PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Mid-Term Examination: Semester II	Academic Year: 2007
Date:20February 2008	Time: 09.00-11.00 (2 hrs)
Subject: 240-542 Queueing and Computer Networks	Room: A400

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- In this exam paper, there are FOUR questions. Answer ALL questions,
- All notes and books are **not** allowed,
- Answers could be either in Thai or English,
- Calculator is allowed,

1. There are n+1 sessions each offering 1 unit/sec of traffic along a sequence of n links with capacity of 1 unit/sec. One session's traffic goes over all n links, while the rest of the traffic goes over only one link.
    a. What is the maximum throughput can be achieved? How does this one happen (what scenario is)? (5 Marks)
    b. However, if our objective is to give equal rate to all session, what is the system throughput? (5 Marks)
    c. Alternatively, if our objective is to give equal resources to all session, what is the system throughput? (5 Marks)

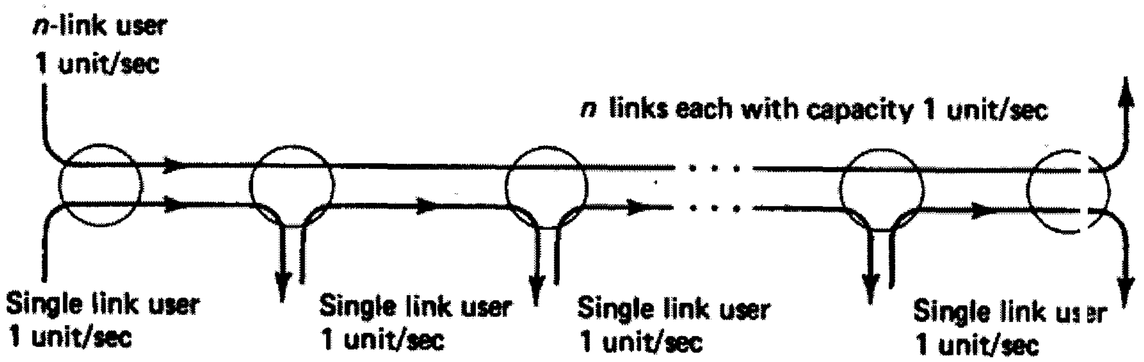

Figure 1 for question 1

2. What are the limitations of end-to-end windows flow control on the following causes? (each cause, you need to draw a picture to explain). (20 Marks)
    - it cannot guarantee a minimum communication rate of a session
    - There is basic trade-off window size
    - There is delay-throughput trade-off
    - It fails to control packet delay of each session

3.1 **Figure 2** shows a periodic model of TCP window dynamics in steady state. In this model, we assume that: (20 Marks)

- A maximum window size is W,
- A minimum window size is W/2
- Constant Packet loss Probability is *p*
- So, *1/p* packets are transmitted between each packet loss,
- TCP run on steady state, so *slow start* (during start up) is not concerned.

