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Performance Analysis  
of a Multi-Server  
Queueing System

CSE 4550

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# Description

In this report, we present the results of the output statistics derived from our Multi-Server Queueing System simulation. The output statistics that were considered are:

* Average queue length
* Average waiting time
* Average server utilization

These values were calculated based on randomly generated arrival and departure times for 100 customers. The mean arrival time was assumed to be exponentially distributed at 1 time-units. The mean departure time was assumed to be exponentially distributed and was varied between 0.05 to 0.9 time-units.

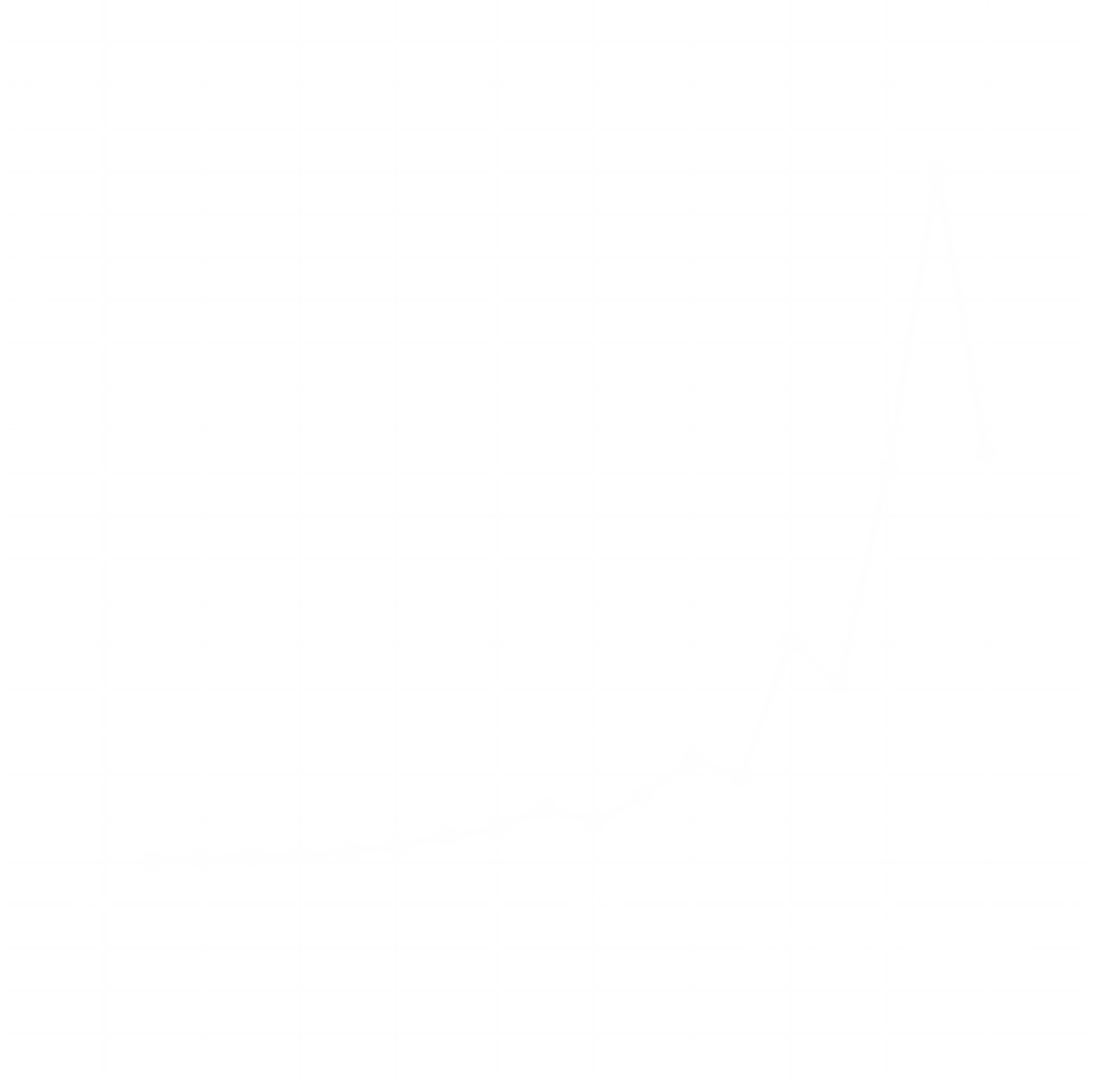
Please note that the mean departure time for the overall system is entirely dependent on the mean departure time of the slowest server in the system. As such, the mean departure times for both servers have been considered to be the same, since it has no effect on the output.

