PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Final Examination: Semester I   Academic Year: 2010
Date: 6 October 2010   Time: 09.00-12.00
Subject: 241- 552 Queueing and Computer Networks   Room: S203

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

- In this exam paper, there are SIX 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)
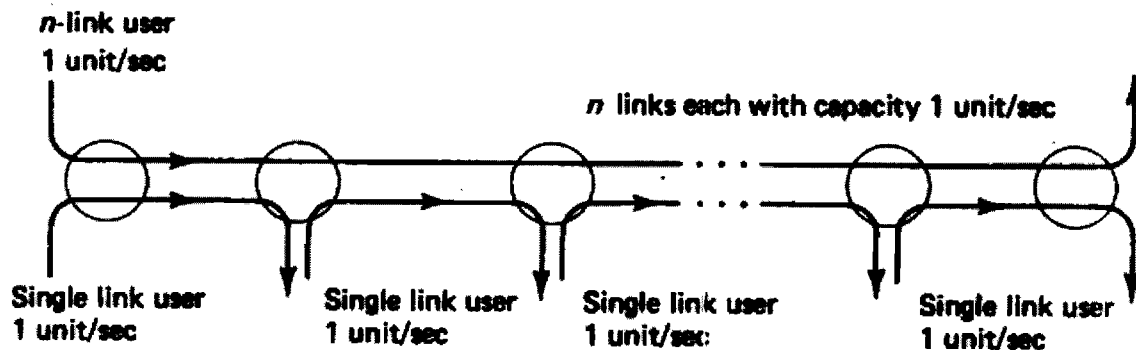
Figure 1 for question 1

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 ccnsider where a round trip time is smaller than a window size, and a round trip time is greater than a full window of packets (10 marks).

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,

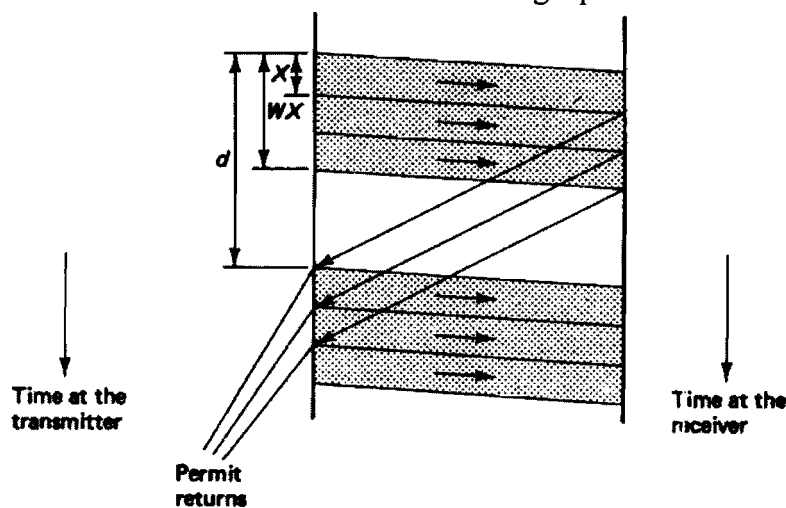   X is the transmission time of a single packet at the full speed.

Figure 2 for question 2

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2.2 There are 4 nodes in the communication system as shown in Figure 3 (A). Node A and B transmit data by using router R to deliver traffic to their destination nodes C and D respectively. Only a single buffer is provided in R (traffic from A and B are stored into the same buffer). The service discipline of R is first-come-first-serve. The link bandwidth, which is a normalised value and indicated by C, are 5, 2, 1, 2 for the link A-R, B-R, R-C, and R-D, respectively. Node B is a fixed transmission rate source while A is a variable rate source. Node A is able to vary its transmission rate, f, up to 5. Node B transmits data first until time zero then node A inserts its traffic. From the given graph in Figure 3 (B), answer the following questions (please explain clearly):

