

## Homework #2

- (5pt) Problem 3.1
- (10pt) Problem 3.5
- (15pt total) Problem 3.8
  - 5pt in 3.8(a) and 10pt in 3.8(b)
  - Hint: 3.8(b) uses M/M/∞ queues, solved in 3.4.2.
  - Hint: 3.8(b) will also use the following property: Let  $X_1$  and  $X_2$  be two exp variables with rates  $\lambda_1$  and  $\lambda_2$ .  $P\{X_1 < X_2\} = \lambda_1 / (\lambda_1 + \lambda_2)$ .

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- A router  $X$  is equipped with three ports, 0, 1, and 2 with capacities 10Mbps, 6Mbps, and 8Mbps, respectively. Packets arrive at port 0 at rate 4000 packets per second with exponentially distributed interarrival times. Among these packets, 30% go to port 1 and the rest to port 2. Packets arrive at port 1 at rate 1000 packets per second with exponentially distributed interarrival times. Among these packets, 80% go to port 0 and the rest to port 2. Packets arrive at port 2 at rate 2000 packets per second with exponentially distributed interarrival times. Among these packets, 60% go to port 0 and the rest to port 1. Packet lengths are exponentially distributed with the average of 2000 bits. Each of the three ports has a dedicated queue of infinite capacity. Answer the following questions.

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- (3pt) Give the service rates  $\mu_0$ ,  $\mu_1$ , and  $\mu_2$  at the three ports.
- (3pt) Give the packet arrival rates  $\lambda_0$ ,  $\lambda_1$ , and  $\lambda_2$  at the queues of the three ports.
- (5pt) Compute the average number of packets on the entire router (including the one currently being transmitted).
- (5pt) Compute the average time packets stay on the router (including the times of transmission)

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- (10pt) Show the state transition diagram of a G/M/1/4 queueing system (the whole system contains at most 4 customers, 3 in waiting and 1 in service).
- (10pt) Show the state transition diagram of a M/M/2/3 queueing system, where the queue size is 3 (the system can have a maximum of 5 customers).
- (10pt) Consider an M/G/1 system with arrival rate 0.1 and uniformly distributed service times from 0 to 10. Compute the average time  $T$  a customer stays in the system.

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