# Simulation Results

## Collected Data

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Arrival Mean** | **Departure Mean (Server 1)** | **Departure Mean (Server 2)** | **Traffic Intensity** | **Average Queue Length** | **Average Waiting Time** | **Average Server Utilization** |
| 1 | 0.05 | 0.05 | 0.05 | 0.00241199 | 0.0049538 | 0.0476709 |
| 1 | 0.1 | 0.1 | 0.1 | 0.00891618 | 0.0179818 | 0.0980353 |
| 1 | 0.15 | 0.15 | 0.15 | 0.0187224 | 0.0388996 | 0.140572 |
| 1 | 0.2 | 0.2 | 0.2 | 0.0245902 | 0.0552228 | 0.165963 |
| 1 | 0.25 | 0.25 | 0.25 | 0.0435039 | 0.100271 | 0.200444 |
| 1 | 0.3 | 0.3 | 0.3 | 0.0655055 | 0.151884 | 0.238717 |
| 1 | 0.35 | 0.35 | 0.35 | 0.117476 | 0.269557 | 0.2816 |
| 1 | 0.4 | 0.4 | 0.4 | 0.141551 | 0.331917 | 0.313825 |
| 1 | 0.45 | 0.45 | 0.45 | 0.249052 | 0.554851 | 0.381483 |
| 1 | 0.5 | 0.5 | 0.5 | 0.180059 | 0.434578 | 0.36923 |
| 1 | 0.55 | 0.55 | 0.55 | 0.301436 | 0.694313 | 0.443554 |
| 1 | 0.6 | 0.6 | 0.6 | 0.47162 | 1.09206 | 0.483769 |
| 1 | 0.65 | 0.65 | 0.65 | 0.389389 | 0.940598 | 0.49075 |
| 1 | 0.7 | 0.7 | 0.7 | 1.01652 | 2.13905 | 0.659811 |
| 1 | 0.75 | 0.75 | 0.75 | 0.821125 | 1.88253 | 0.62153 |
| 1 | 0.8 | 0.8 | 0.8 | 1.81622 | 3.82939 | 0.737823 |
| 1 | 0.85 | 0.85 | 0.85 | 3.19997 | 7.15802 | 0.749558 |
| 1 | 0.9 | 0.9 | 0.9 | 1.89561 | 4.59878 | 0.678027 |

