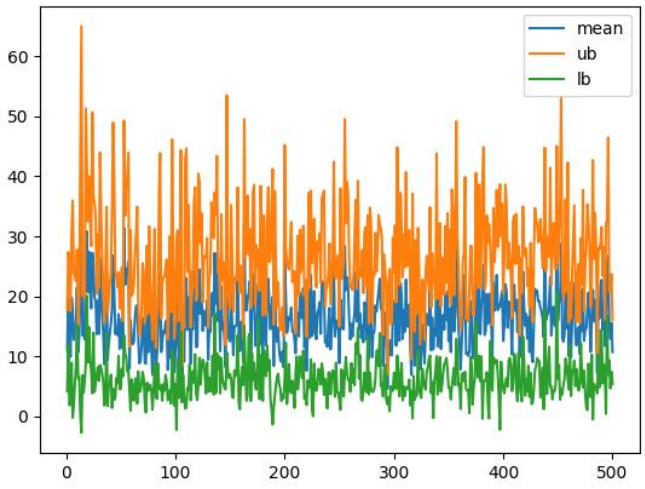
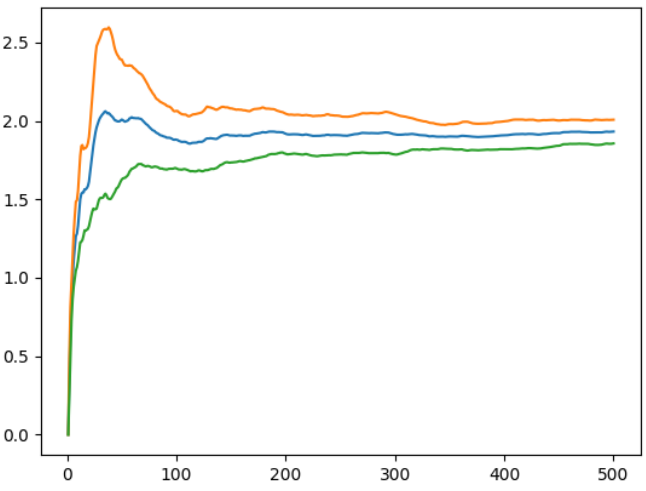
Student Names: Deniz Ünal, Yunus Emre Altuğ
Student Numbers: 2019400234, 2019400057

0.6 Utilization, 10 Run



In the plot of W, there is no apparent changes in the beginning of the plot and the end. This can be the result of system not getting crowded in the long term because of the low utilization. However it can be seen that there is a slight increase at the first 50-60 customers compared to the rest of the plot. From the graph, line converges to approximately 15.



In the plot of L it can be clearly seen that as a result of the system being empty L increases in a very high speed and only after around 100 customers (we decided on 100 as warmup period) it starts to resemble the steady state results. L(t) value converges around 1.9.

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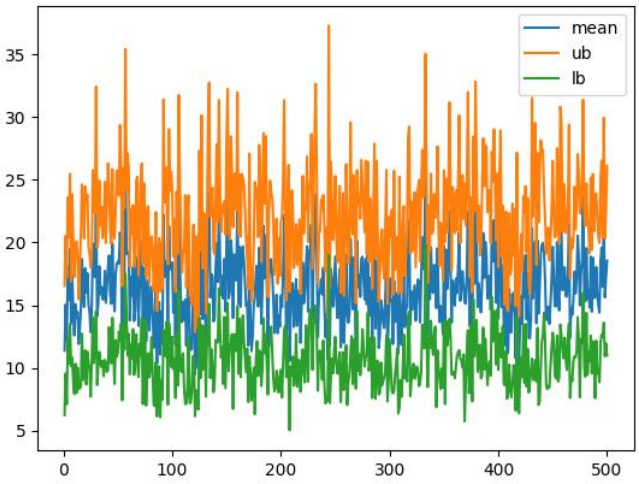
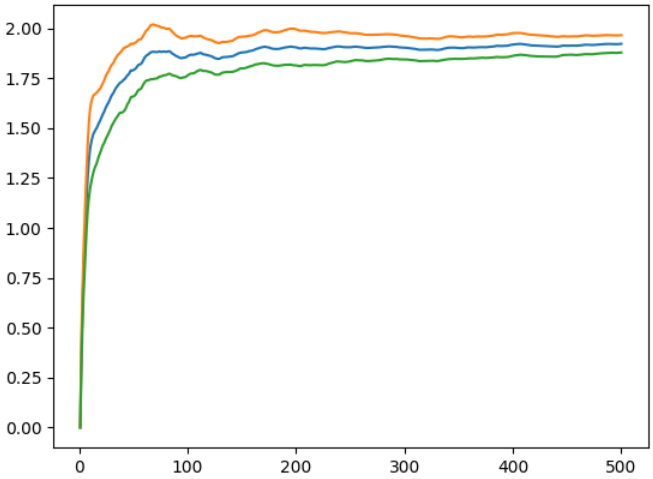
0.6 Utilization, 30 Run



