

Carleton University

SYSC 4005 PROJECT

Final Project

**Fabrice Anon 100796773, Minh Hoang 100806548, Vijith
Navarathinarasah 100796858**

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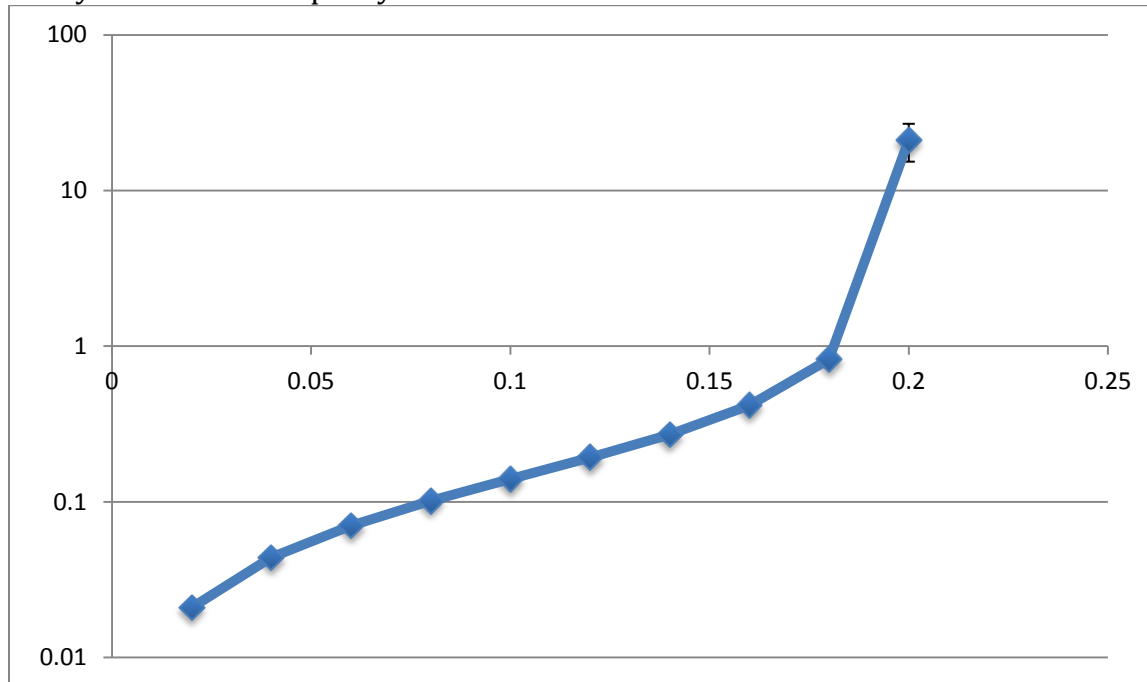
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Topology 1: Single-queue single-server system with random connectivities

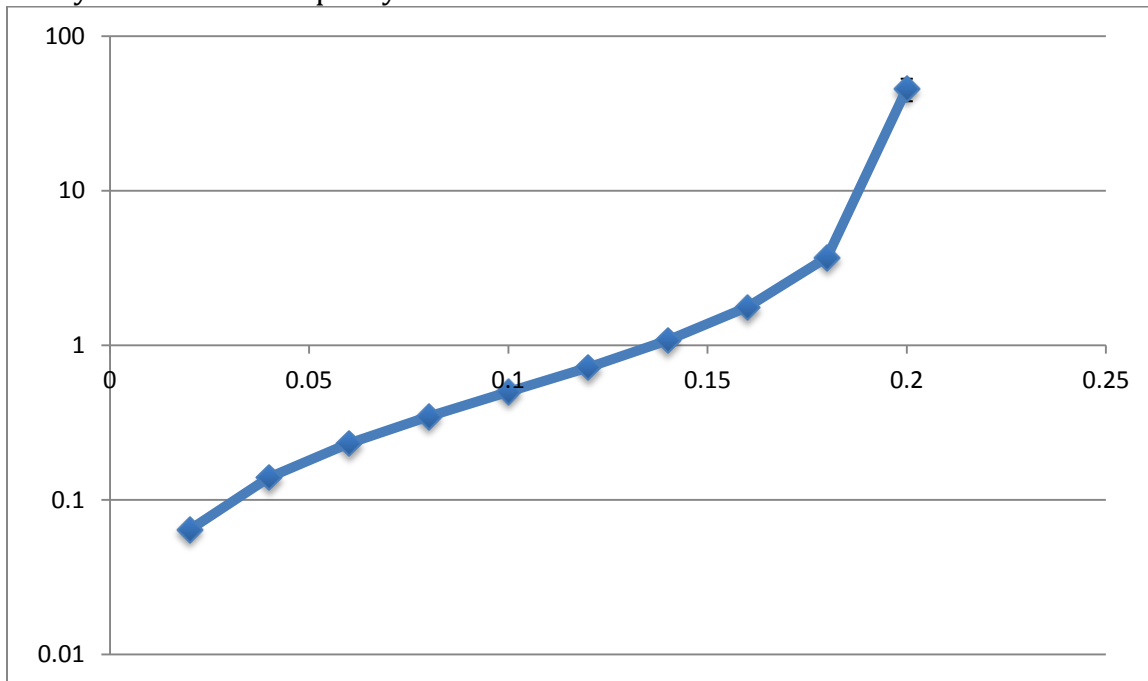
Symmetric Scenario 1: $p = 1, \lambda = 0.02 * i$ with $i = 1$ to 10