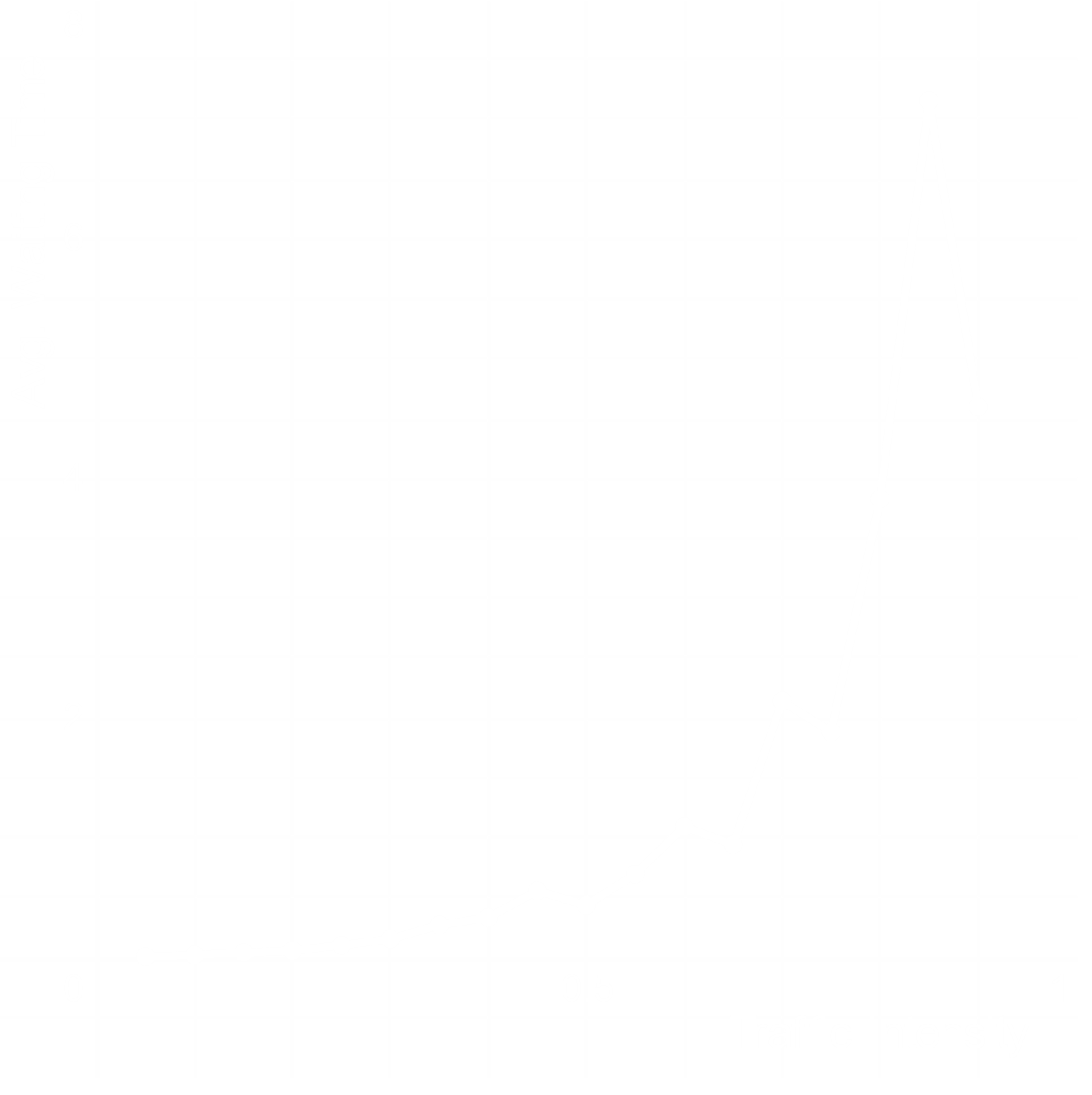
## Average Queue Length



The average queue length was calculated as the ratio of the sum of the time average queue lengths of each server to the total number of servers.

As can be seen, the average queue length tends to increase as the traffic intensity is increased. This makes sense, since if customers are arriving almost as fast as they can be served, the queue size will likely begin to approach infinity.

