Assignment 4

CS232/NetSys201/EECS248 Fall 2025

November 19th, 2025

Deadline: December 2nd @11:59PM on Gradescope (upload your answers in PDF under Assignment 4 and please mark each problem accordingly).

Turn in: A pdf file of your answers to each question.

Note: You must fully compute fractions/equations in your answers to the final numbers when possible. Also show all steps taken to reach the final answer.

1 Problem 1:

Consider an M/M/1/3 system with arrival rate $\lambda = 4$ pkt/s and service rate $\mu = 12\ pkt/s$. Please note that the total number of packets include packets being served as well.

a) Compute the probability that the system has 1 packet being served and 1 packet waiting in the buffer.

b) Compute the expected time a packet needs to go through the system. Please note that the time includes queueing and service.

2 Problem 2:

Consider an M/M/1/∞ system with arrival rate $\lambda = 6$ pkt/s and service rate $\mu = 12\ pkt/s$.

a) Compute the expected time a packet spends in the system.

b) Compute the time a packet is expected to wait in the buffer before getting served.

3 Problem 3:

Consider a large system that is composed of five separate M/M/1/∞ servers serving five different applications, each application has λ = 3 pkt/s in packet generation rate and each server has μ = 6 pkt/s in service rate.

a) Which is better in terms of packet delay, having a dedicated server for each application with μ = 6 per server or having a single powerful server with 5μ service rate serving all of the five applications simultaneously? Compute a proof for your answer (Hint: compute the packet delay E[T] for both cases and compare them).

b) Assume that the separate five servers have been combined into a single powerful server with service rate 5μ. Compute the probability that there are 6 packets in the system.

4 Problem 4:

Suppose you and your friends begin a new start-up together and the service it provides requires that you set up a web server to service client requests which follows an M/M/1/K queueing model (where K = 2). What would be the average number of customers that you expect your server to have to handle (i.e. expect in your system) in the following phases of your business?

a) In the beginning, the business is not very popular and your web server's service rate, $\mu_{startup} = 10$, is greater than the inter-arrival times of service requests, $\lambda_{startup} = 2$

b) As you become more popular, your adolescent business begins to see more requests and now $\lambda_{adolescent} = 8 \; and \; \mu_{adolescent} = 10$

c) A viral interview with your CEO leads to a spike in requests causing ($\lambda_{popular} = 15$) > ($\mu_{popular} = 10$).

d) You are the CTO, and upon seeing the interview reach 1 million views, are worried about the spike. You ask the CFO about your budget for higher performance servers the CFO tells him/her that you don't yet have enough money for them yet. You do have enough money for extra queue/buffer storage though and your CTO asks you if the company should double the queue size to 2K. What do you tell the CTO regarding the success or failure of this plan? And what general rule of networking does your response imply?

5 Problem 5:

a) Consider an M/M/c/c system where $c = 3$, the arrival rate $\lambda = 2$, and the service rate $\mu = 4$. What is the probability that at time $t = 1$ the number of customers in the system is 3.

b) What does the probability in part (a) represent with respect to the system's state?