No correlation: $a=0.5, b=-0.5$

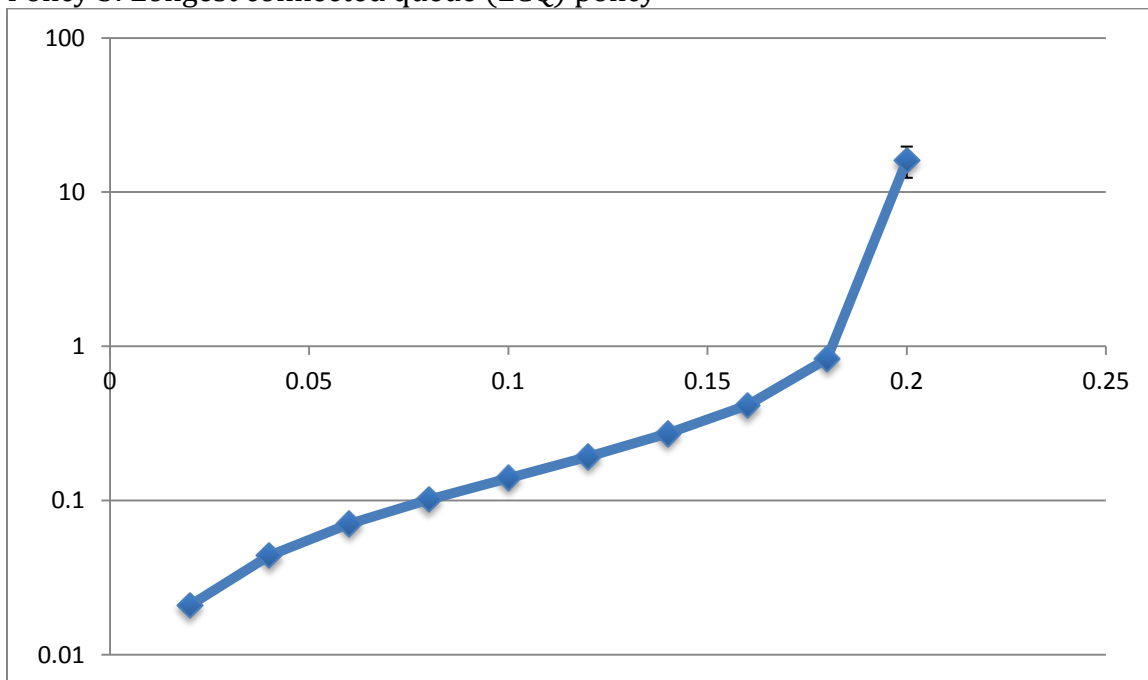
Policy 1: Randomized policy



Policy 2: Round Robin policy

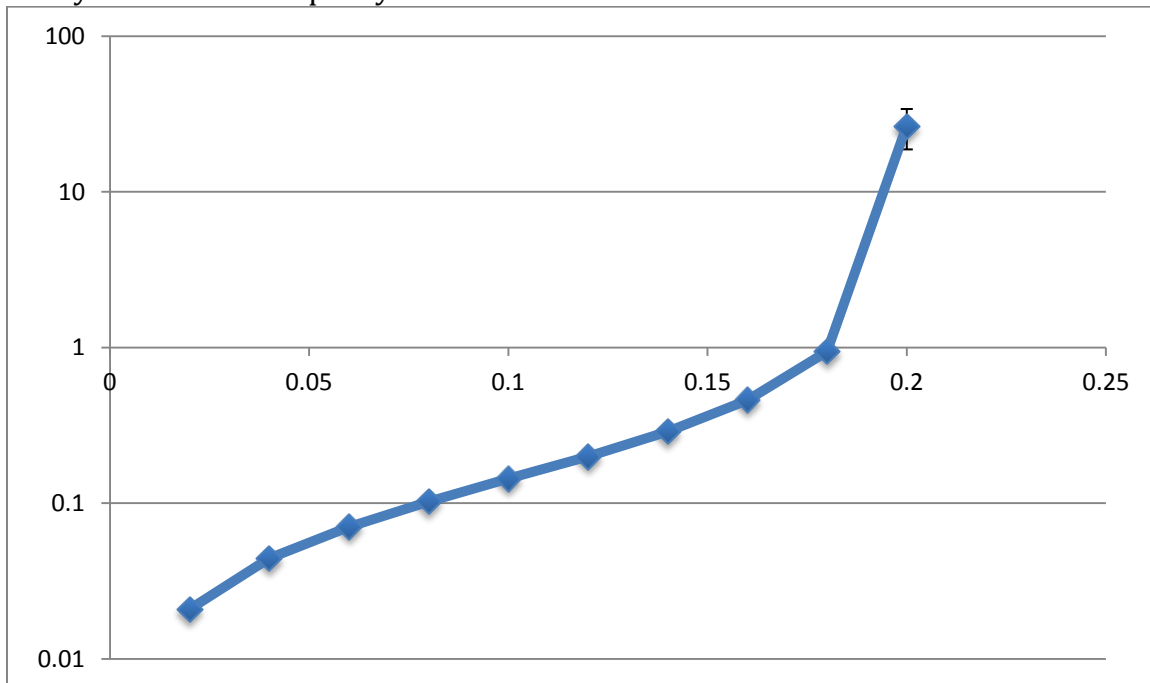


Policy 3: Longest connected queue (LCQ) policy

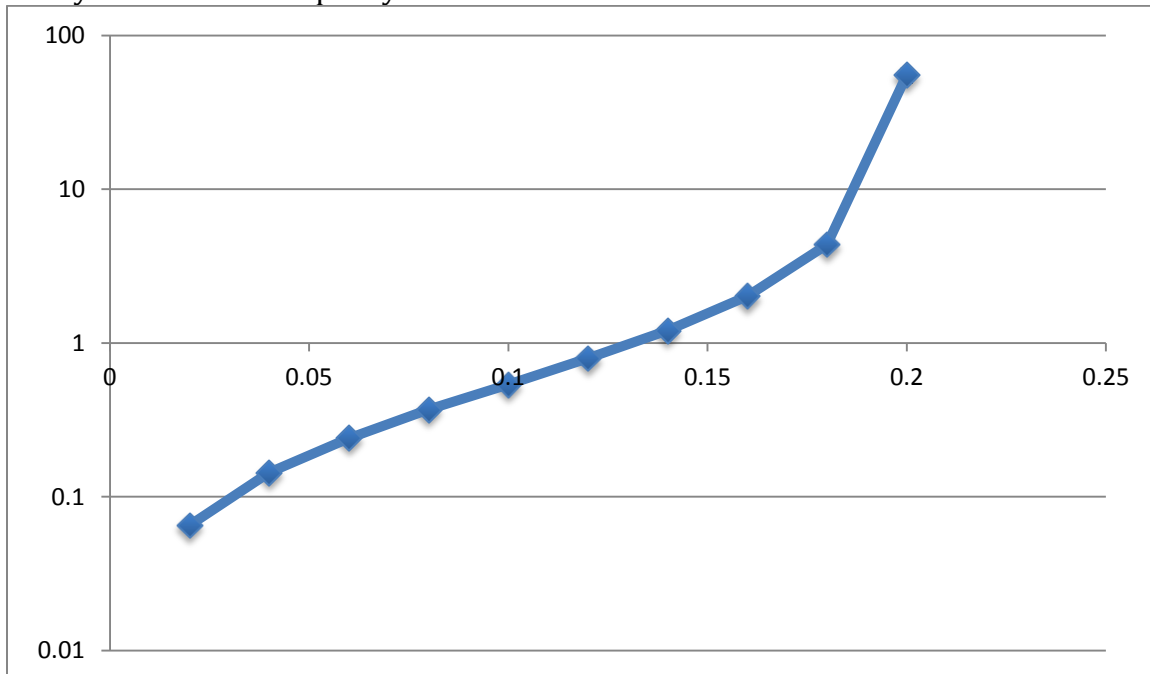


Small correlation: $a=0.4$, $b=-0.4$

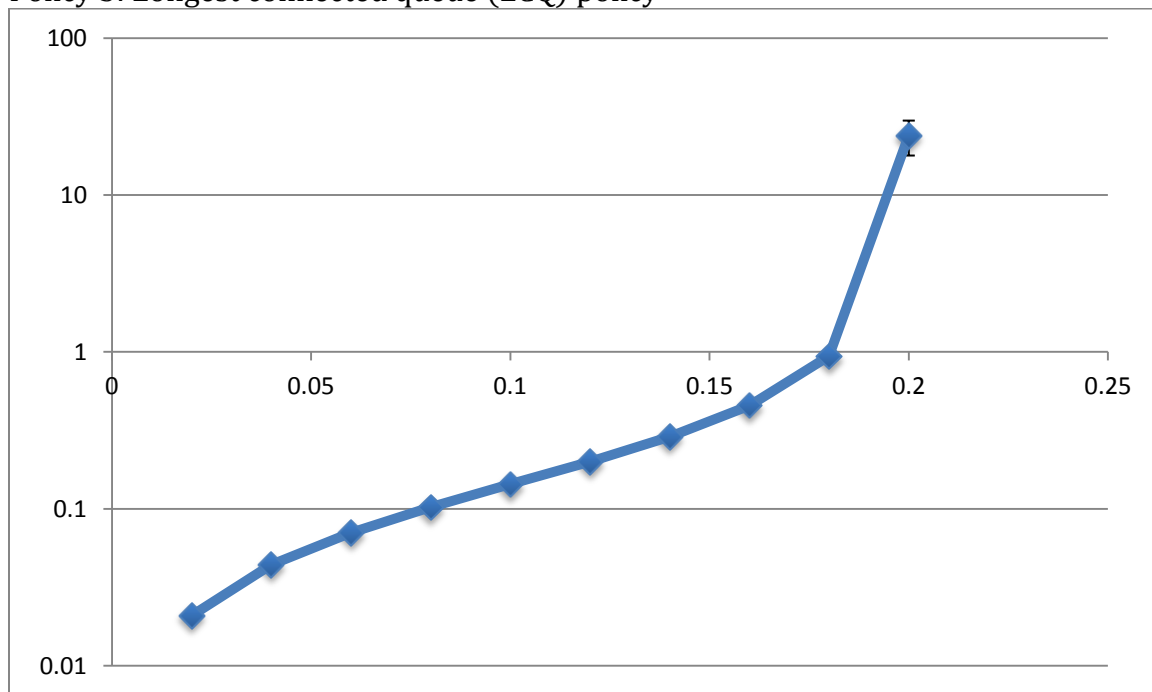
Policy 1: Randomized policy



Policy 2: Round Robin policy

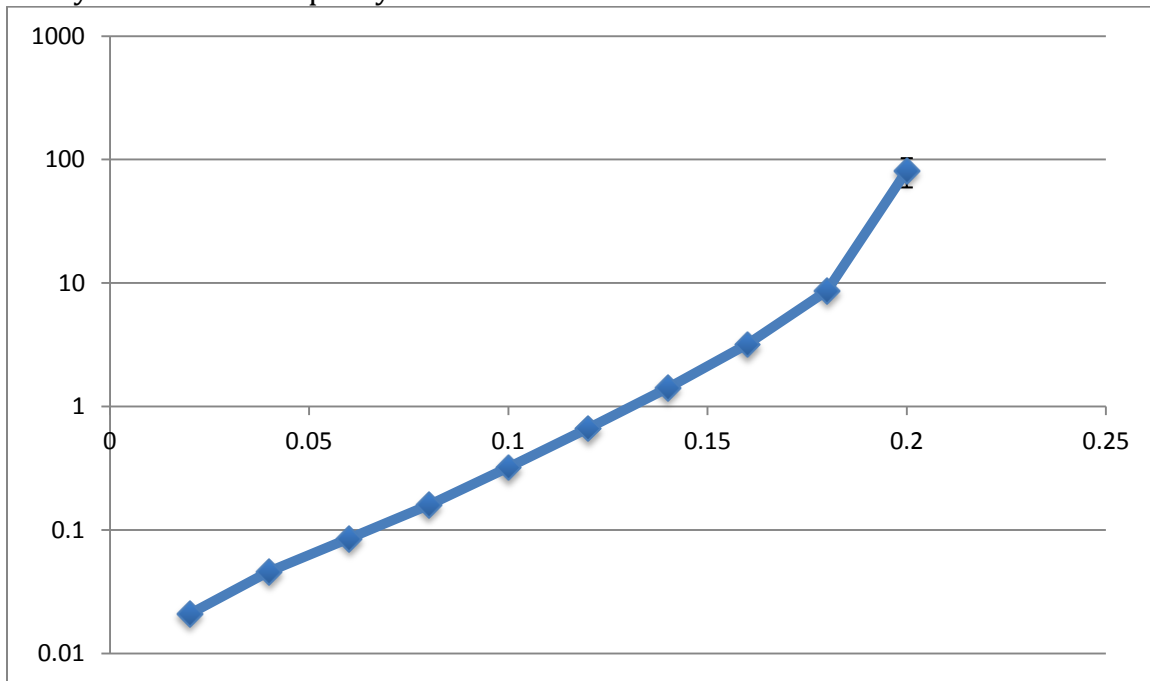


Policy 3: Longest connected queue (LCQ) policy

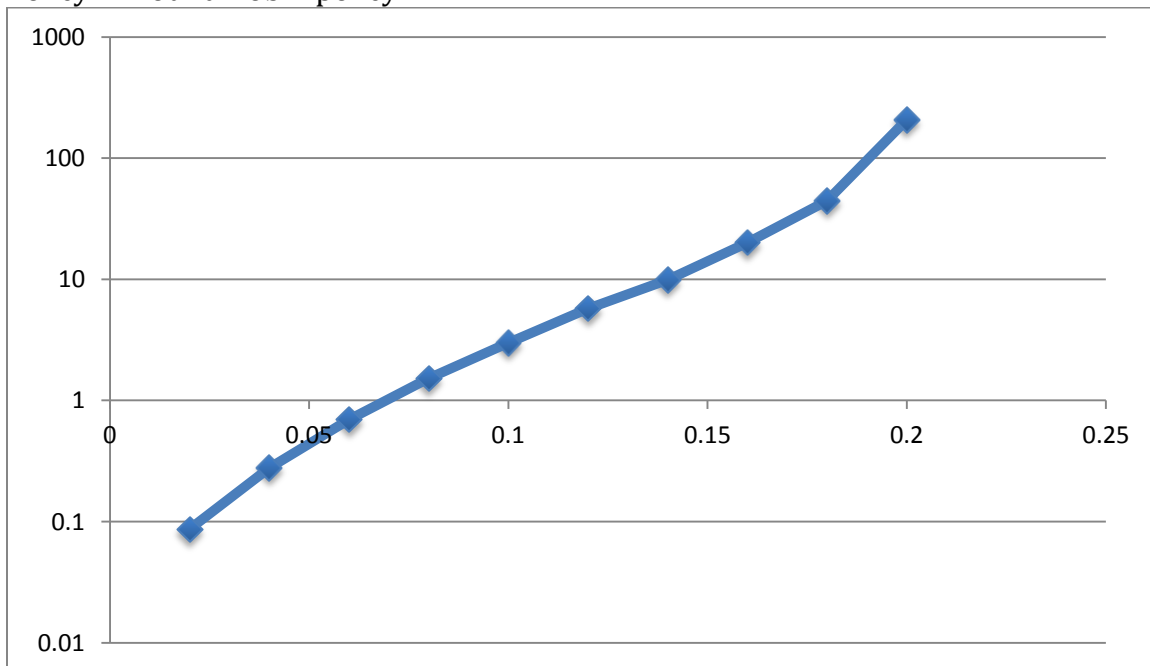


High correlation: $a=0.1$, $b=-0.1$

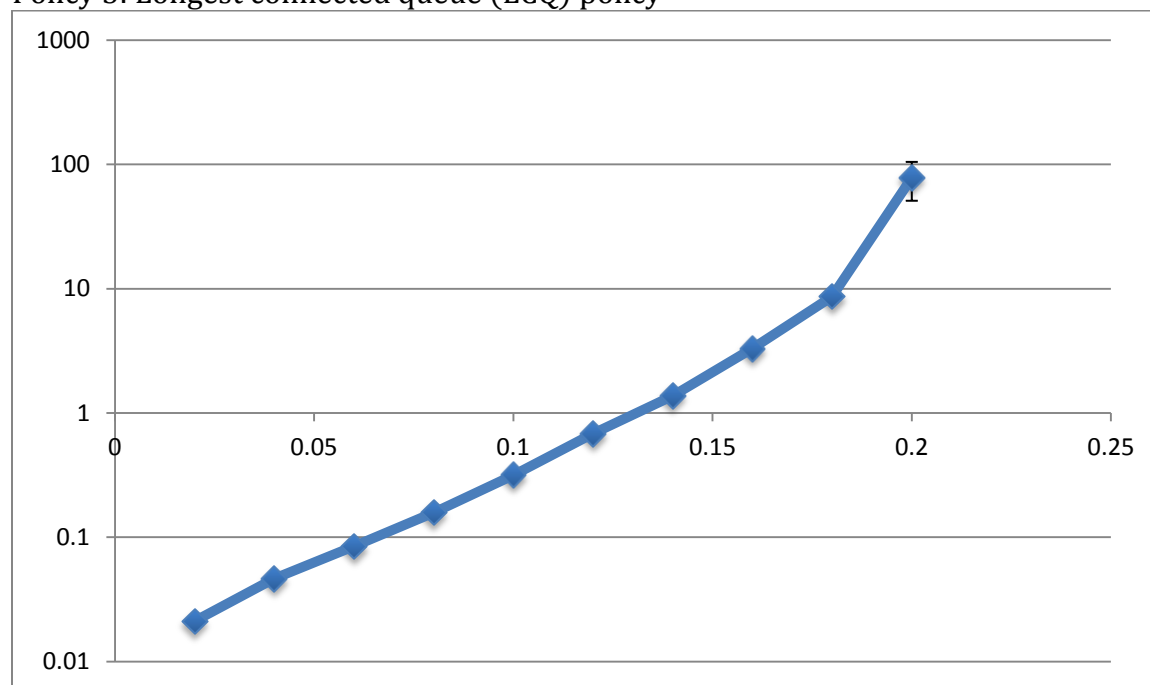
Policy 1: Randomized policy



Policy 2: Round Robin policy



Policy 3: Longest connected queue (LCQ) policy



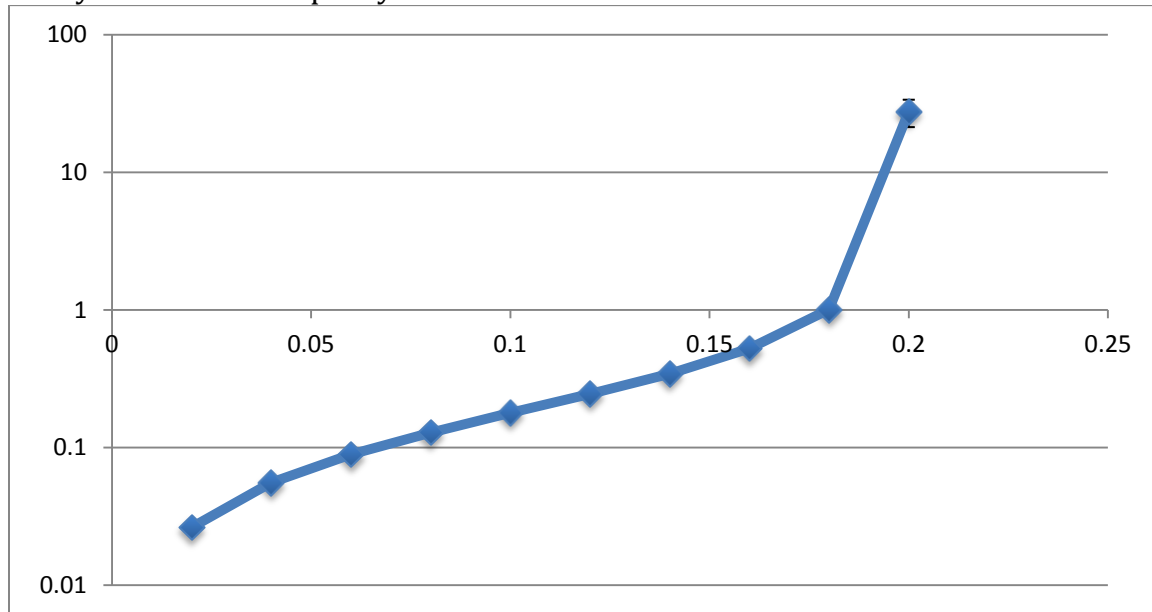
In the case for a randomly connected server, the server may be idle if the connected queues are empty and the unconnected queues are non-empty. In this scenario, the server is not able to service any packets, hence it is not optimal even though the server implements a work conserving policy (i.e. LCQ).

The performance of the different policies (Randomized, Round Robin, Longest Connected Queue) are all evaluated by observing the average queue occupancy in each policy scenario. The Randomized and Longest Connected Queue policies are nearly identical whereas the Round Robin policy is visibly worse having more packets in the queue in comparison. The Randomized Policy and Longest Connected Queue Policy perform the same because the server is never idle when there is a non-empty queue (both policies are work conserving policies) and hence it services roughly the same number of packets at the same rate regardless of the scheduling policy, whereas the Round Robin queue does not check to see if the server is connected to the queue or if the queue is non-empty and hence the server is more idle relative to the other scheduling policies. The expectation of decreasing the probability of connectivity p is that the average queue occupancy will increase because the server's chances of connecting to a queue decrease. This provides an opportunity for idle time slots where the server is unable to service packets from any queues because the non-empty queues are possibly disconnected.

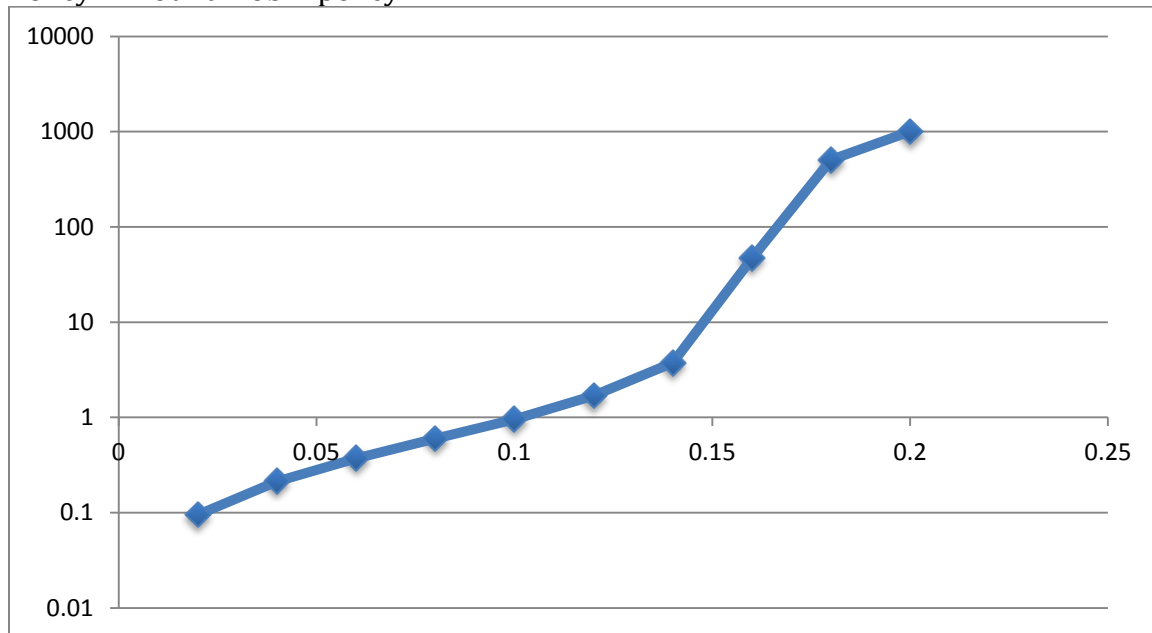
Symmetric Scenario 2 : $p = 0.8, \lambda = 0.02 * i$ with $i = 1$ to 10