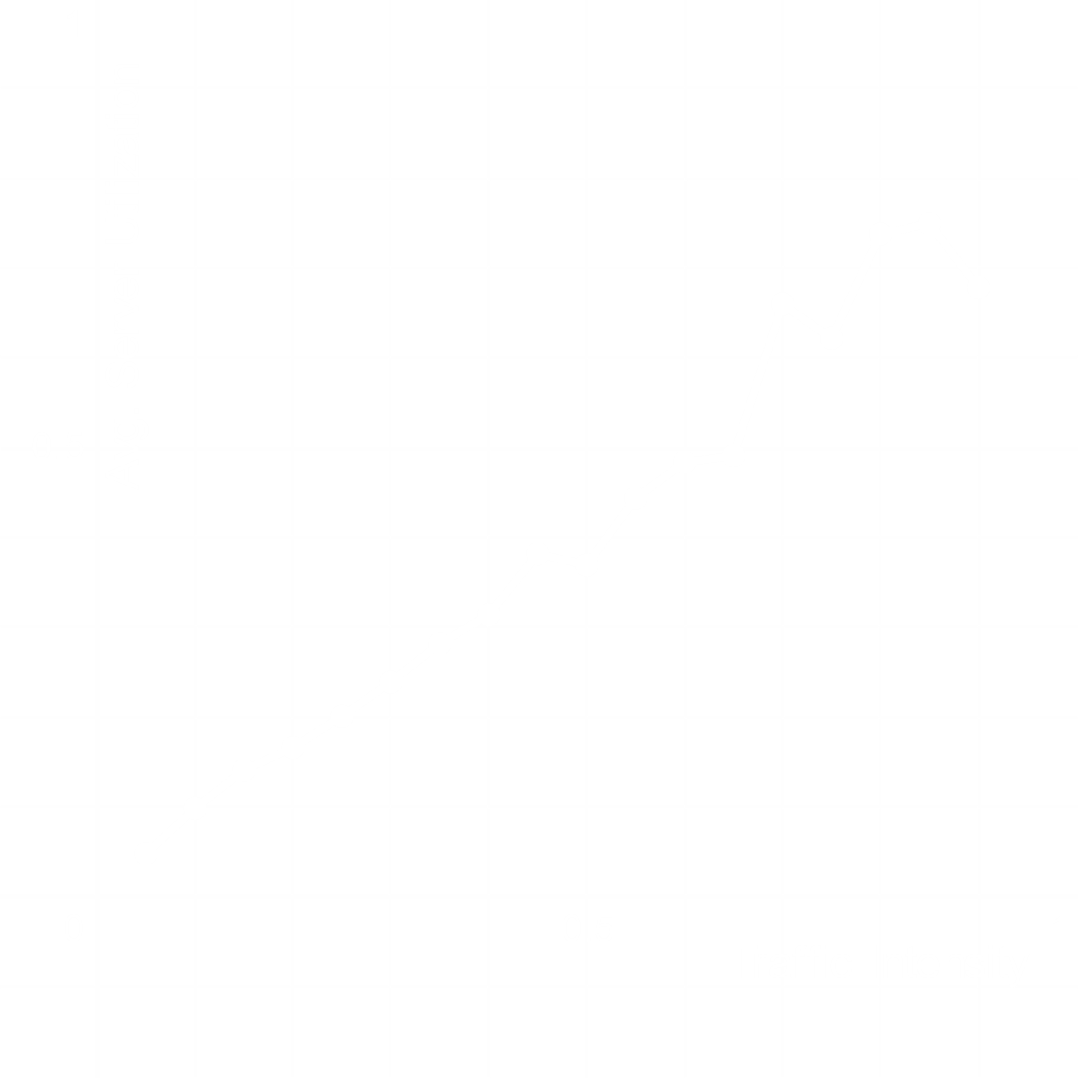
## Average Waiting Time



The average waiting time was calculated as the ratio of the sum of the cumulative queuing delays of all customers for each queue to the total number of customers.

Similar to the average queue length, the average waiting time also shows a tendency to increase as traffic intensity increases, for the same reason. A longer queue will result in customers having to wait for longer.

## Average Server Utilization



The average server utilization was calculated as the ratio of the sum of the average server utilization at each server to the total number of servers.

The average server utilization shows a tendency to increases as traffic intensity increases. Since service times increase, the gap between one customer finishing their service and another customer arriving decreases. This results in a lower chance of the server sitting idle, since the next customer will have to be served soon after, if not immediately after, the previous one has departed.