PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

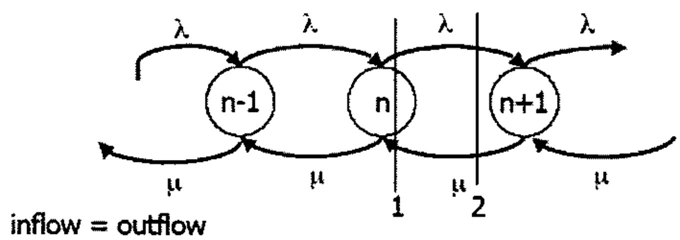
Mid-Term Examination: Semester I — Academic Year: 2010
Date: 3 August 2010 — Time: 13.30 – 15.30 (2 hrs)
Subject: 241-552 Computer and Queueing Networks — Room: S203

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- In this exam paper, there are FOUR questions, 12 pages (including cover page). Answer ALL questions,
- All notes and books are **not** allowed,
- Answers could be either in Thai or English,
- Any calculators are not allowed.

1. Explain the following terms clearly (20 Marks)

1.1 Below is a birth-death process, at equilibrium, write down balance equations at 1 and 2 (3 Marks)



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1.2 What are the differences between Poisson and Exponential Distributions? (3 Marks)

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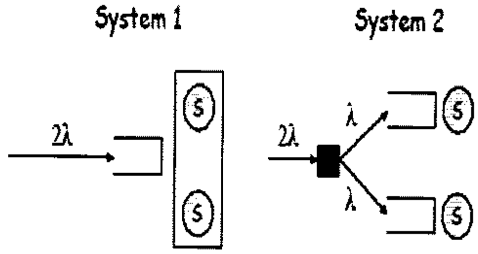
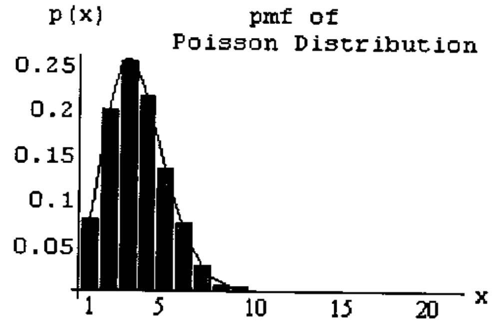
1.3 There are 2 systems below: System 1 and System 2. Which one gives a better performance in terms of waiting time, and number of packet in queue. Why? (4 Marks)

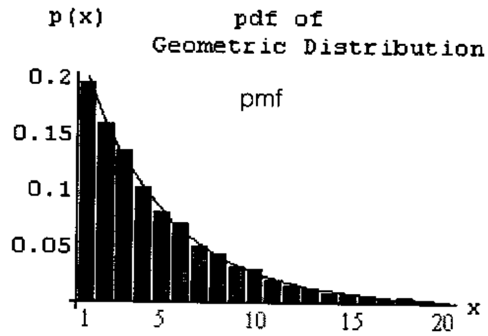


1.4 Queue delay, service delay, time delay in a system, packet delay of arrivals, (5 Marks)

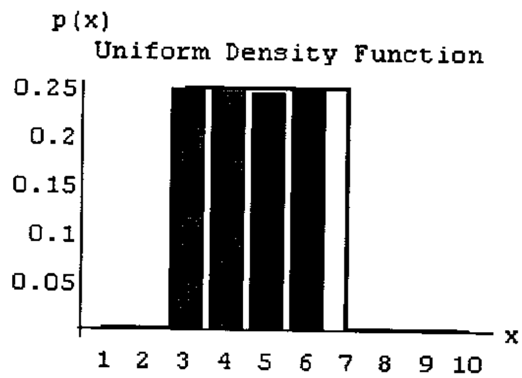
1.5 From the graphs shown below, please use your knowledge to explain, interpret, and/or compare to each other (as much as you can): (5 Marks)



(a)



(b)



(c)

2. One particular Pizza restaurant in Hatyai City has an average customer arrival at 100 per hour. This restaurant has only one service counter which be able to server 120 customers per hour in average. Each customer takes 30 seconds (average) to be served at the counter. By using M/M/1 model:
    a. How much time each customer spend in the restaurant? (3 Marks)
    b. How much time each customer wait in line? (3 Marks)
    c. How many (an average) customers are in the restaurant (2 Marks)?
    d. How busy is the restaurant counter? (2 Marks)

Repeat all above questions by using M/D/1.