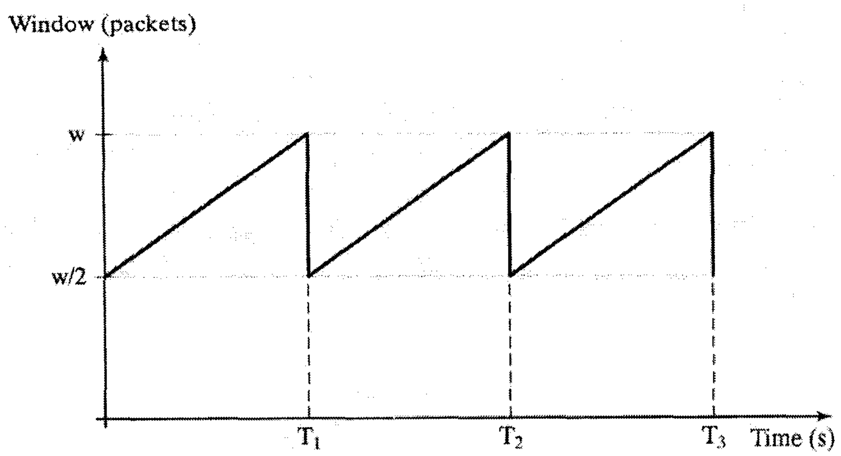

Figure 2 A periodic model of TCP window dynamic behaviour in steady state

Use the above information answer the following question

a) Prove that the number of packet transmitted during each period of window is

$$\text{Number of Pkts} = \frac{1}{2}\frac{T}{RTT}\left(\frac{W}{2} + W\right)$$

Where *T* is the periodic between detecting packet losses.

b) Prove that the average transmission rate in this model is

$$\frac{1}{RTT}\sqrt{\frac{3}{2p}}$$

The result is known as the ***inverse square-root p law***

c) If a TCP connection has an average round trip time of 200 ms, and packets are lost along the connection with probability 0.05, please find the average rate of the TCP source.

3.2 Performance of ARQ

a) 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? (10 marks)

b) What is the utilization percentage of the link in 3.2 a) uses Go-Back-N ARQ with a 15-frame sequence? (10 marks)

4. A small router has only one output port with a large single FIFO queue. Packets arrive at this output port at random from 1 to 8 seconds apart. Each possible value of inter arrival time has the same probability of occurrence, as shown in Table 1. The service times vary

from 1 to 6 second with the probability shown in Table 2. Table 3 and Table 4 show a set of generated data for 20 packets of arrival and departure processes. The problem is to analyse the system by simulating the arrival and service of 20 packets. Please fill ι p an appropriated simulated data in. (20 Marks)

Table 1 Distribution of time between arrivals

Time between arrival (seconds)	Probability	Cumulative probability	Random digit assignment
1	0.125	0.125	001-125
2	0.125	0.125	126-250
3	0.125	0.125	251-375
4	0.125	0.125	376-500
5	0.125	0.125	501-625
6	0.125	0.125	626-750
7	0.125	0.125	751-875
8	0.125	0.125	876-000

Table 2 Service time distribution

Service time (seconds)	Probability	Cumulative probability	Random digit assignment
1	0.10	0.10	01-10
2	0.20	0.30	11-30
3	0.30	0.60	31-60
4	0.25	0.85	61-85
5	0.10	0.95	86-95
6	0.05	1.00	96-00

Table 3 Time-between-arrival determination

Packet No.	Random digits	Time between arrivals (seconds)	Packet No.	Random digits	Time between arrivals (seconds)
1	-	-	11	109	1
2	913	8	12	093	1
3	727	6	13	607	5
4	015	1	14	738	6
5	948	8	15	359	3
6	309	3	16	888	8
7	922	8	17	106	1
8	753	7	18	212	2
9	235	2	19	493	4
10	302	3	20	535	4

Table 4 Service time generated

Packet No.	Random digits	Service time (seconds)	Packet No.	Random digits	Service time (seconds)
1	84	4	11	32	3
2	10	1	12	94	5
3	74	4	13	78	4
4	53	3	14	05	1
5	17	2	15	79	5
6	79	4	16	84	4
7	91	5	17	52	3
8	67	4	18	55	3
9	89	5	19	30	2
10	38	3	20	50	3

Answer the following questions:

(a) What is the average waiting time for a packet? (3 Marks)

(b) What is the probability that a packet has to wait in the queue? (3 Marks)

(c) What is the system utilisation? (3 Marks)

(d) What is the average service time? (3 Marks)

(e) What is the average between arrivals? (3 Marks)

(f) What is the average time a packet spends in the system? (3 Marks)

(g) What is the average number of packets waiting in queue? (2 Marks).

Name: .... Student ID: ....

(Used for Question 2)

Table 5 Simulation table

Packet No.	Time since last arrival (seconds)	Arrival time	Service time (seconds)	Time service begins	Time packet waits in queue (seconds)	Time service ends	Time packets spend in system (seconds)	Idle time of server
1	-	0						
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								