PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I — Academic Year: 2009
Date: 30 September 2009 — Time: 09.00-12.00 (3 hrs)
Subject: 241-552 Queueing and Computer Networks — Room: A201

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- In this exam paper, there are FIVE 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)

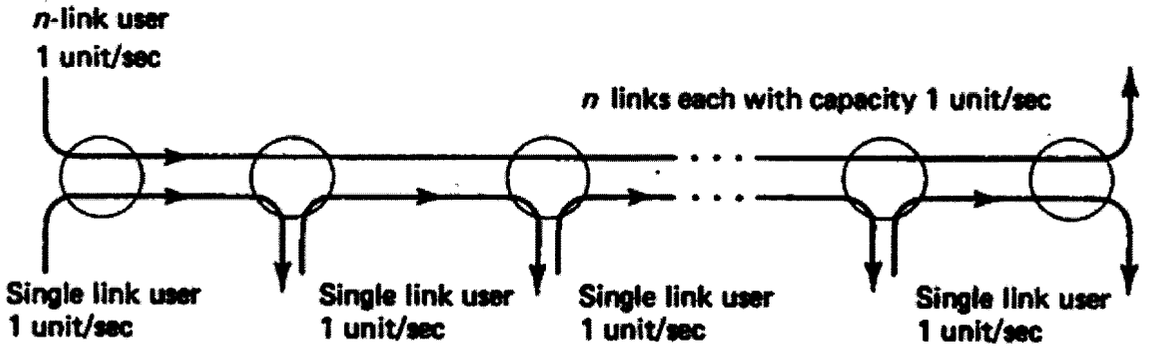

Figure 1 for question 1

Answer:

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2. There are 2 questions for window flow control:
   2.1 Suppose that 2 nodes of source and destination in the network given below are using ARQ system. There are 2 cases to be consider where a round trip time is smaller than a window size, and a round trip time is greater than a full window of packets.

Proof that the maximum rate of transmission corresponding is

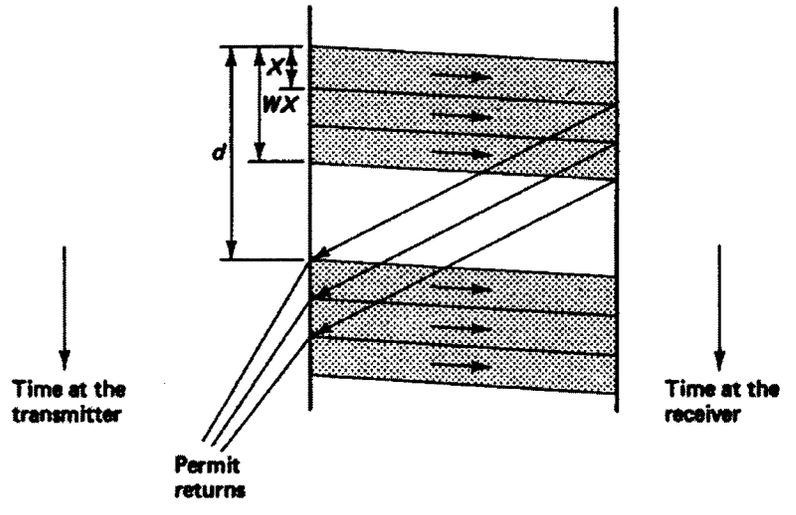
$$r = \min\left\{\frac{1}{X}, \frac{W}{d}\right\}$$

Where

d is the round-trip delay including round trip propagation delay, packet transmission time, and permit delay.

W is the window size,

X is the transmission time of a single packet at the full speed.



Answer:

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2.2 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

Answer:

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3. Consider the below pseudo code of TCP control mechanism, please draw a transmission rate versus time (Y-axis is cwnd, and X-axis is time) at least 3 times of execution.

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Initially:
    cwnd = 1;
    ssthresh = infinite;
New ack received:
    if (cwnd < ssthresh)
        /* Slow Start*/
        cwnd = cwnd + 1;
    else
        /* Congestion Avoidance */
        cwnd = cwnd + 1/cwnd;
Timeout: (loss detection)
    /* Multiplicative decrease */
    ssthresh = win/2;
    cwnd = 1;
while (next < unack + win)
    transmit next packet;

where   win = min(cwnd,
                  flow_win);
```

However, if such mechanism is changed to the below condition

- After a fast-retransmit set cwnd to ssthresh/2
- But when RTO expires still do cwnd = 1

Draw a graph of this scenario

Answer:

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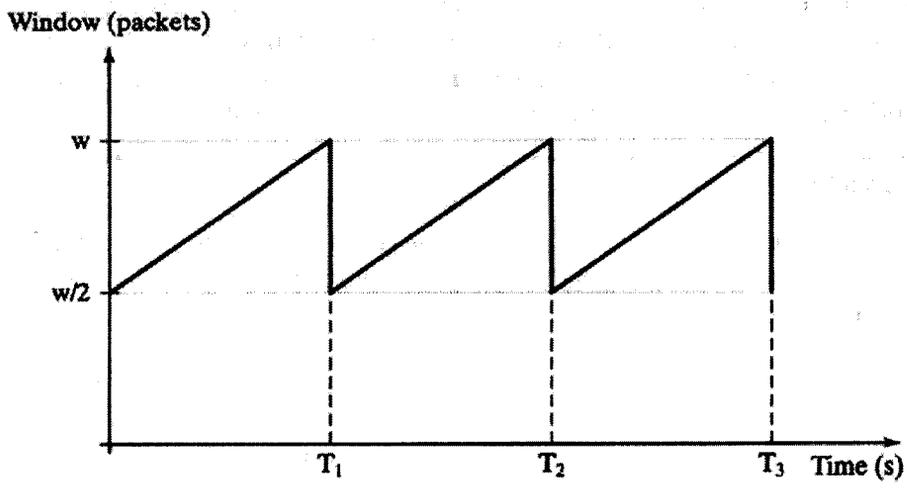
4. The given below traffic behavior is drawn from TCP periodic model where:
   - A maximum window size is W,
   - A minimum window size is W/2
   - Constant Packet loss Probability is p
   - So, 1/p packets are transmitted between each packet loss,

TCP run on steady state, so slow start (during start up) is not concerned.



Please proof that the average transmission rate is:

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

Answer:

5. 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 up 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).

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(Used for Question 5)

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						
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Answer:

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