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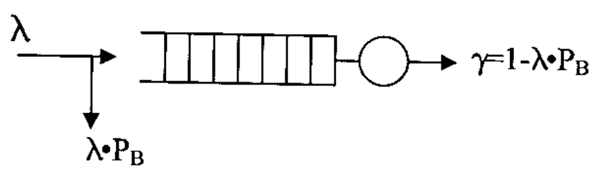
3. (A) Consider queue with finite buffer N, FIFO service discipline and single server. If the system requires dropped packets not more than one packet every 1,000,000 packets when traffic intensity is 0.6, and packet arrival rate is 6. Determine N, system throughput, and probability that queue is not empty. (10 Marks)



P_B = Blocking probability

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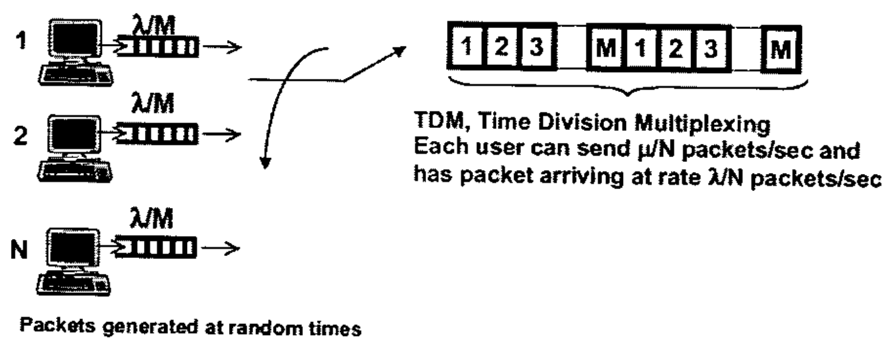
(B) A system shown below is using a TDM (Time Division Multiplexing). There are M sources with arrival rate of λ/M. TDM has M slots to carry all sources traffic. Please proof that waiting time of each source is $T = M/\mu + M(\lambda/\mu)/(\mu-\lambda)$ (by using M/M/1). (10 Marks)



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4. ARQ Protocol Performance
   4.1 Stop-and-Wait ARQ Protocol performance: use the below information to answer the following question. **Calculate the efficiency of Stop-and-Wait ARQ in the**

system that transmits at R=1 Mbps and with reaction time of 1 msec for channels with a *bit error rate* of 10^-6, 10^-5, and 10^-4 (be careful, these are not probability of frame loss). (10 Marks)

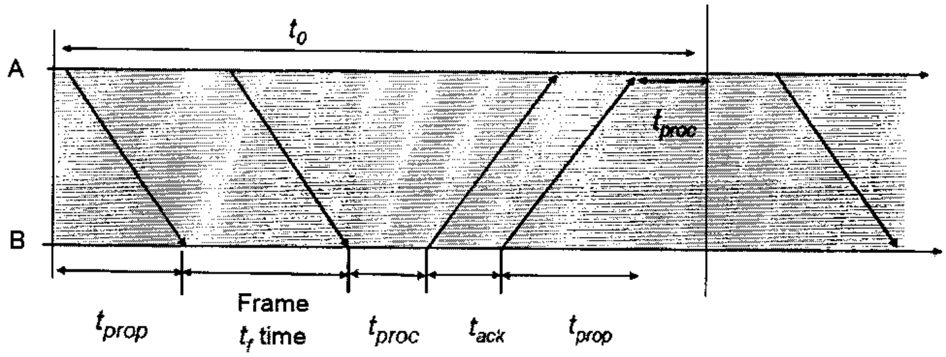

Figure 1 Delay components of Stop-and-Wait ARQ

- The basic time to send a frame and receive an ACK, in the absence of errors, is given by

