ECE671
Fall ‘10 – Exam III

Prof. Wolf

Name: _____

ID Number: _____

	Maximum	Achieved
Question 1	10	
Question 2	11	
Question 3	15	
Question 4	14	
Total	50	

This exam is closed book, closed notes. Three pages handwritten notes are allowed. No electronic devices (other than calculators) are allowed. Be concise, but show your work. Write legibly.

Time: 75 minutes.

Question 1 (10 points):
Answer the following questions regarding queuing theory. For each scenario, determine what queuing system model is most suitable (using Kendall's notation) and calculate the system property based on the parameters given.

a) Consider a network node with one input and one output port. Packets arrive on the input port with an exponential distribution. The node queues incoming packets (in a queue with infinite space) and then performs a protocol processing step that takes constant time (and includes the transmission of the packet on the output port).

   What is the simplest suitable queuing model to describe this node? (2 points)

   If there are 8 packet arrivals per second and the processing step takes 100 ms, what is the expected queue length? (3 points)

b) Consider a network node with two inputs and one output port. Packets arrive on each input with an exponential distribution. The node queues incoming packets (in a queue with infinite space) and then performs a protocol step that takes an exponentially distributed amount of time (and includes the transmission of the packet on the output port).

   What is the simplest suitable queuing model to describe this node? (2 points)

   If there are 150 kpps (kilo packets per second) arriving on one input port and 325 kpps on the other input port and the processing step takes 2µs on average, what is the expected waiting time for a packet? (3 points)

Question 2 (11 points):
Answer the following questions regarding prefix lookup data structures. For all sub-problems in this question, use the following set of prefixes:

A: 01001*
B: 0101*
C: 011*
D: 1*
E: 11001*
F: *

a) Consider binary prefix trees. Draw a binary tree that contains the address prefixes listed above. Let all “0s” branch to the left and all “1s” branch to the right. Mark nodes that correspond to a prefix with *A*, *B*, etc. (4 points)

b) Consider tries. Draw a trie with a stride length of 3 that contains the address prefixes listed above. Expand all prefixes such that prefixes only occur in leaf nodes. Mark nodes that correspond to a prefix with *A, B,* etc. (4 points)

c) For your solutions in a) and b) of this question, determine the storage requirements (number of nodes) and the worst case lookup speed (number of transitions along an edge in the tree or trie without backtracking). Discuss your observations. (3 points)

Storage requirements for a) _____, for b) _____

Worst case lookup speed for a) _____, for b) _____

Discuss your observations (do not exceed given space):

_____

_____

_____

_____

Question 3 (15 points):

Answer the following questions regarding packet classification on two fields, F1 and F2.

a) Show the grid-of-tries data structure that matches the following rule set. (5 points)

	F1	F2
R1	1*	10*
R2	0*	0*
R3	*	0*
R4	11*	11*
R5	*	1*

b) Consider a scenario where the packet classification process is used to determine the output port (either 1 or 2) for packets that match the rules from above:

	F1	F2	Output port
R1	1*	10*	1
R2	0*	0*	2
R3	*	0*	1
R4	11*	11*	2
R5	*	1*	2

Determine a new set of rules that shows the same forwarding behavior, but uses the minimum number of rules. (5 points)

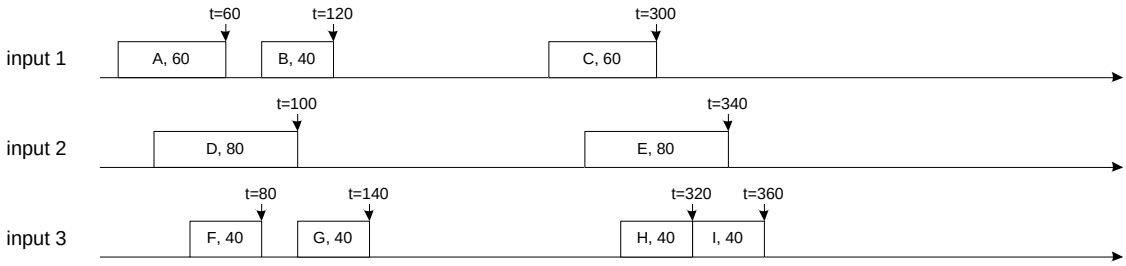
Answer (new rule set):

	F1	F2	Output port

c) Show the grid-of-tries data structure that matches your rule set from b). (5 points)

Question 4 (14 points):
Answer the following questions regarding link scheduling.

a) Consider the following sequence of packet arrivals on three input links (the arrival time of each packet is noted with "t=…"). All arriving packets need to be scheduled on the same output link. All input links are treated equally with a single FIFO queue (of infinite length). Each packet is denoted with an identifier (A, B, etc.) and its length. The speed of the output link is the same as that of one input link. Determine the output sequence of packets. Note the identifier of packets in order of transmission on the output link and the packets' start and finish times in the table. (5 points)

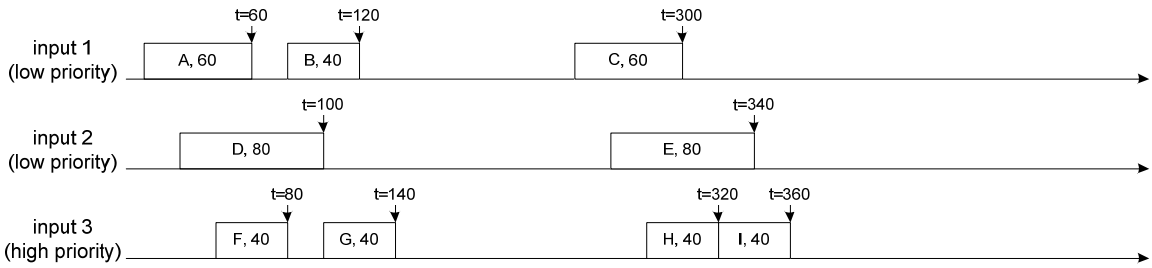


Answer:

Packet identifier (in order of transmission)	Start time of transmission of packet	Finish time of transmission of packet

b) Consider a FIFO scheduler and the same packet arrival scenario as in a). Assume the queue is limited to a maximum queue length of 2 packets (independent of size and not counting packets that are being transmitted). Which packet(s) get dropped? (4 points)

c) Consider a strict priority scheduler (with no preemption) that gives high priority to all packets from input 3 and low priority to all other packets. Using the same sequence of packet arrivals as in a). Note the identifier of packets in order of transmission on the output link and the packets' start and finish times in the table. (5 points)



Answer:

Packet identifier (in order of transmission)	Start time of transmission of packet	Finish time of transmission of packet