July 19, 2024

Goal

We aim to analyze the performance of a queueing system under two service disciplines: the Last In, First Out (LIFO) and First In, First Out (FIFO). Specifically, we will simulate an M/M/1 queue with infinite capacity, where arrivals follow an exponential distribution with rate λ values chosen and service times follow an exponential distribution with rate $\mu = 1$. The goal is to compare the mean delay and mean number of customers in the system under the FIFO and LIFO schemes for different values of the traffic intensity $\rho = \lambda/\mu$.

Experiments

Parameters

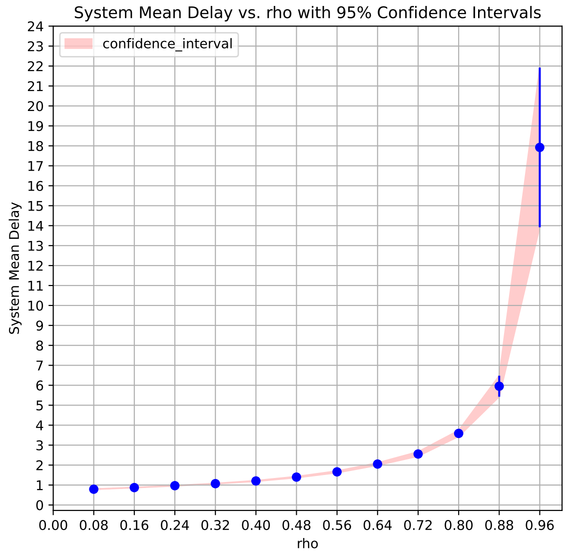
- Arrival rate λ: Varied from 0.08 to 0.96 in steps of 0.08, 12 values such that $0 < \rho < 1$
- Service rate μ: Fixed at 1
- Number of simulations: 30 per data point.
- Total number of customers: 3000 per simulation.
- Confidence interval: 95% using z=1.96.
- Random number generator: Python's built-in random module with seed 1234567
- Performance measures: Mean delay and mean number of customers in the system.

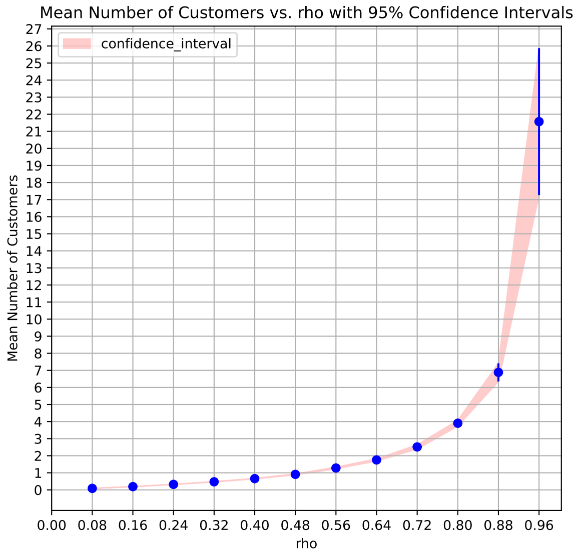
Experiment Setup

- Using two different code files for FIFO and LIFO schemes
- For each value of $\rho = \lambda/\mu$, perform 30 simulations to obtain reliable estimates.
- In each simulation, initialize the queueing system and simulate until 3000 customers have been served.
- Use the FIFO/LIFO scheme for service order
- Record the data starting from 801th customer to calculate the mean delay and mean number of customers in the system for each simulation.
- Calculate the mean and confidence intervals for each ρ value based on the 30 simulations.

Experimental Results

(First in First Out (FIFO):

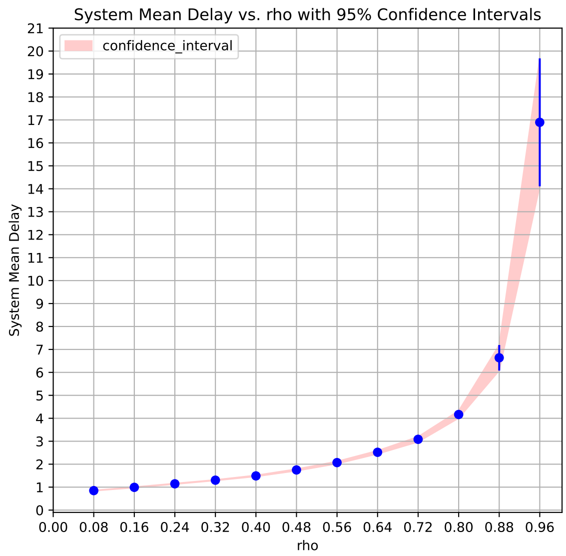


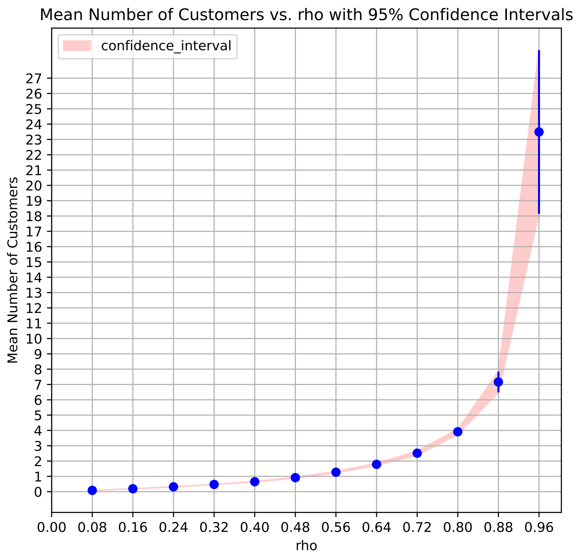


In the results obtained for the FIFO scheme, it is evident that both the system's mean delay and the number of customers exhibit an exponentially increasing trend with increasing traffic intensity. The system's mean delay starts near 1, which aligns with the service rate of 1 customer per time unit ($\mu = 1$). It is notable that the confidence interval widens as the traffic intensity increases, indicating higher uncertainty in the performance estimates.

Furthermore, the mean number of customers in the system at any given point in time starts from values close to zero for lower traffic intensities and increases at a similar rate to the system's mean delay.

Last In First Out (LIFO):





In the results obtained for the LIFO scheme, similar observations are made to those in the FIFO scheme. Both the system's mean delay and the number of customers exhibit an exponentially increasing trend with increasing traffic intensity. The system's mean delay starts near 1, reflecting the service rate of 1 customer per time unit. The confidence interval also widens as the traffic intensity increases, indicating higher uncertainty in the performance estimates.

Additionally, the mean number of customers in the system at any given point in time starts from values close to zero for lower traffic intensities and increases at a similar rate to the mean delay.

Conclusions

In conclusion, the analysis of an M/M/1 queueing system under both FIFO and LIFO service disciplines revealed several key insights. Both schemes exhibited similar trends, with the system's mean delay and the number of customers in the system increasing exponentially with higher traffic intensity. They both show same mean delays for lower traffic and at higher traffic intensity LIFO has higher number of customers waiting in queue and slightly higher mean delay (except for the last observation point). System's mean delay and mean number of customers seem to be directly related. These observation suggests a direct relationship between traffic intensity and the average number of customers in the system, indicating that as traffic increases, more customers are likely to be present in the system at any moment.

Also, the widening of confidence intervals with increasing traffic intensity indicates higher uncertainty in performance estimates. These findings underscore the importance of considering different service disciplines and traffic intensities when designing and analyzing queueing systems to optimize performance and resource allocation.