$$t0 = 2tprop + 2tproc + tf + tack$$

$$= 2tprop + 2tproc + nf/R + na/R$$

Where

nf = number of bits in the information frame

na = number of bits in the ack frame

R = bit rate of the transmission channel

** The effective information transmission rate of the protocol in the absence of errors

$$Reff = (nf - n0)/t0$$

Where n0 = number of overhead bits in a frame (given by the total number of bits in the header and the number of CRC bits

- Let *Pf* be the probability that a frame transmission has errors and needs to be re-transmitted.

- The probability of no error frames is *1-Pf*

Stop-and-Wait ARQ on average requires *tSW=t0/(1-Pf)* seconds to get a frame through. Thus the efficiency of Stop-and Wait ARQ with packet loss is:

$$\eta_{SW} = \frac{\frac{n_f - n_a}{t_{SW}}}{R} \qquad \eta_{SW} = \frac{1 - \frac{n_0}{n_f}}{1 + \frac{n_a}{n_f} + \frac{2(t_{prop} + t_{proc})R}{n_f}}(1 - P_f)$$

Suppose that frames are 1,250 bytes long including 25 bytes of overhead. Also assume that ACK frame are 25 bytes long.

4.2 In a Stop-and-Wait ARQ system, the bandwidth of the line is 1 Mbps, and 1 bit takes 20 ms to make a round trip. What is the bandwidth-delay product? If the system data frames are 1000 bits in length, what is the utilization percentage of the link?

The following information may be useful when students have to deal with queueing theory.

- <u>M/M/1</u>
    - **Number of Customers in the system in steady state**

$$L = \frac{\rho}{1-\rho}$$

where L is the number of customers in the system in steady state,
ρ is the utilisation factor or traffic intensity

- **The mean queue length in steady state**

$$L_q = \frac{\rho^2}{1-\rho} \quad \text{or} \quad L_q = \frac{\lambda^2}{\mu(\mu-\lambda)}$$

where L_q = mean queue length in steady state
λ = average arrival rate
μ = average service rate

- **Mean waiting time in the queue in steady state**

$$W_q = \frac{\lambda}{\mu(\mu-\lambda)}$$

where W_q is the mean waiting time in the queue in steady state

- <u>M/D/1</u>
    - **Number of Customers in the system in steady state**

$$L = \rho + \frac{\lambda^s}{2\mu^2(1-\rho)}$$

where L is the number of customers in the system in steady state,
ρ is the utilisation factor or traffic intensity
μ = average service rate

- **The mean queue length in steady state**

$$L = \frac{\lambda^s}{2\mu^2(1-\rho)}$$

- **Mean waiting time in the queue in steady state**

$$L = \frac{\lambda}{2\mu^2(1-\rho)}$$

- LOG Values:

log (0.5)	-	0.30
log (0.6)	-	0.22
log (0.7)	-	0.15
log (0.8)	-	0.10
log (0.9)	-	0.05
log (1.0)	-	0.00
log (1.1)		0.04
log (1.2)		0.08
log (1.3)		0.11
log (1.4)		0.15
log (1.5)		0.18
log (1.6)		0.20
log (1.7)		0.23

log (1.8)	0.26
log (1.9)	0.28
log (2.0	0.30
log (2.1)	0.32
log (2.2)	0.34
log (2.3)	0.36
log (2.4)	0.38
log (2.5)	0.40
log (2.6)	0.41
log (2.7)	0.43
log (2.8)	0.45
log (2.9)	0.46