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MSDS 460 Decision Analytics

Assignment 05

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*Problem:*

Dean Smith is dissatisfied with the time it takes to get a new faculty ID made and believes more servers will speed up service AND reduce costs thanks to shorter lines. Prof. Joe is tasked to study the situation.

Prof. Joe observes an average of 20 customers/hr. arriving and each technician (service window) serves 5 customer/hr, on average. Assume an M/M/s queue system.

*Solution:*

Customer arrival rate,  $\lambda$ : **25**

Service rate,  $\mu$ : **5**

1. What is the minimum number of servers required to create new IDs without the queue growing to infinity? **5**

2. Prof. Joe calculates the operational cost of each server as \$20/hr. and assumes a cost of waiting in the SYSTEM as \$25/hr. per customer. Find the following:

i. Optimal # of service windows that minimizes Total Cost: **6 Servers**

ii. At this **Optimal Number of Service Windows**, what are the:

Service Cost/Hr	Wait Cost/Hr	Total Cost/Hr
\$120	\$114.24	\$234.24

**Assume an M/M/5 queue system for this question ONLY:**

**3.)** Dean Smith orders Prof. Joe to recommend changes to the process in order to reduce the average **time in the QUEUE** to 4 minutes without adding more servers (i.e., keep servers at 5). Thus, this improvement can only be done by getting the servers to work faster. Prof. Joe responds,

“Sir, that represents over a 65% reduction! Servers can’t possibly perform that fast!”

Student David, shadowing the Dean for a day, whispers to Prof. Joe,

“I think you can meet the Dean’s goal with just about a 7% improvement in service rate.”

How fast must each servicer work to achieve 4 minutes on average in the Queue?

i. New Service Rate:

**5.36325**

ii. Who is more correct? (Pick/Circle One)

**Student David**

iii. Explain:

The increase to the service rate is 7.01%, while the decrease in queue time is 6.65 minutes to 4 minutes, which represents a -49.8% reduction.

*Problem:*

Golden Gates is an analysis of the South Gate of a nearby military base. Assume an average arrival rate during the morning hours is **8 cars/minute** and assume an optimistic average service time of **6 seconds/car**. Assume a **single gate** and that both the inter-arrival and service times are **exponentially distributed**.

The Security Forces Commander is concerned that the number of cars at the South Gate is creating a safety hazard at the Registration Center intersection (which is outside of the gate, but if there is a backup it backs up beyond the intersection). He calculates that when **3 or more cars** are in the South Gate queue, the intersection is **BLOCKED**, creating a safety hazard.

*Solution:*

- a) In KENDALL Notation, this is what type of system? **M/M/1**
- b) With an Arrival Rate = **8/min**, Service Rate = **6/second = 10/minute**, and # of Servers = **1**
- c) Using the Queuing template, what is the **average number of cars in the queue**? **3.2**
- d) What percent of the time will the **Registration Center Intersection be OPEN (< 3 in QUEUE)**? **51.2%**
- e) The Commander is dissatisfied with the percent of time that the Center is blocked and is looking for solutions. For the following questions, assume that cars continue to arrive in a **single lane** and then proceed to the first available of **two gates**.

Recall that this system has **2 gates** (servers). Use the following new information:

**ARRIVAL RATE = 8/minute and SERVICE RATE = 12/minute.**

What **percent of time** will the **Registration Center Intersection be BLOCKED**? **1.9%**

- f) Assume the average probability of blocking the Center during that time is only **5%** when using **two gates**! Yet the SF Commander finds himself in a **queue that blocks the Center two mornings in a row**! How could this happen? Explain.

The event of blocking the registration center is an independent event each morning, so successive blockings is a .25% chance probability.

- g) Assume on average, **16 cars arrive and 12 cars are served each minute** (both inter-arrival and service times are exponentially distributed). If the life cycle cost of a Gate is **\$76.00 per minute**, and the cost of personnel employees **waiting in the system** is **\$2008 per minute**, how many Gates should be used to minimize cost? Complete the table below and **CIRCLE** the best number of gates.

Servers, S	Total Cost	Cs	Cw
1	\$ 4,971.20	\$ 152.00	\$ 4,819.20
2	\$ 4,971.20	\$ 152.00	\$ 4,819.20
3	\$ 3,195.76	\$ 228.00	\$ 2,967.76
4	\$ 3,033.32	\$ 304.00	\$ 2,729.32
5	\$ 3,066.54	\$ 380.00	\$ 2,686.54
6	\$ 3,134.85	\$ 456.00	\$ 2,678.85
7	\$ 3,209.56	\$ 532.00	\$ 2,677.56
8	\$ 3,285.36	\$ 608.00	\$ 2,677.36
9	\$ 3,361.34	\$ 684.00	\$ 2,677.34
10	\$ 3,437.33	\$ 760.00	\$ 2,677.33

h) Assume the following:

**1 Gate, Arrival rate of 16 cars/min**, Inter-arrival & Service times are **exponentially distributed**  
What is the slowest **service rate (cars/minute)** that will provide an **avg time in the System  $\leq 10$  seconds**?

**Service rate = 22**