No correlation: $a=0.5, b=-0.5$

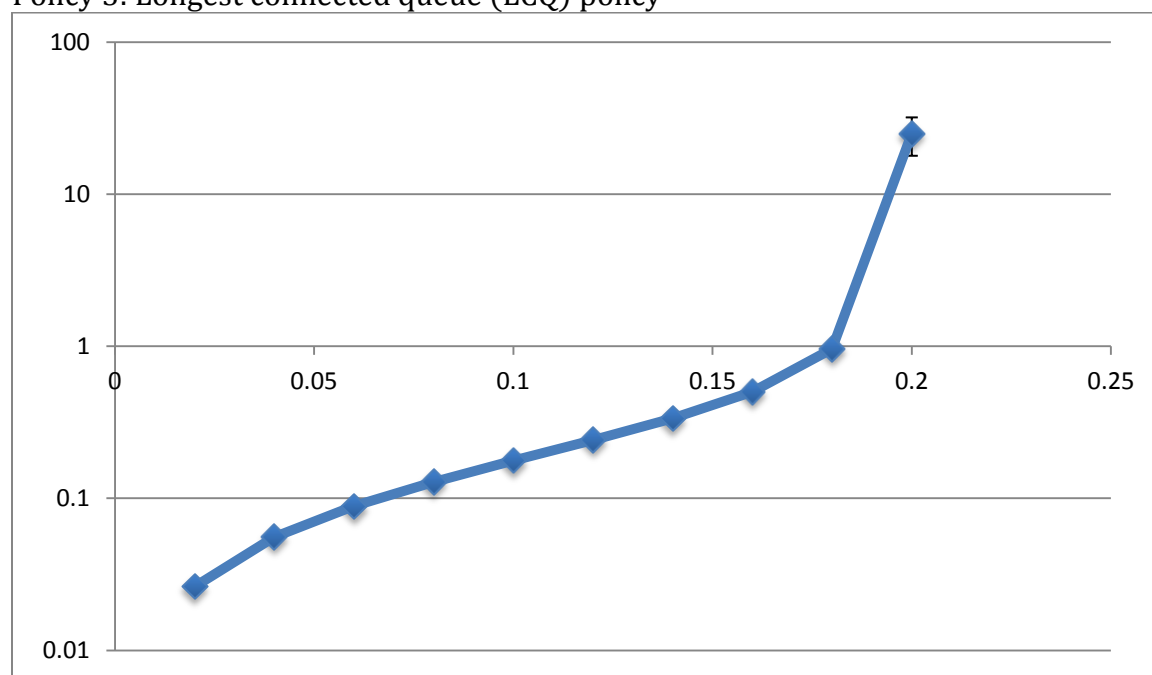
Policy 1: Randomized policy



Policy 2: Round Robin policy

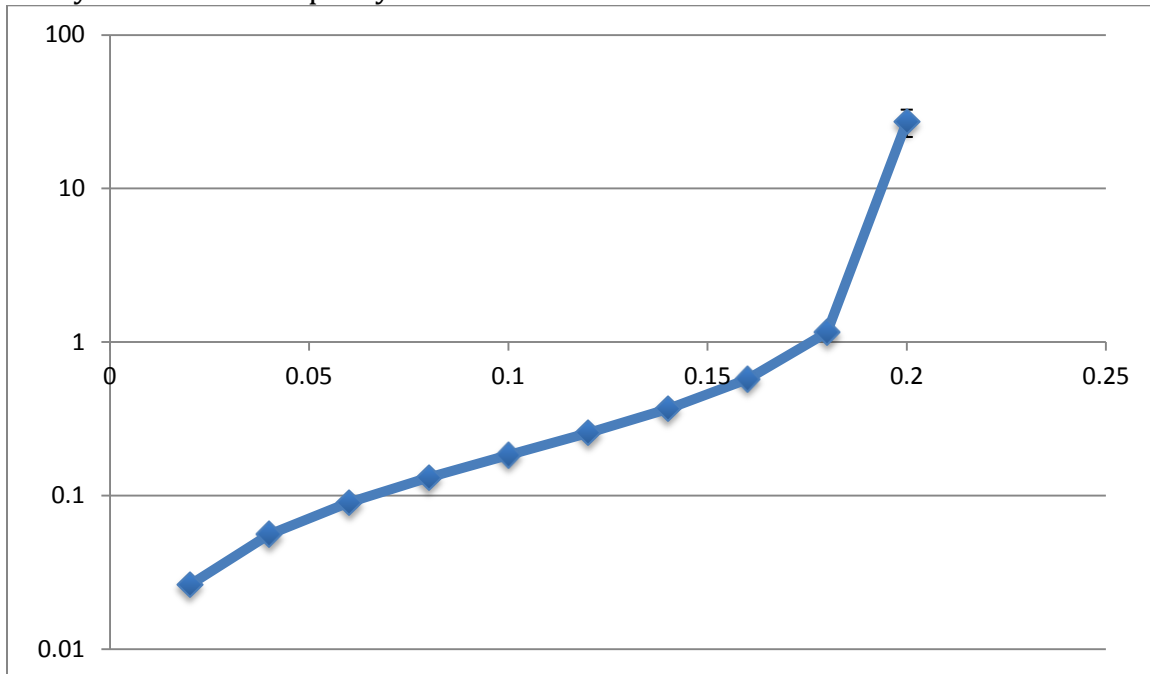


Policy 3: Longest connected queue (LCQ) policy

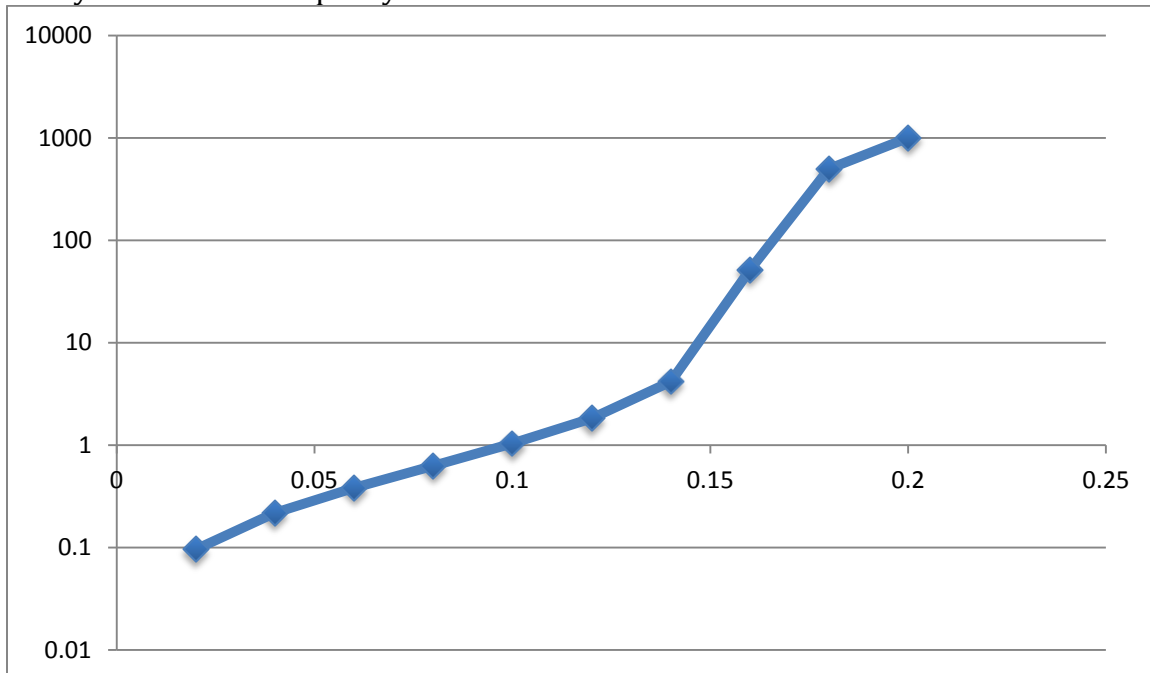


Small correlation: $a=0.4$, $b=-0.4$

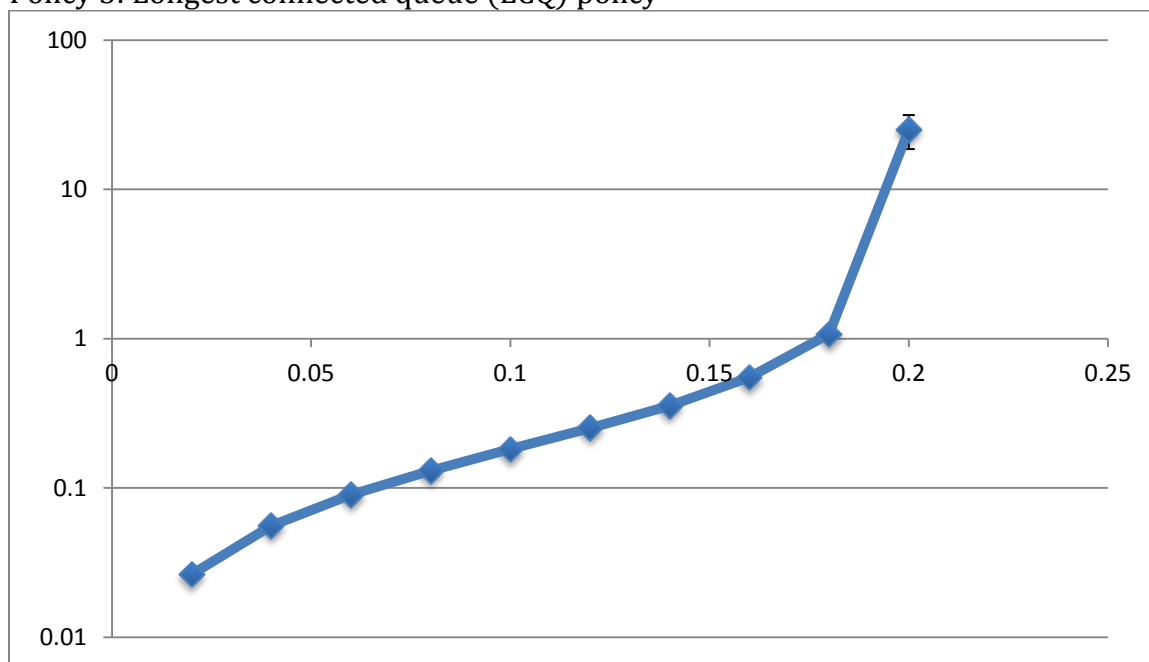
Policy 1: Randomized policy



Policy 2: Round Robin policy

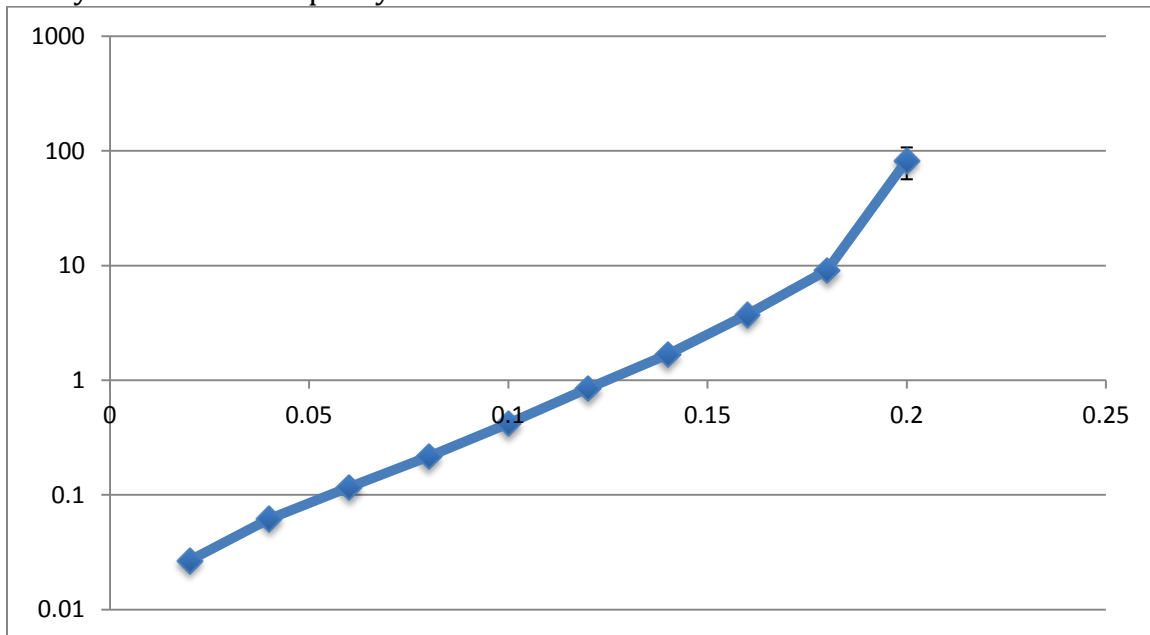


Policy 3: Longest connected queue (LCQ) policy

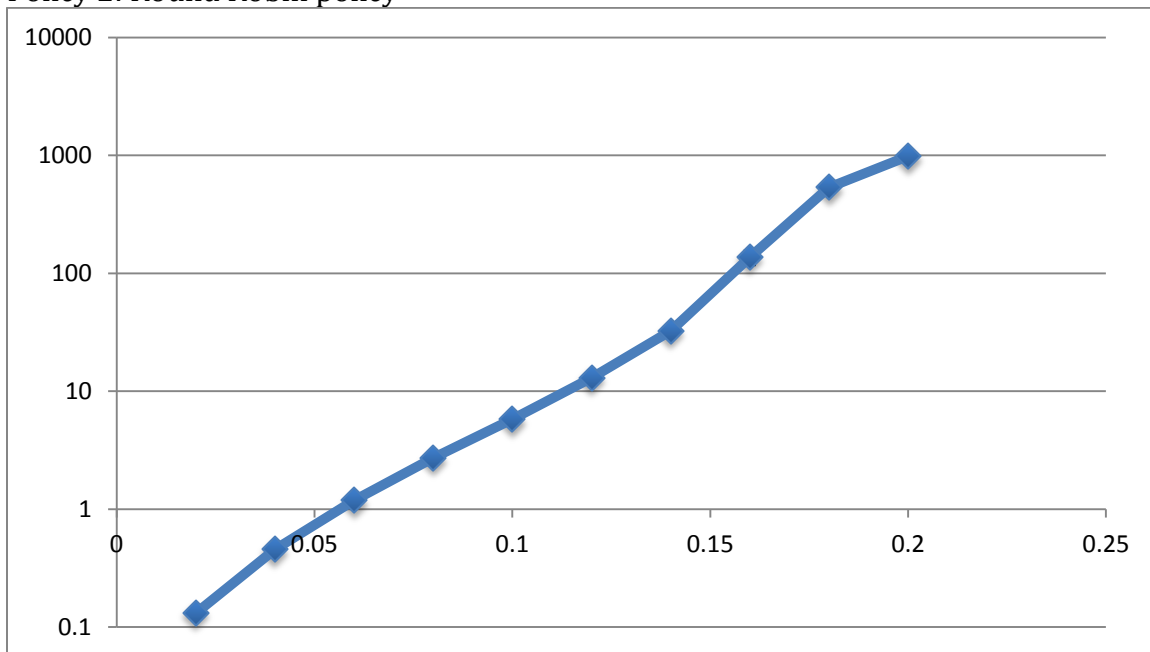


High correlation: $a=0.1$, $b=-0.1$

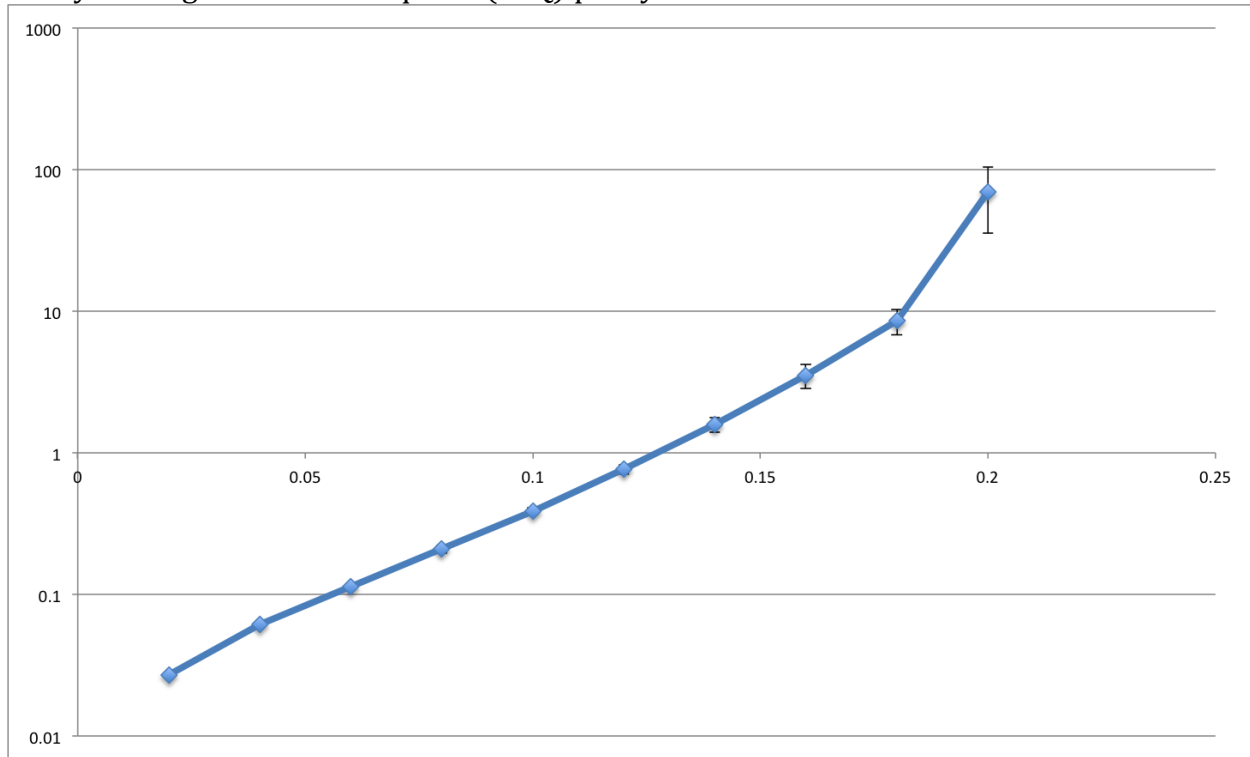
Policy 1: Randomized policy



Policy 2: Round Robin policy



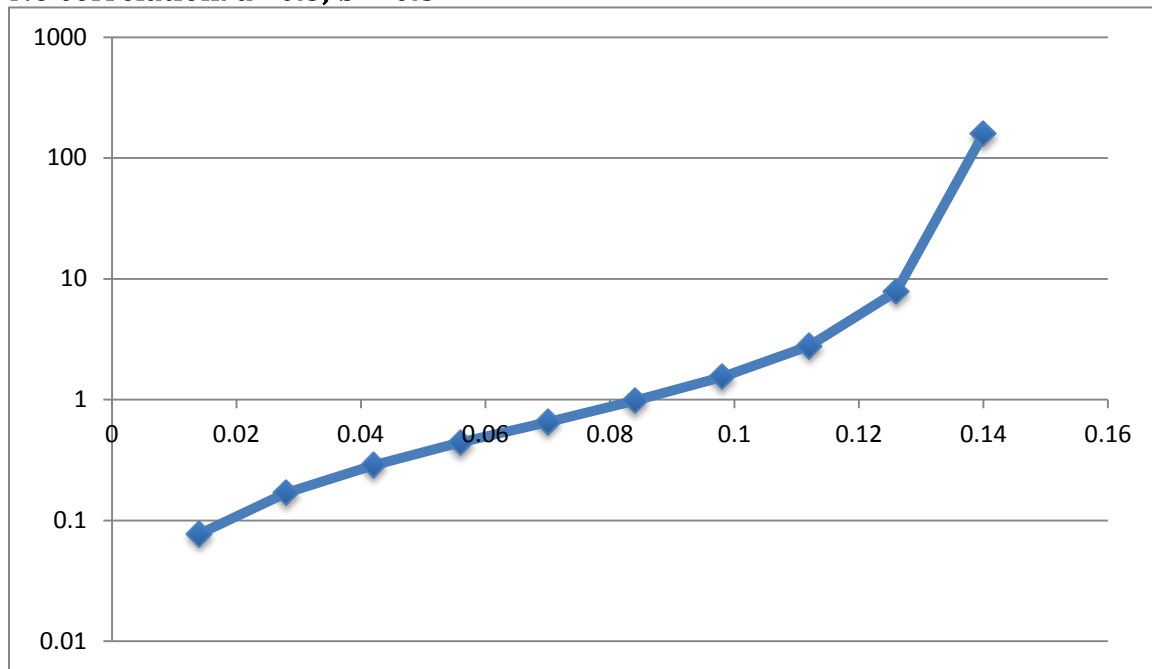
Policy 3: Longest connected queue (LCQ) policy



As expected, the average queue occupancy got worse as the probability of connectivity p decreased from 1 to 0.8. The Randomized Policy and Longest Connected Queue Policy perform the same because the server is never idle when there is a non-empty queue (both policies are work conserving policies) and hence it services roughly the same number of packets at the same rate regardless of the scheduling policy, whereas the Round Robin queue does not check to see if the server is connected to the queue or if the queue is non-empty and hence the server is more idle relative to the other scheduling policies. Also it is worth noting here that the Round Robin Scheduling policy gets significantly worse (very high average queue occupancy) as the probability of connectivity is reduced slightly. This is because the server is idle more than the scenario where the queues were always connected because it has a lower chance of selecting a connected queue to service.

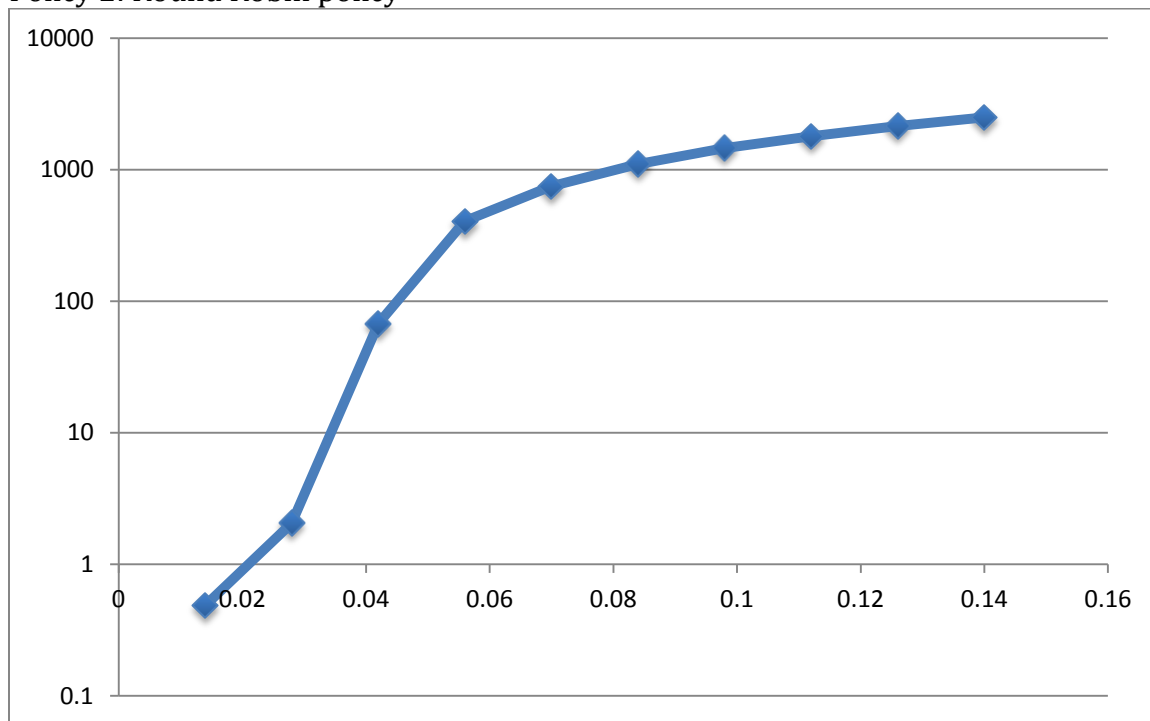
Symmetric Scenario 3: $p = 0.2, \lambda = 0.014 * i$ with $i = 1$ to 10

