satellite (i.e. d = 36,000 km) – speed of light, c, is $3\text{x}10^8$ m/sec.

b) (**10 points**) Given a string of s_i bits where i=1,2, …,n. A single parity bit is added c_{n+1} such that c_{n+1} is equal to the Modula 2 sum of all s_i's. If the bit error probability is p and bit errors are independent and identically distributed (IID), what is the probability of an undetected error in the code word using this scheme? What is the *burst detecting capability* of this single parity check scheme?

c) **(20 points)** Assume frame lengths occur as follows: 30% of frames are of length equal to 64K bytes, 50% of frames are of length 256K bytes, while the remaining 20% are of length 512K bytes.

(1) What is the average frame length? And the standard deviation for frame lengths?
(2) Draw the cumulative distribution function for the frame length variable.
(3) What is the minimum number of bits required to encode the frame length information.
(4) If *all* frames are of length 256K bytes, then what is the minimum number of bits required to encode the frame length information.

Q.3) (**30 points**) On the subject of Fourier series expansion, channels, and channel capacity and modulation

Consider the transmitted signal $s(t)$ in Volts for $t \in (-\infty, \infty)$ given by

$$s(t) = (2\cos(t))^2 + \sin(t)$$

(1) **(3 points)** Compute the period T in seconds for the signal $s(t)$.

(2) **(5 points)** Specify all the harmonics including the DC component and specify the amount of power for each component.

(3) **(2 points)** Compute the power for the signal $s(t)$.

(4) **(3 points)** Compute the energy for the signal $s(t)$.

(5) **(7 points)** The signal $s(t)$ is transmitted using a carrier radio frequency of 500 MHz to a receiver that is located 5 Km away from the transmitter. Compute the power of the received signal in dBW. Assume the free-space propagation model applies with unity gains for the transmit and receive antennas.

(6) **(10 points)** If the channel bandwidth for the described communication link is 4000 Hz and noise spectral density figure N_0 is equal to -150 dBW per Hz, compute the maximum possible capacity for this link in bits per second.

Hint: The term $(\cos(t))^2$ may be written as $0.5 + 0.5\cos(2t)$ and the Fourier series expansion of a signal $s(t)$ is given by $\frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos(2\pi f_0 t) + \sum_{n=1}^{\infty} b_n \sin(2\pi f_0 t)$, where $a_0 = \frac{2}{T}\int_0^T s(t)dt$, . $a_n = \frac{2}{T}\int_0^T s(t)\cos(2\pi n f_0 t)\, dt$, and $b_n = \frac{2}{T}\int_0^T s(t)\sin(2\pi n f_0 t)\, dt$. f_0 is the fundamental frequency for the periodic signal in Hz. Let the speed of light be $c = 3 \times 10^8$ m/s. The end numerical result of part Y may depend on the end numerical result from a preceding part X. If you cannot obtain the required numerical result of one part, if any, to use in part Y, please assume the desired quantity to be equal to some variable and proceed with the solution.