2.2.1 Explain what, why, and how (a),(b),(c) and (d) happen (8 marks),

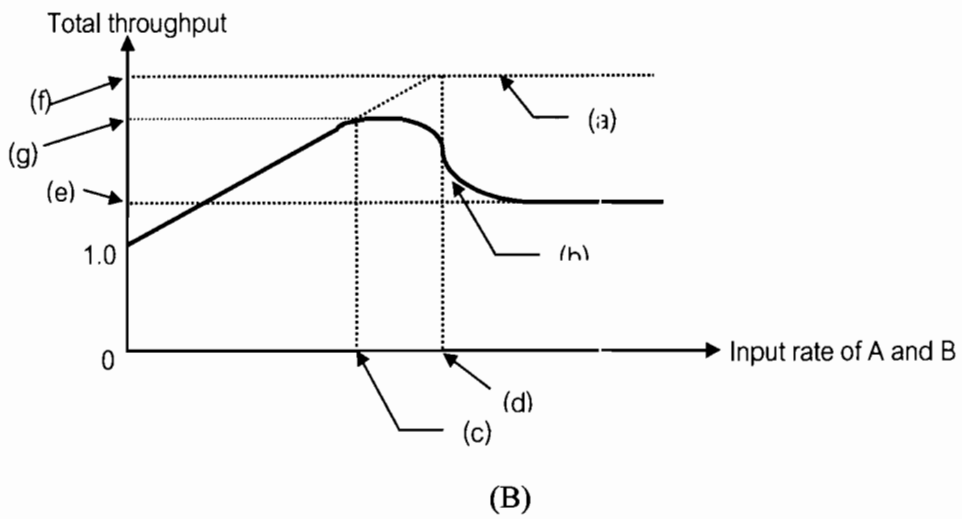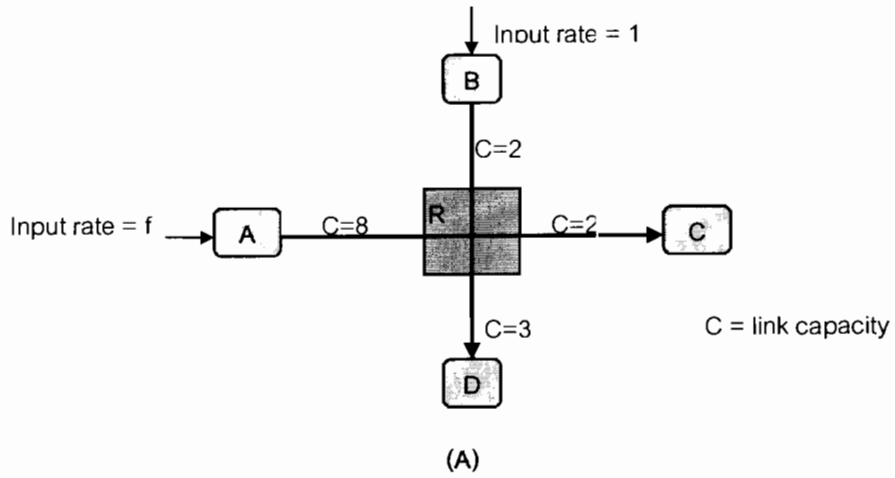2.2.2 Give the normalised values in (e) and (f). Please show how you get such figures (7 marks),

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(A)

(B)

Figure 3 Figure (A) and (B) used for question 2.2

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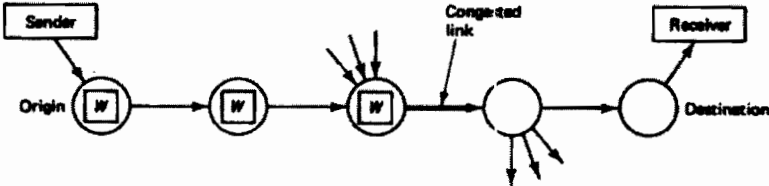..

2.3 From figure given below, explain how node-by-node windows for virtual circuit works (10 marks)

Answer

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3. We consider TCP Latency Modeling: Slow Start, with the following parameters:
   - P is the number of times TCP stalls (idle) at server
   - Q is the number of times the server would stall if the object were of infinite size.
   - K is the number of windows that cover the object.

   In TCP model we have 2 cases to consider:
   a. $WS/R > RTT + S/R$:
      ACK for first segment in window returns before window's worth of data sent
   b. $WS/R < RTT + S/R$:
      wait for ACK after sending window's worth of data sent
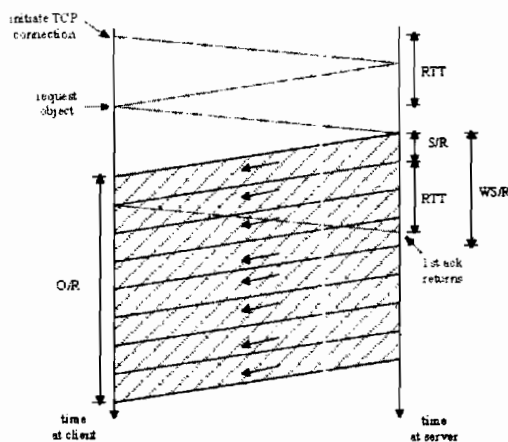
Figure 4 for question 3

Please find the delay model of case (a) ($WS/R > RTT + S/R$) in terms of RTT, O, and R (10 marks)

Answer

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4. 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 (10 marks)

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;

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while (next < unack + win)
    transmit next packet:

where   win = min(cwnd,
              flow_win);
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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:

5. The given below traffic behavior is drawn from TCP periodic model where:
Stop-and-Wait ARQ Protocol performance: use the following information to answer the
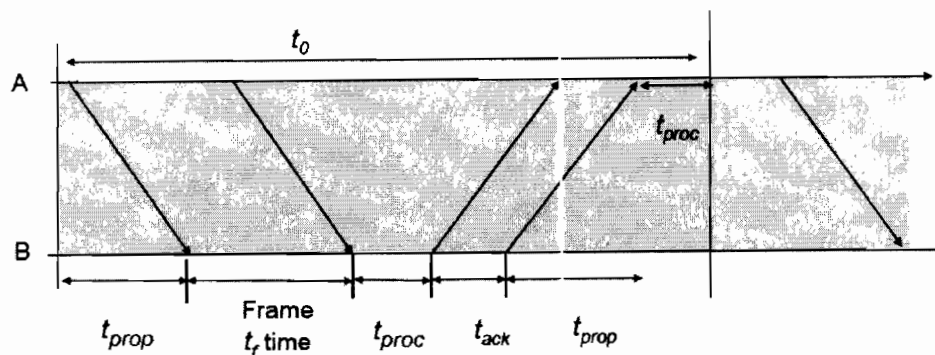question below (15 marks)

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Figure 5 Delay components of S:op-and-Wait ARQ

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

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

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

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 pack:t loss is:

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

Suppose that frames are 1,250 bytes long including 25 bytes of overhead. Also assume that ACK frame are 25 bytes long. 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 (not probability of frame loss).

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6. 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).

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

(Answer sheet used for Question 6)

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
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