No correlation: $a=0.5, b=-0.5$

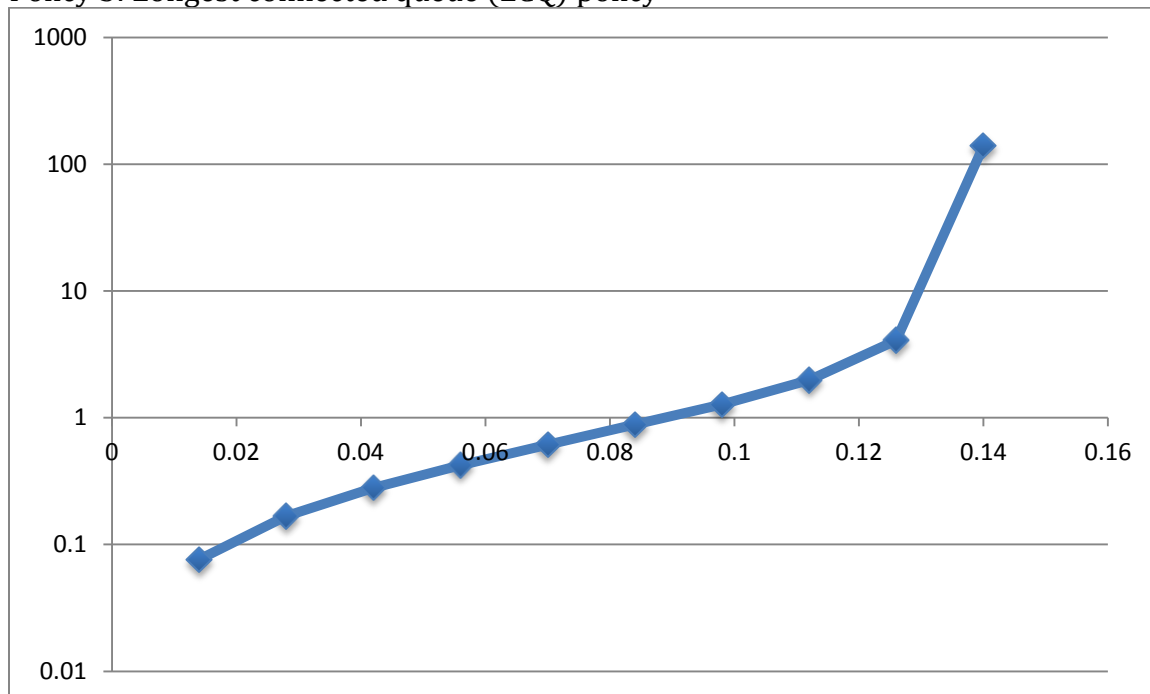


Policy 1: Randomized policy

Policy 2: Round Robin policy

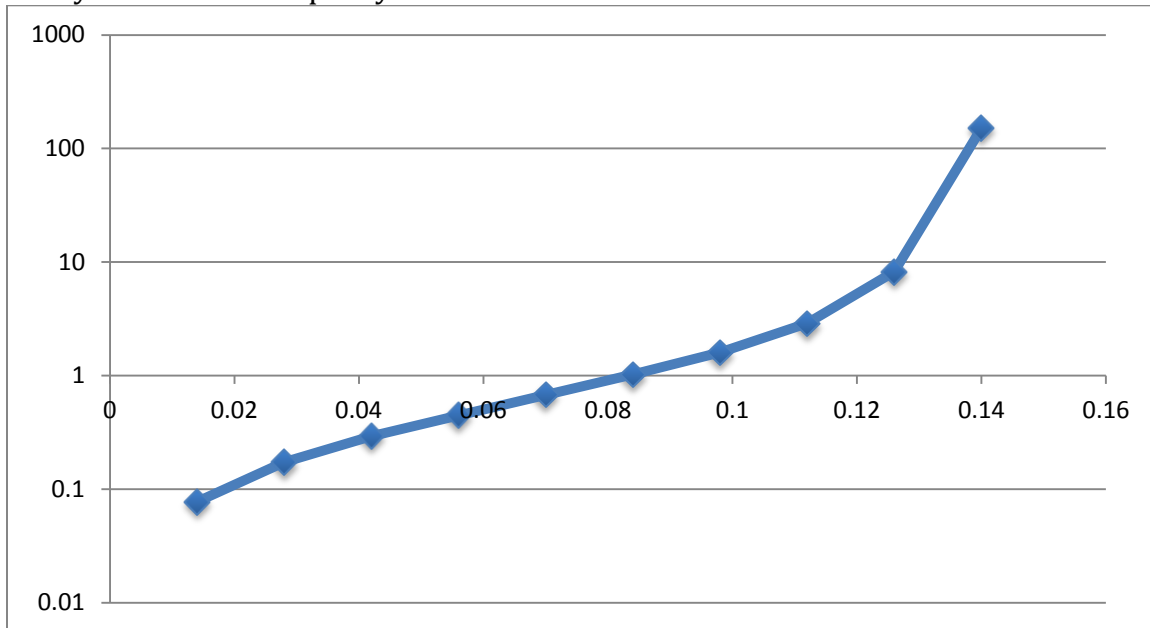


Policy 3: Longest connected queue (LCQ) policy

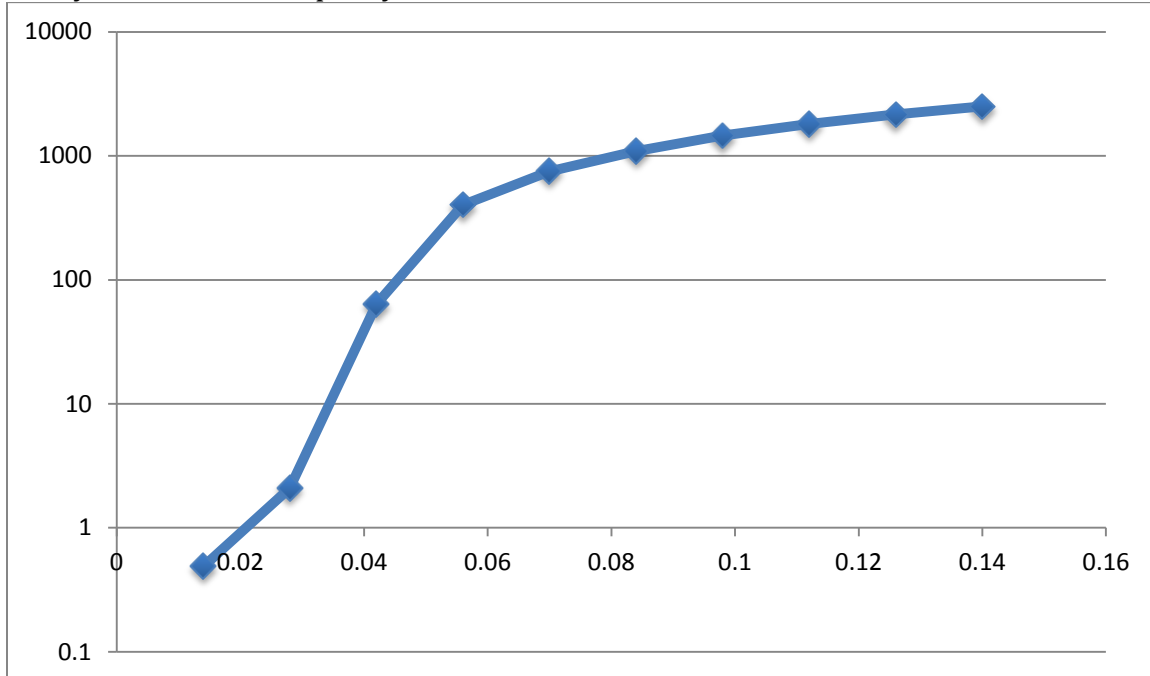


Small correlation: $a=0.4$, $b=-0.4$

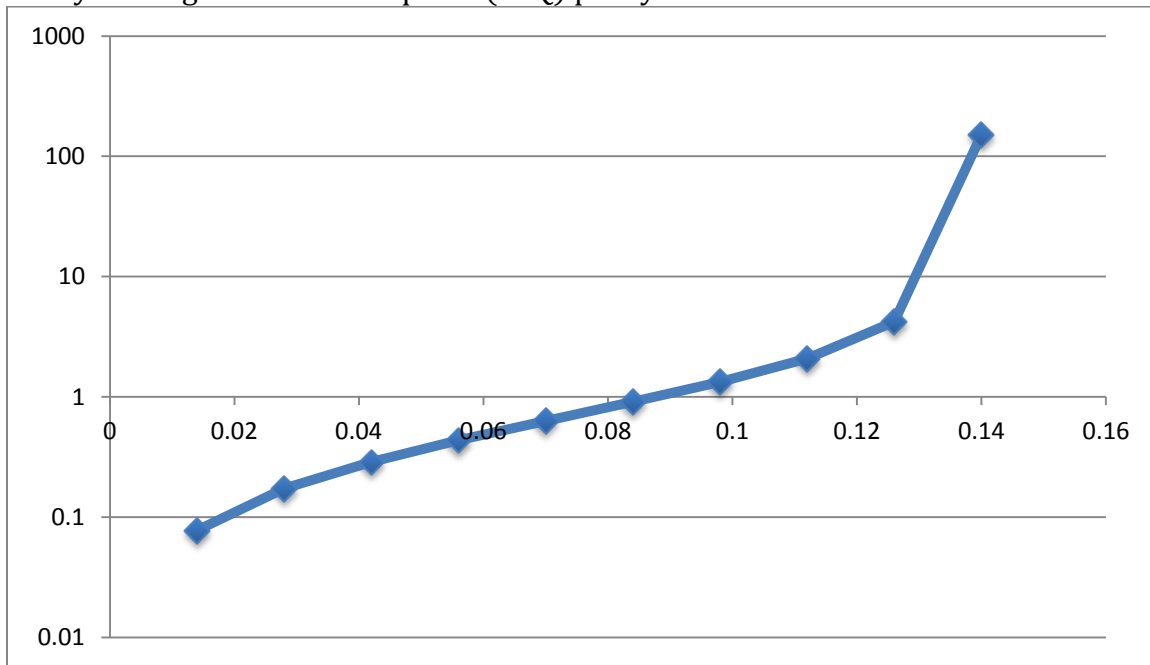
Policy 1: Randomized policy



Policy 2: Round Robin policy

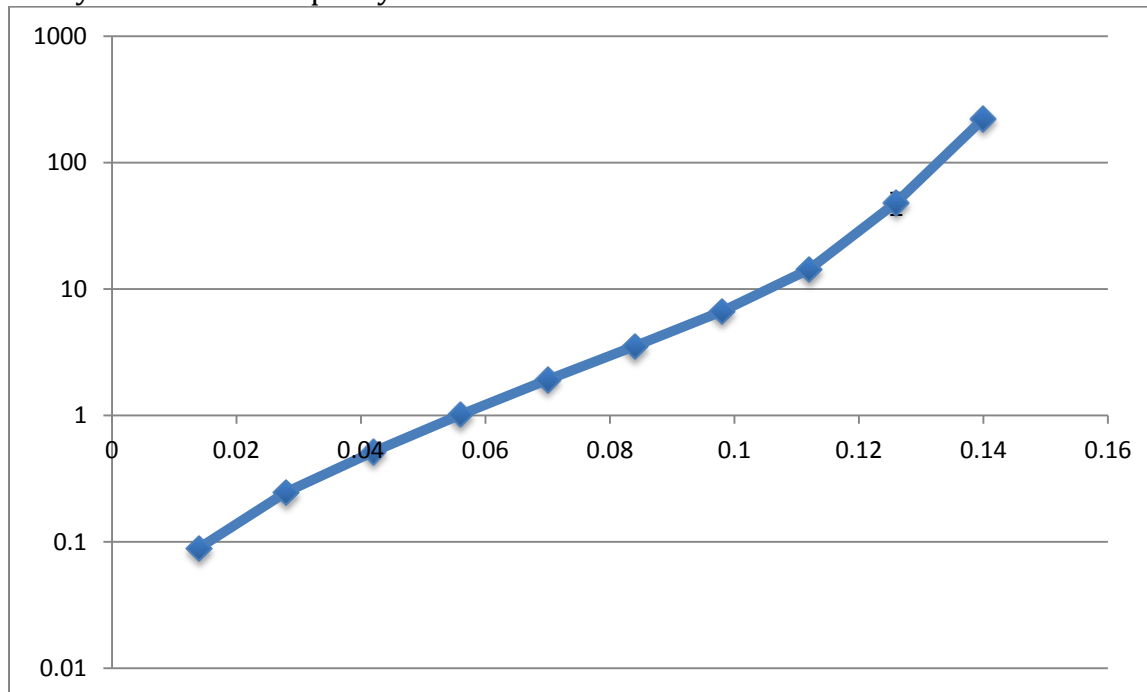


Policy 3: Longest connected queue (LCQ) policy

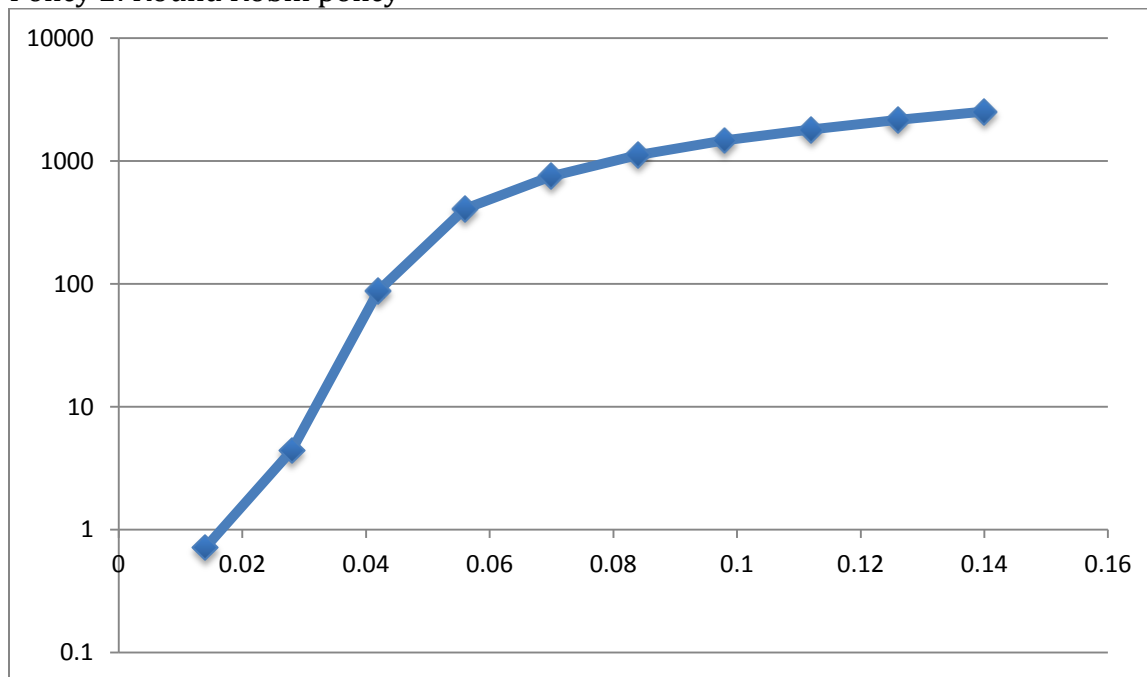


High correlation: $a=0.1$, $b=-0.1$

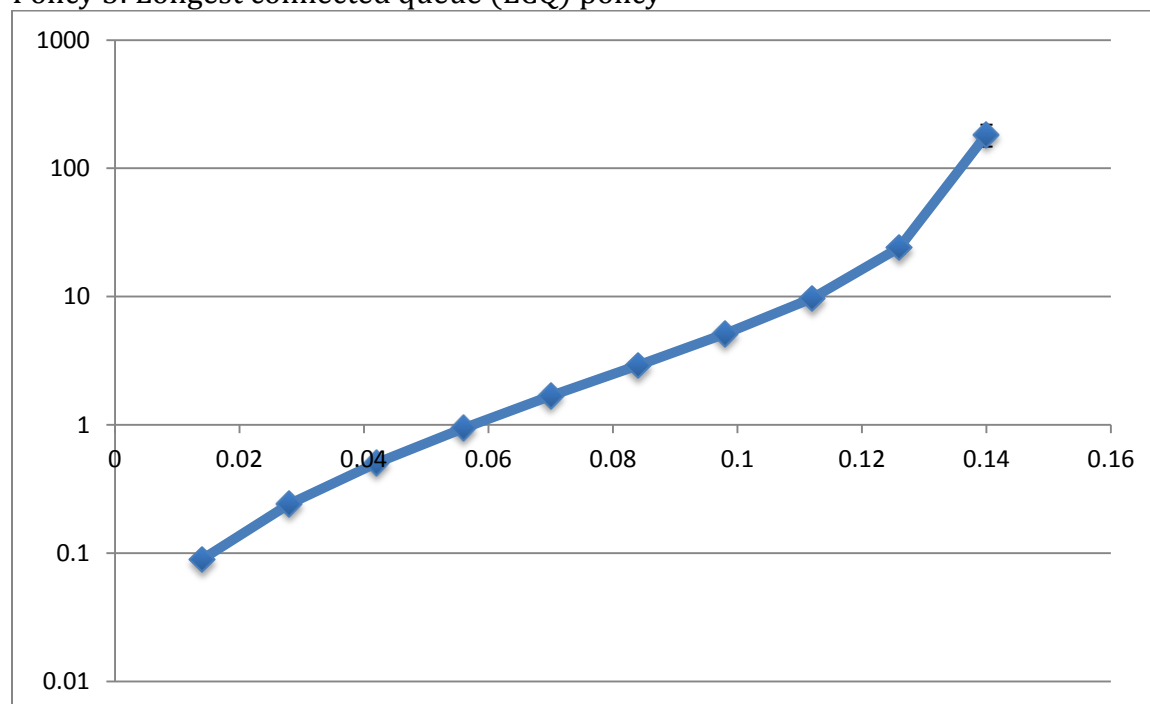
Policy 1: Randomized policy



Policy 2: Round Robin policy



Policy 3: Longest connected queue (LCQ) policy



In this scenario the probability of connectivity is reduced to 0.2 but the packet arrival probability is also in each queue since the arrival rate probability has decreased but also the server's ability to service the queues to remove the packets also decreases since the probability of connectivity is also reduced to 0.2. Graphing the results it is evident that the average queue occupancy has increased for each of the three scheduling policies significantly. Also it is worth noting here that the Round Robin Scheduling policy gets significantly worse (very high average queue occupancy) as the probability of connectivity is reduced significantly. This is because the server is idle much more than the other scenarios because it has a lower chance of selecting a connected queue to service.

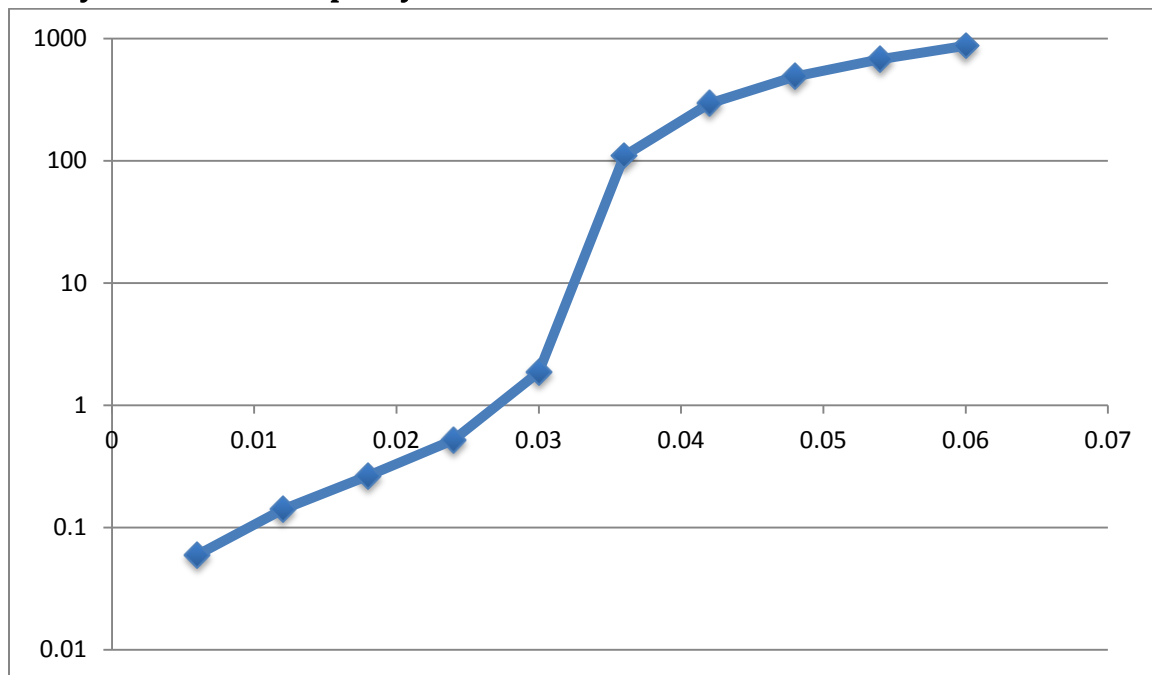
Decreasing the probability of connectivity increases the average queue occupancy because the scheduling policy may not have any queues to connect to, or the connected queues may not have any packets ready to be serviced (empty queue). These two scenarios are possibilities for the server to be idle during any given time slot, hence increasing the average queue occupancy values.

When all queues are connected to the server, the stability point is the same for all scheduling policies ($\lambda = 0.18$ approximately). When the probability of connectivity decreases to 0.8, there are visible changes in the stability points of each of the scheduling policies. The stability point for the Random and LCQ scheduling policies remain relatively the same ($\lambda = 0.18$ approximately) while the Round Robin scheduling policy's stability point occurs at a much smaller λ value ($\lambda = 0.14$ approximately).

