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CS342 LAB 4

Airport Security Screening Process

Comparative Analysis Report

This report presents a comparative analysis of four different methods used in simulating airport security lines, highlighting their respective strengths and limitations. The methods examined include the Single Queue-Single Server Model, the Buffered Single Queue-Single Server Model, the Multi-Server Model, and the Buffered Multi-Server Model.

In queueing theory, the Poisson process and exponential arrival and service rate are fundamental concepts used to model the arrival and service times of entities, such as customers or packets, in a queueing system. They are commonly employed to analyze the behavior of queues in various fields, including computer networks. Here's an overview of these concepts:

In the Poisson process, the inter-arrival times (time between consecutive arrivals) follow an exponential distribution, and the service times (time taken to process a packet) also follow an exponential distribution.

It follows Little's Law:

Mean number tasks in system = arrival rate x mean response time

1.Single Queue-Single Server Model:

arrival rate:	2
service rate:	3

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Total Waiting Time:	66332.7
Total Simulation Time:	50073.2
Total Service Time:	33317.7
Average Waiting Time:	0.663327
Average Queue Length:	1.32472
System Utilization:	66.538%

We can see that it follows Little's law (approximately) i.e.

Average Queue Length = (Average Waiting Time) * (arrival rate)

arrival rate:	1.5
service rate:	3
Total Waiting Time:	33709.7
Total Simulation Time:	66360.4
Total Service Time:	33364.5
Average Waiting Time:	0.337097
Average Queue Length:	0.507979
System Utilization:	50.2777%

CONCLUSION:

We can see that as arrival rate decreases average waiting time decreases and queuing length also decreases as there are less number of packet arriving. Also due to less arrival rate it may be the case that the queue is empty and system don't have any work to do hence resulting in less System utilization. If the service rate increases then average waiting time will increase hence average queue length will also increase.

2.Buffered Single Queue-Single Server Model

Enter the arrival rate: 2

Enter the service rate: 3

Enter the buffer size: 2

Total Service Time	Total Waiting Time	Total Simulation Time
33329.3	36639.2	50041.8

Average Waiting Time: 0.366392

Average Queue Length: 0.732173

System Utilization: 66.6029%

Enter the arrival rate: 2

Enter the service rate: 3

Enter the buffer size: 1000

Total Service Time	Total Waiting Time	Total Simulation Time
33338.2	64100.2	49921.4

Average Waiting Time: 0.641002

Average Queue Length: 1.28402

System Utilization: 66.7813%

CONCLUSION:

We can see it follows Littles law .

We can see that as buffer size increases the average waiting time increases hence increasing the average queue length

3.Multi-Server Model

Enter the arrival rate: 2

Enter the service rate: 3

Enter the buffer size: 15

Enter the number of servers: 2

Total Service Time	Total Waiting Time	Total Simulation Time
3362	407.677	4984.45

Average Waiting Time: 0.0407677

Average Queue Length: 0.0817898

System Utilization: 33.7249%

Enter the arrival rate: 2

Enter the service rate: 3

Enter the buffer size: 15

Enter the number of servers: 3

Total Service Time	Total Waiting Time	Total Simulation Time
3368.36	53.4358	4999.41

Average Waiting Time: 0.00534358

Average Queue Length: 0.0106884

System Utilization: 22.4584%

CONCLUSION:

It follows Littles law

We can see that as the number of server increases, the average waiting time decreases and hence average queue length also decreases.

Also since there are more server so there will be less work left to do by the server hence system utilization deceases.

4.Buffered Multi-Server Model

Enter arrival rate :	2
Enter service rate:	1
Enter buffer size:	15
Enter number of servers:	2
Total service time:	10094.1
Total wait time:	136235
Total simulation time:	5058.7
Average Waiting Time:	13.6235
Average Queue Length:	26.9308
System Utilization:	0.9977

Enter arrival rate :	2
Enter service rate:	1
Enter buffer size:	100
Enter number of servers:	2
Total service time:	10043.6
Total wait time:	470023
Total simulation time:	5065.32
Average Waiting Time:	47.0023
Average Queue Length:	92.7924
System Utilization:	0.99141

CONCLUSION:

It follows Little’s Law.

We can see that if buffer size increases keeping the arrival rate and service rate fixed, the average waiting time increases, which results in increasing average queue length.

Here is a comparison of the four different methods used in simulating airport security lines, emphasizing their respective strengths and limitations.

Single Queue-Single Server Model:

Strengths:

Simple and easy to implement.
Suitable for basic and low-traffic queueing systems.

Limitations:

Inefficient during high traffic, leading to long wait times and potential congestion during peak hours.

Buffered Single Queue-Single Server Model:

Strengths:

Introduces a buffer to manage temporary traffic surges, reducing the risk of congestion.
Relatively straightforward implementation compared to more complex models.

Limitations:

Limited improvement in handling high traffic compared to more advanced models.
Susceptible to bottlenecks during intense traffic flows.

Multi-Server Model:

Strengths:

Enhanced service capacity due to multiple servers operating concurrently.
Effective in managing high traffic and reducing overall wait times.

Limitations:

Increased complexity in implementation and management compared to single-server models.
Higher operational costs associated with maintaining multiple servers.

Buffered Multi-Server Model:

Strengths:

Combines the benefits of buffering and multiple servers for efficient handling of regular and peak-hour traffic.
Reduces congestion and wait times even during high traffic scenarios.

Limitations:

Requires a more sophisticated management system and infrastructure, leading to higher initial setup and maintenance costs.
More complex to implement and optimize compared to single-server models.

These comparisons highlight the significant improvements achieved by the more advanced models, particularly the multi-server and buffered multi-server models, in terms of reduced waiting times and shorter queues, even during high traffic scenarios. However, these advanced models come with increased complexity and higher initial and operational costs.