In the plot with 30 runs instead of 10, the increase at the start is more apparent. Also now it can be seen that this increase extends to around 100 customers, which is more in line with the conclusion we have reached while inspecting the plot of L. From the graph, line converges to approximately 15.



In the plot of L the same conclusion with the 10 run is reached. As a result of the system being empty L increases in a very high speed and only after around 100 customers (we decided on 100 as warmup period) it starts to resemble the steady state results. However unlike the 10 run plot in 30, we can see that the overshoot at the end of the warmup period is now decreased. L(t) value converges around 1.9.

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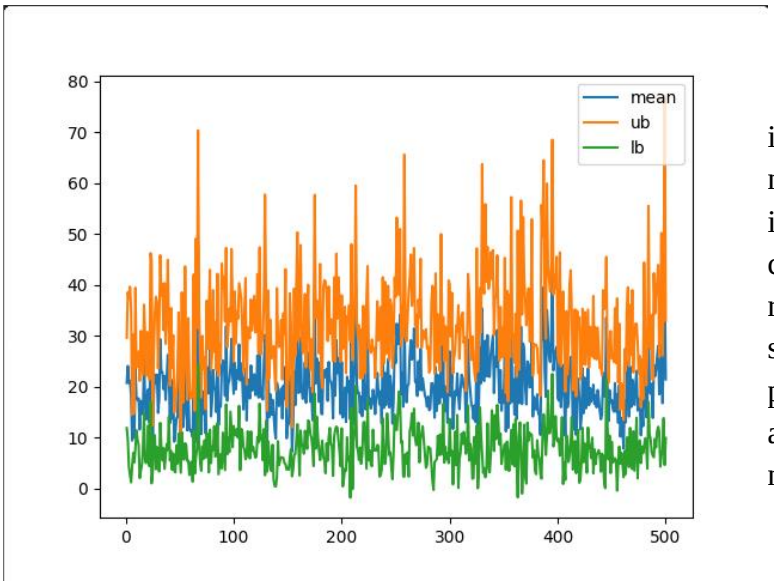
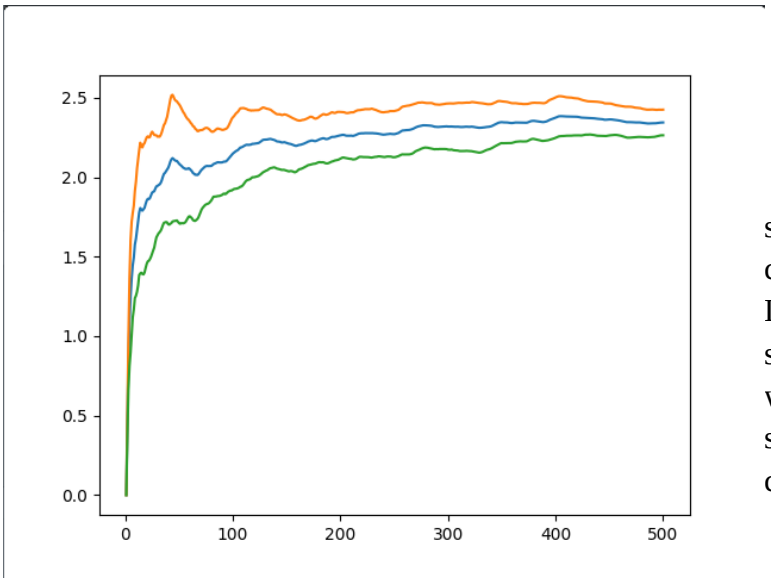
0.7 Utilization, 10 Run



In the plot of W, there is no clear indication of warmup period since it is mostly consistent apart from a slight increase at the start. This consistency can be the result of system keeping relatively empty throughout the simulation. There is no clear warmup period seen here. However after approximately 80 customers graph is more stable and converges around 20.