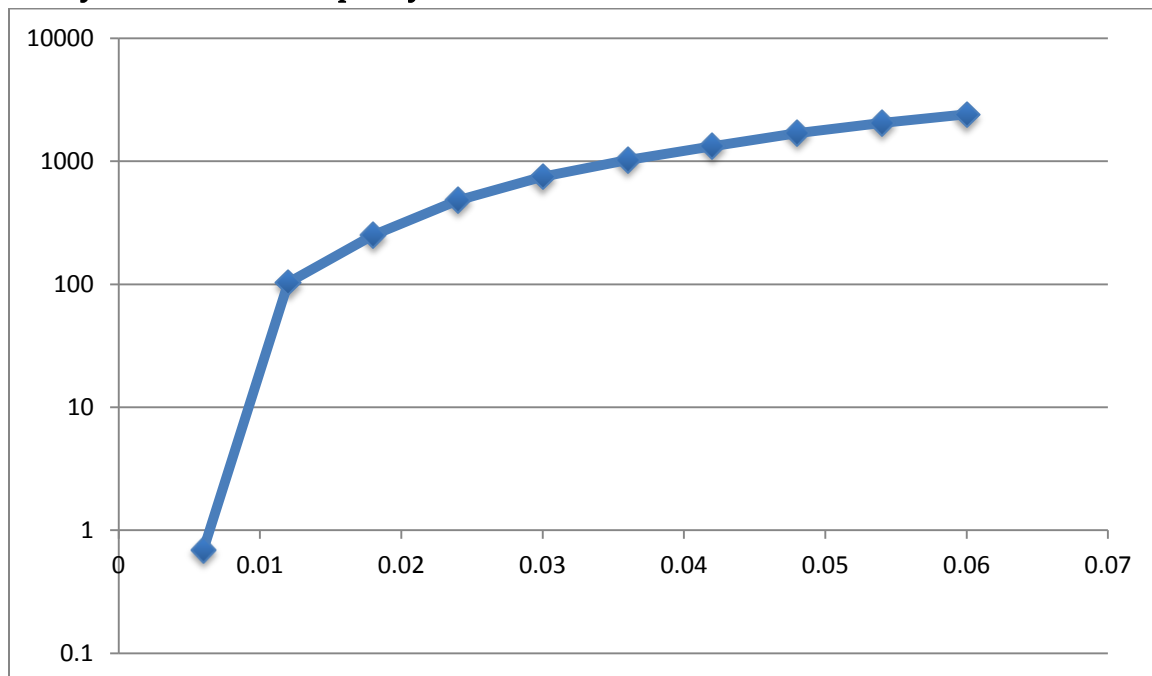
Since the system is unstable for λ values greater than the stability point λ value, it can be seen that the Round Robin scheduling policy is much more unstable than LCQ and Random Scheduling policies at greater λ values (packet arrival probability). When the probability of connectivity decreases to 0.2, the stability point values decrease also for all scheduling policies. The Random and LCQ stability points (λ^*) decrease approximately from 0.14 to 0.126 while the Round Robin policy decreases to $\lambda = 0.028$ approximately. The amount of decrease would be higher had the packet arrival probability stayed the same, but it also decreased which compensated a little for the stability points.

Asymmetric – No Correlation – $a=0.5$, $b=-0.5$, $\lambda = 0.006 * i$ with $i = 1$ to 10

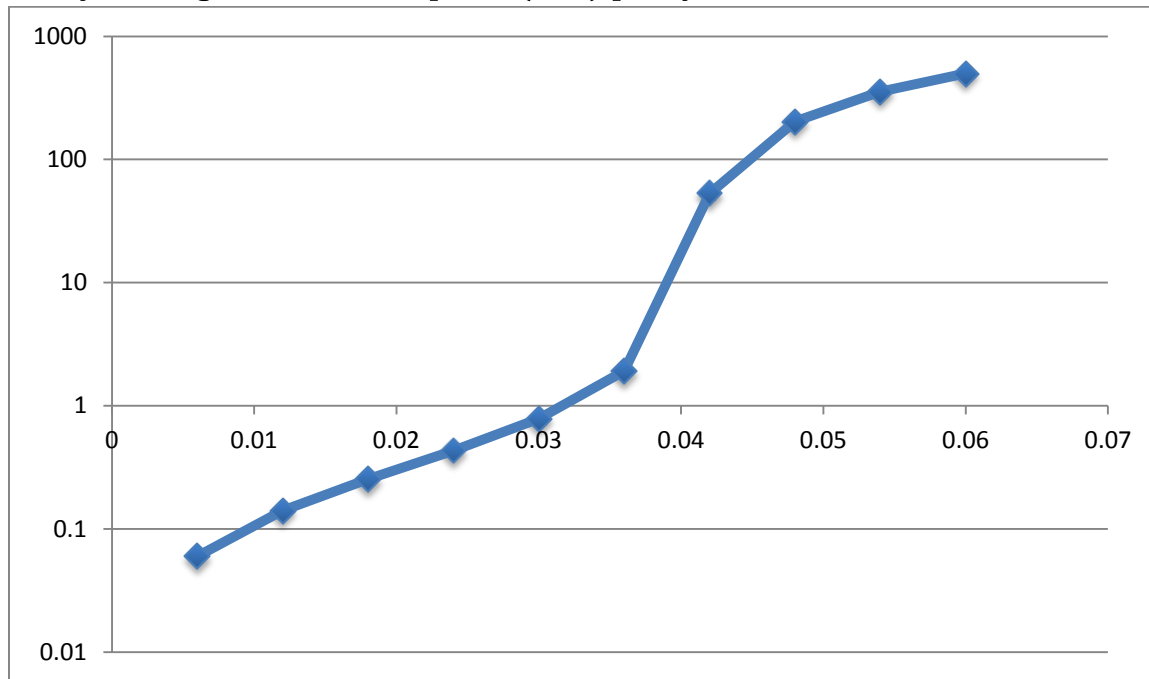
Policy 1: Randomized policy



Policy 2: Round Robin policy

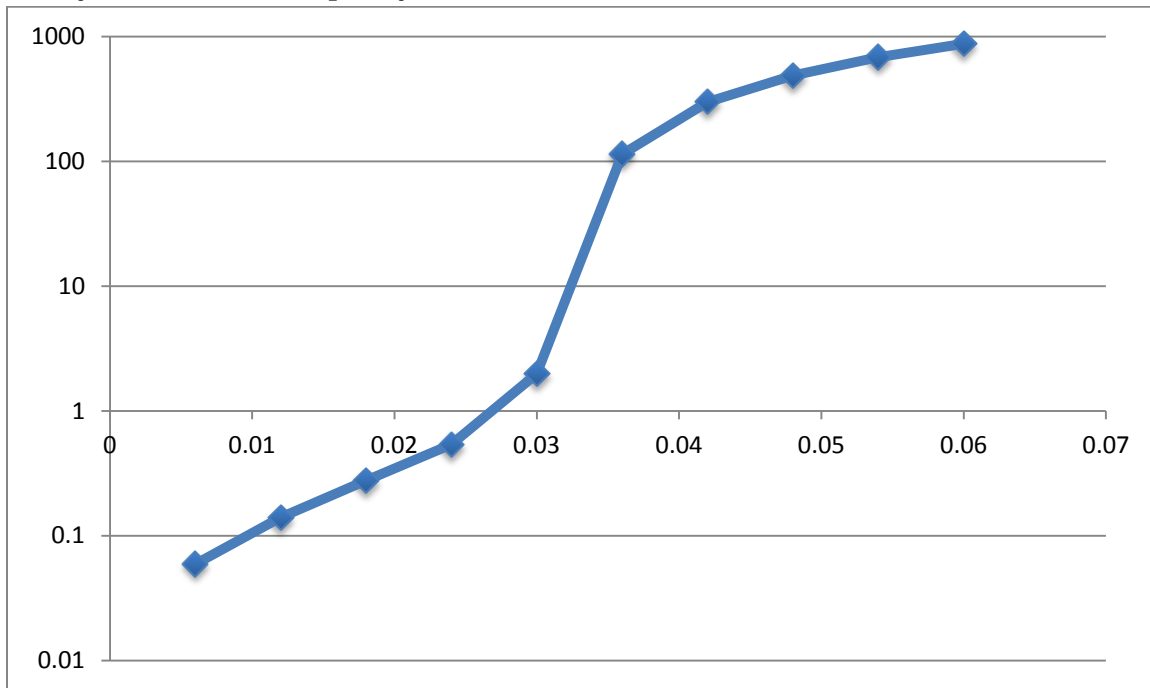


Policy 3: Longest connected queue (LCQ) policy

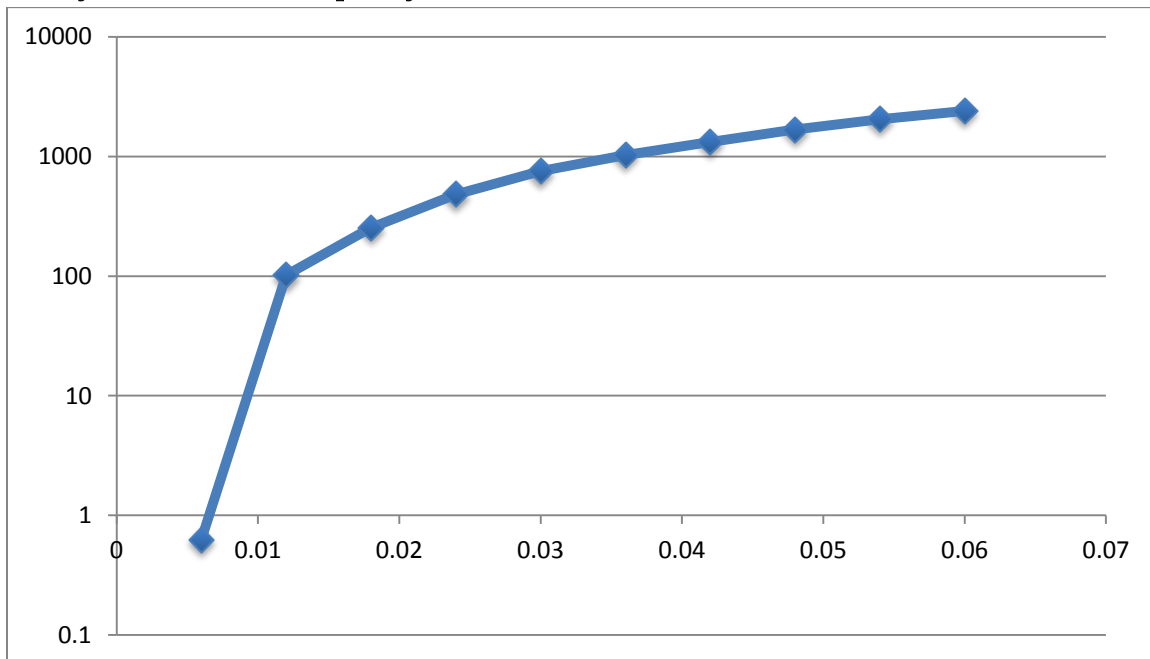


Asymmetric – Small Correlation – $a=0.4$, $b=-0.4$

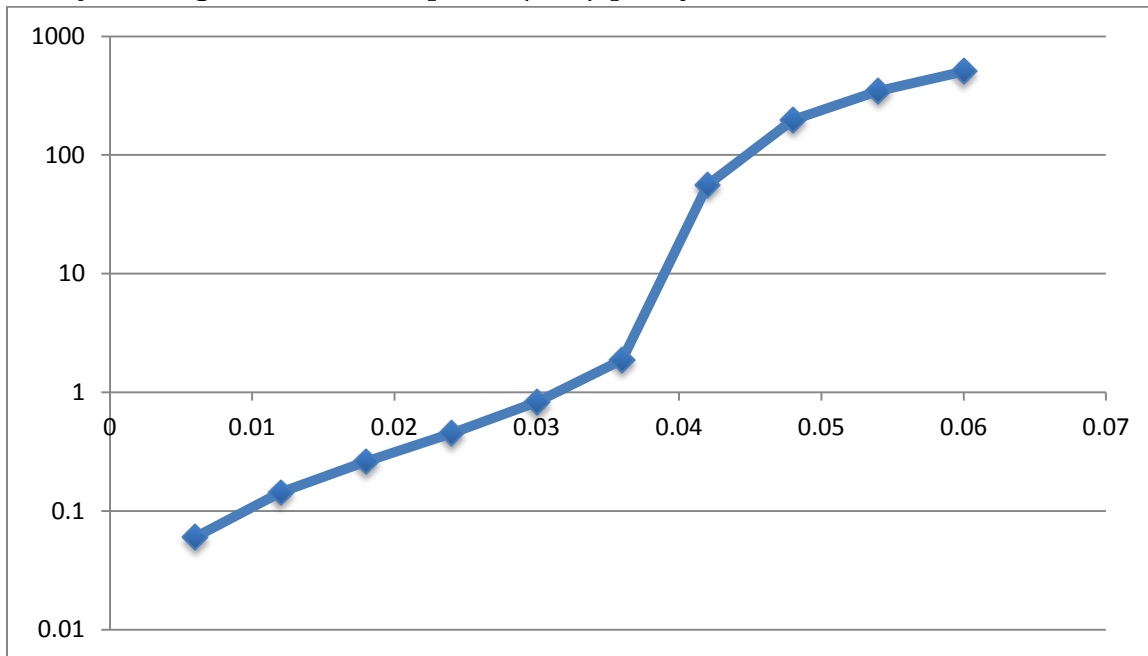
Policy 1: Randomized policy



Policy 2: Round Robin policy

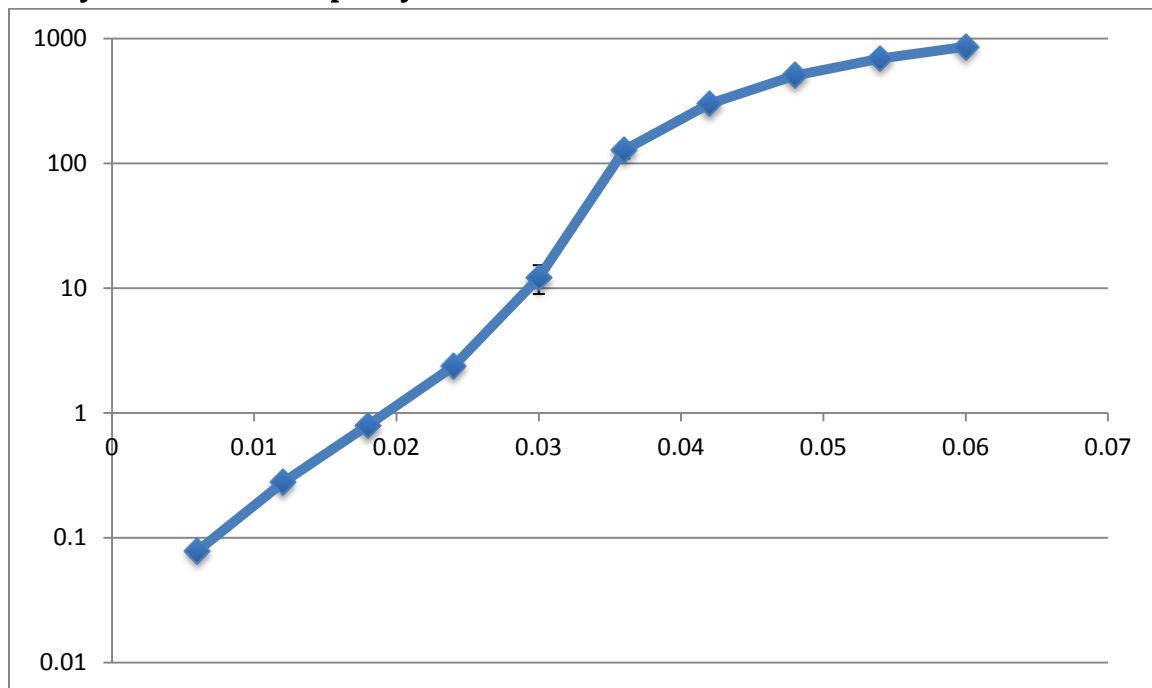


Policy 3: Longest connected queue (LCQ) policy

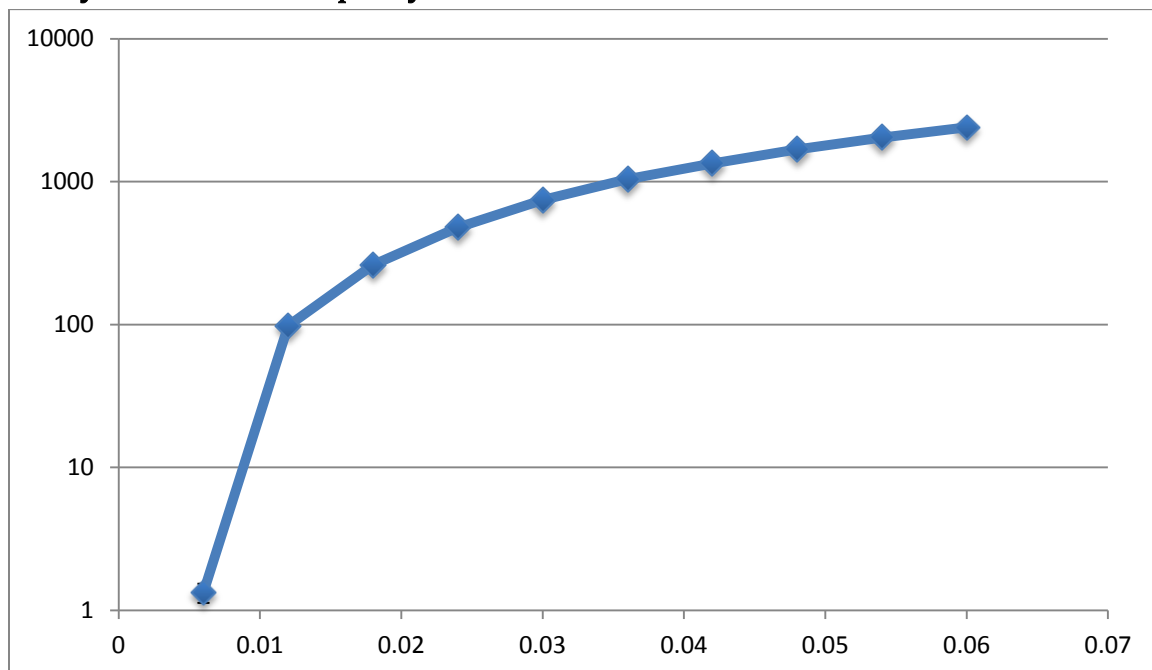


Asymmetric – High Correlation – $a=0.1$, $b=-0.1$

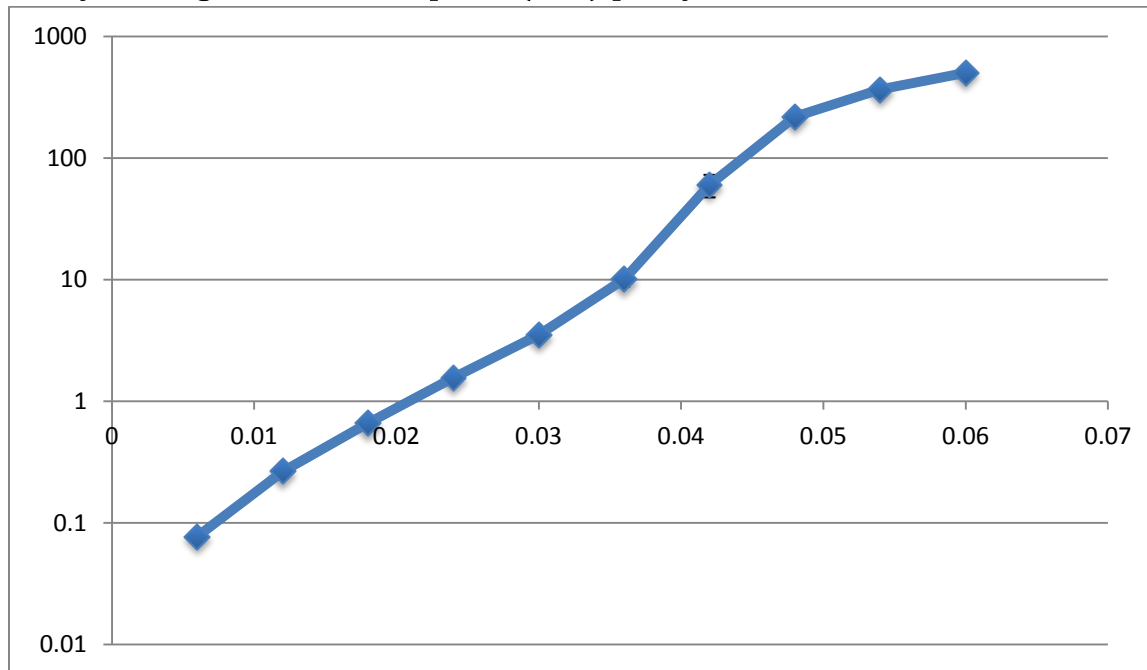
Policy 1: Randomized policy



Policy 2: Round Robin policy



Policy 3: Longest connected queue (LCQ) policy

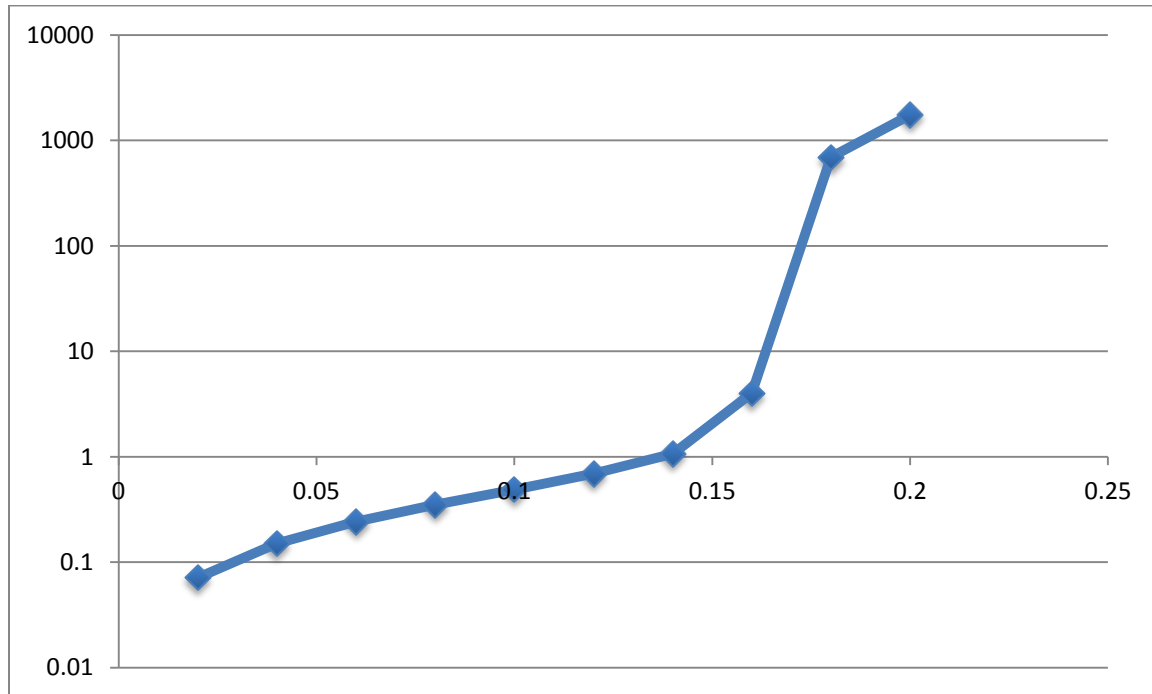


In the asymmetric scenario, the average queue occupancy for the three scheduling policies are all different. The highest average queue occupancy still remains the Round Robin scheduling policy, while the next worst policy is Random. The best scheduling policy in terms of average queue occupancy is the LCQ scheduling policy. The stability region is smallest for Round Robin with the stability point being $\lambda = 0.012$ approximately. The stability region for Random scheduling policy is slightly larger than Round Robin and has a stability point value of $\lambda = 0.03$ approximately. The scheduling policy with the largest stability region is the LCQ which has a stability point of $\lambda = 0.036$ approximately.

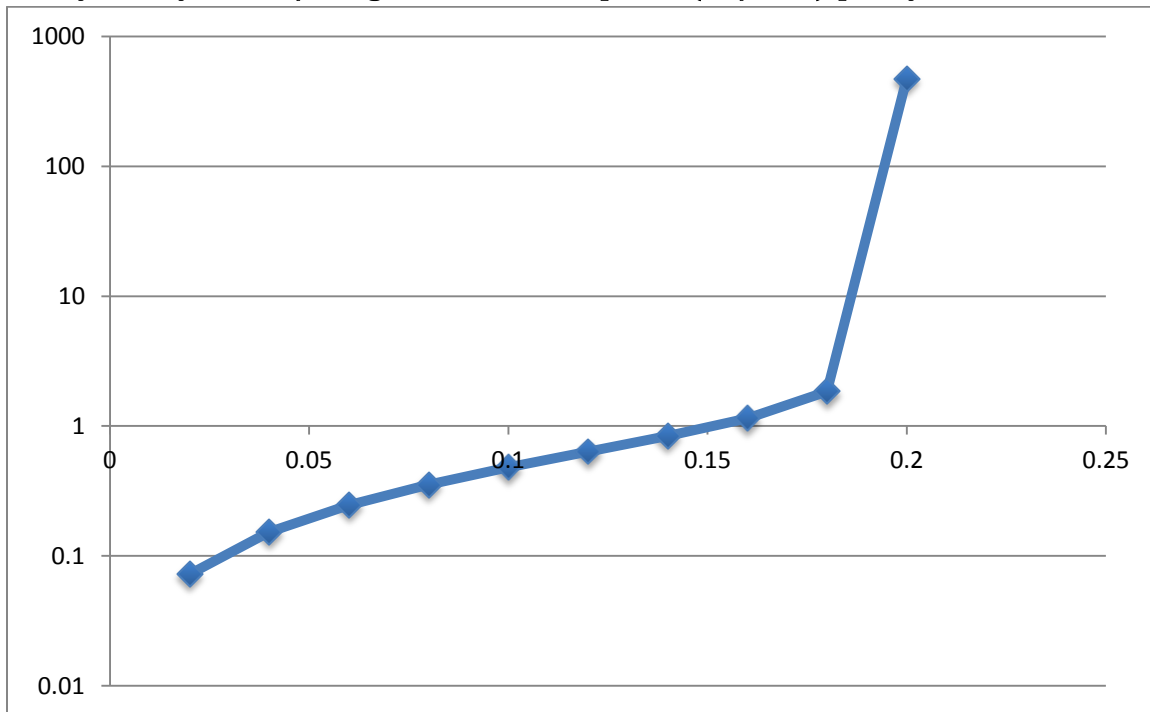
Topology 2: Multi-queue single-server system with random connectivities

No Correlation - $a=0.5$, $b=-0.5$

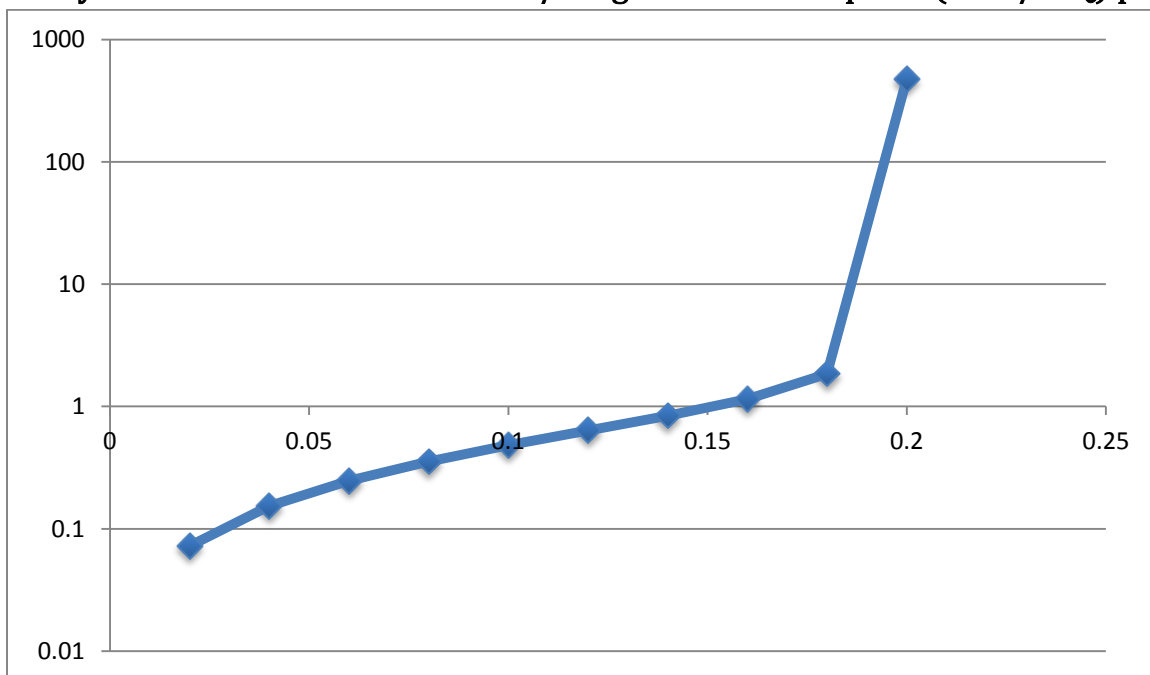
Policy 1: Randomized policy



Policy 2: Any server/ longest connected queue (AS/LCQ) policy

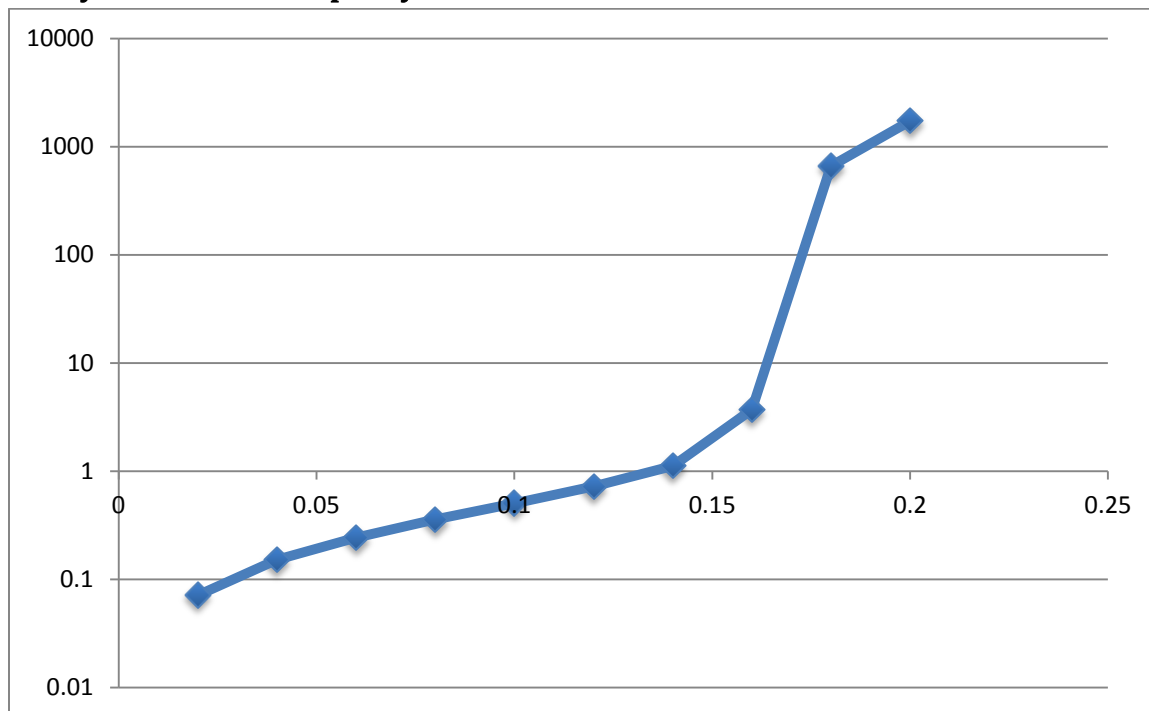


Policy 3: Least connected server first/ longest connected queue (LCSF/LCQ) policy

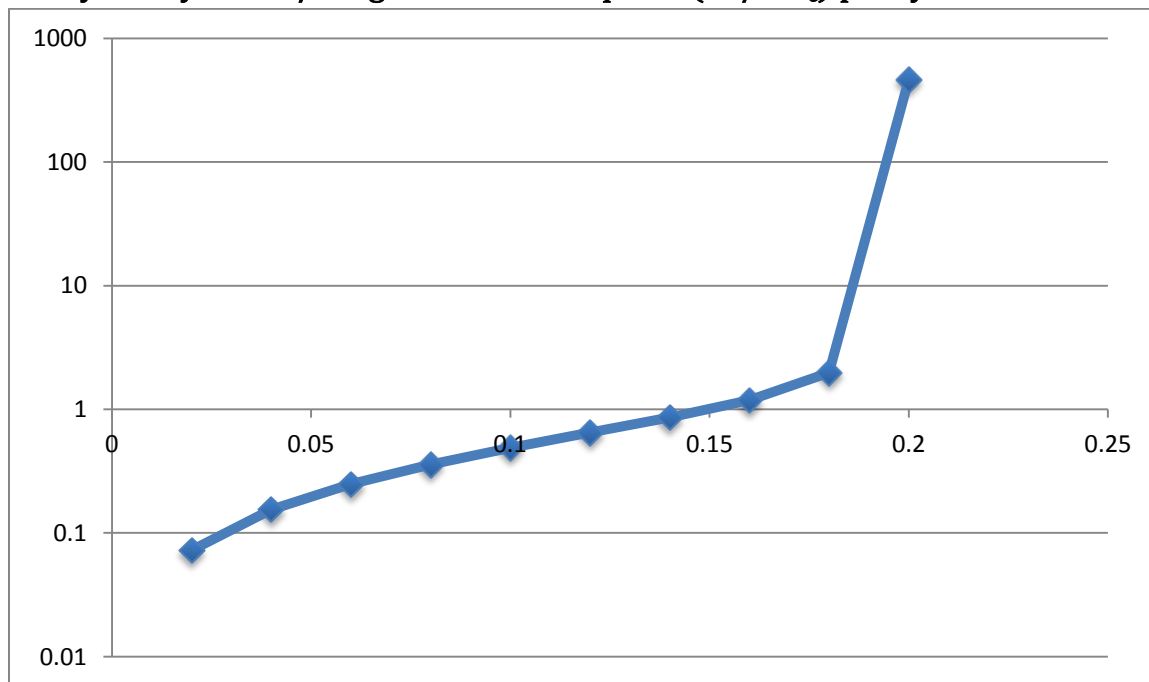


Small Correlation – $a=0.4$, $b=-0.4$

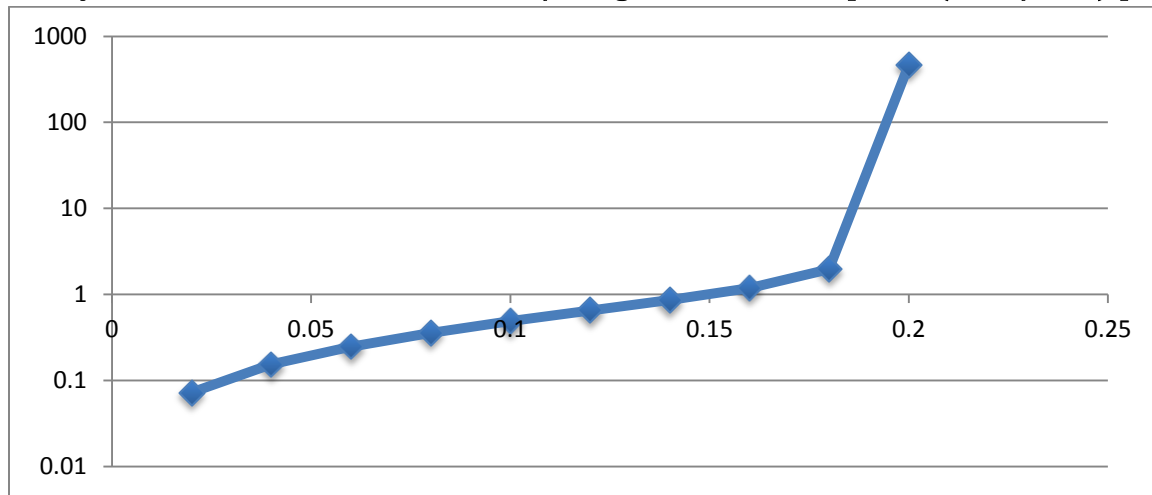
Policy 1: Randomized policy



Policy 2: Any server/ longest connected queue (AS/LCQ) policy

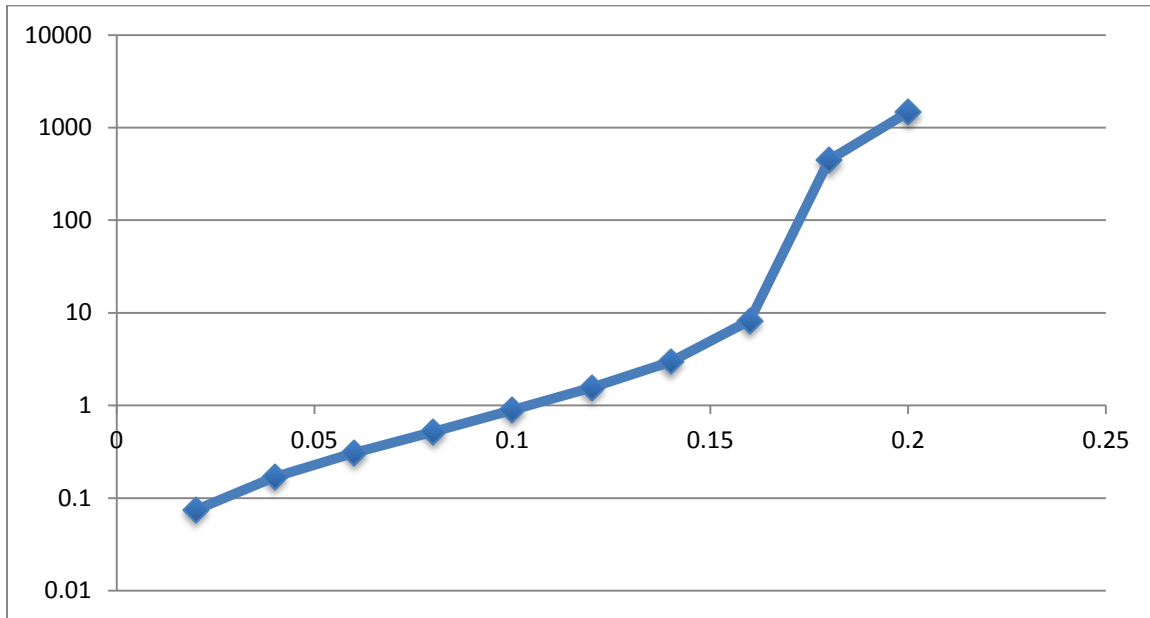


Policy 3: Least connected server first/ longest connected queue (LCSF/LCQ) policy

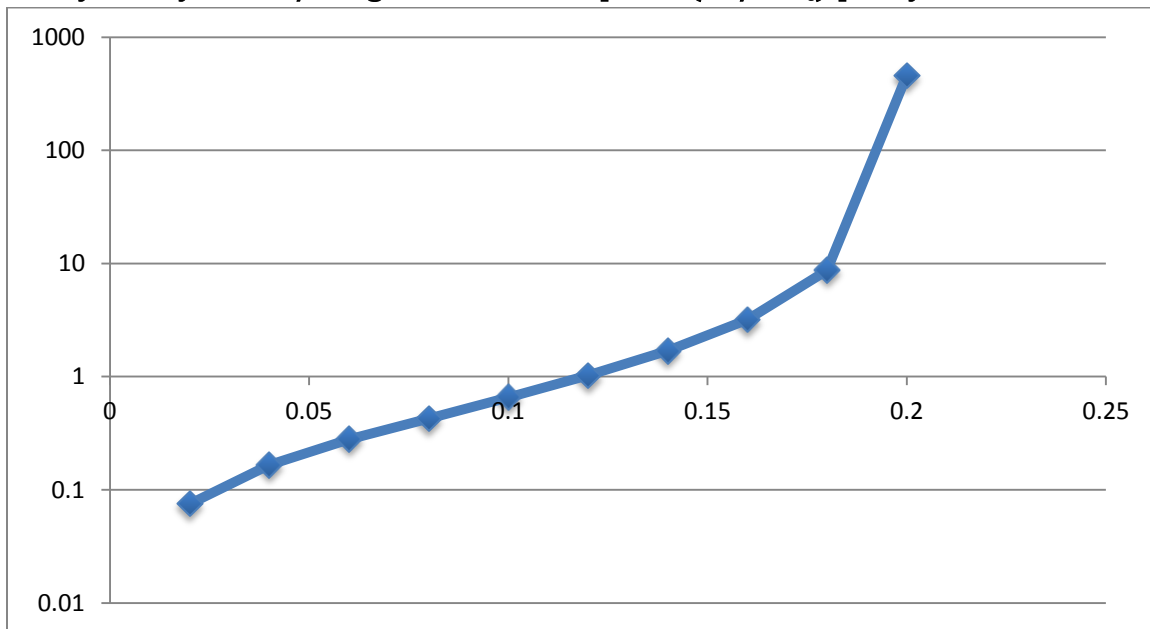


High Correlation - $a=0.1$, $b=-0.1$

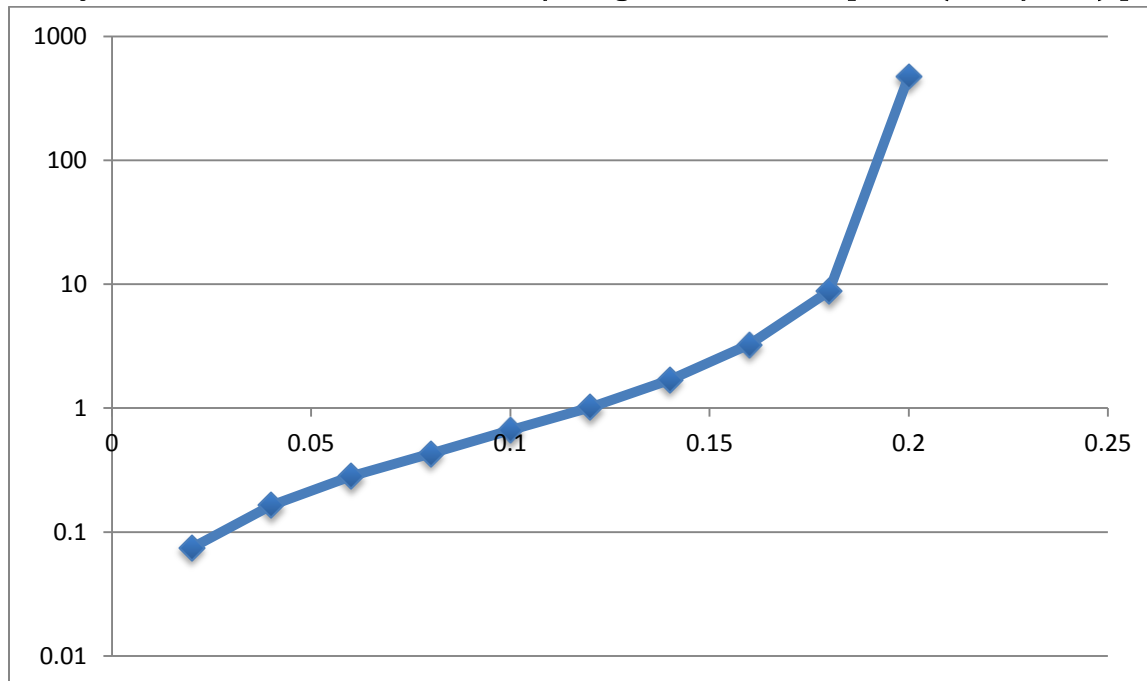
Policy 1: Randomized policy



Policy 2: Any server/ longest connected queue (AS/LCQ) policy



Policy 3: Least connected server first/ longest connected queue (LCSF/LCQ) policy.



The average queue occupancy for the three scheduling policies are roughly the same for the packet arrival probability (λ) range from 0.02 to .12. After this point the average queue occupancy increases for the Random scheduling policy while the average queue occupancy for the other two scheduling policies (AS/LCQ, LCSF/LCQ) remain roughly the same. The stability region for the AS/LCQ and LCSF/LCQ policies are the same and also larger than the stability region for the Random scheduling policy. The stability point for the Random scheduling policy is at $\lambda = 0.16$ approximately whereas the stability point for the other two policies are $\lambda = 0.18$ approximately. The AS/LCQ policy causes the least average queuing delay because AS/LCQ picks the queue with the most remaining packets. Since queues with many remaining packets have long queuing delay (more packets to be processed before a new one can be executed), this approach reduces such delay by prioritizing the order of execution based on the amount of jobs a queue has.