In the case of L, it can be seen that same conclusion with the 0.6 utilization can be reached. Up until 100 customers L quickly increases from 0 to steady state values, however it can be seen that with higher utilization system is not steady as it was in the 0.6 utilization case. L(t) value converges around 2.2.

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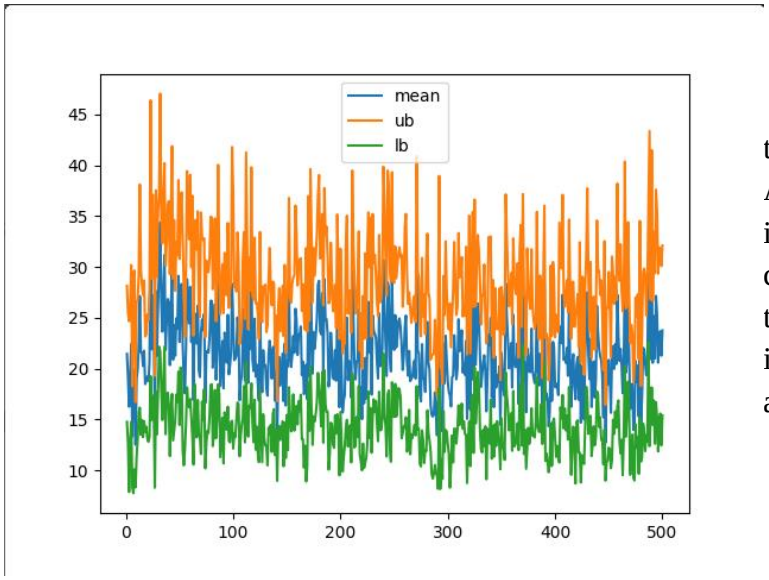
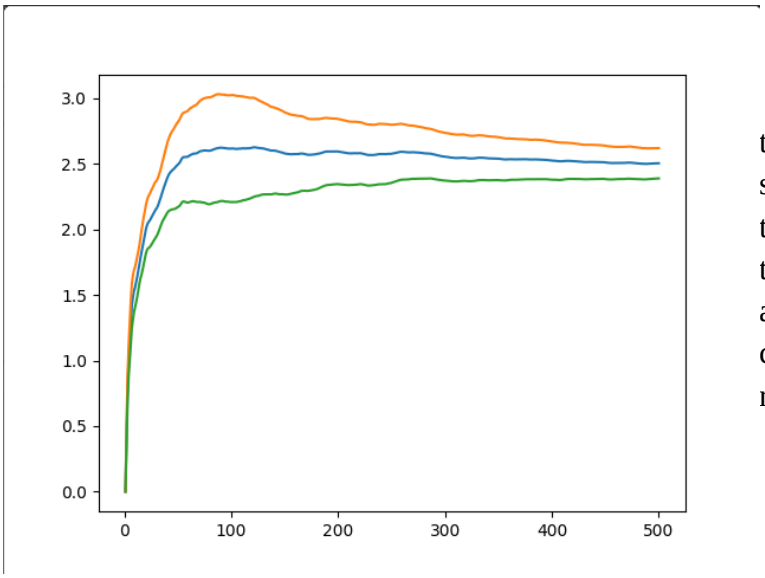
Student Numbers: 2019400234, 2019400057

0.7 Utilization, 30 Run



In the plot with 30 runs instead of 10, the increase at the start is more apparent. Also now it can be seen that this increase extends to around 60-70 customers, which is more in line with the conclusion we have reached while inspecting the plot of L. Converges around 20.



In the plot of L, we can see that while the warmup period is staying roughly the same, the confidence intervals around that period is much wider than it was in the previous case indicating that results are not as stable. In this graph l(t) converges 2.5 which may be result of random seed difference.

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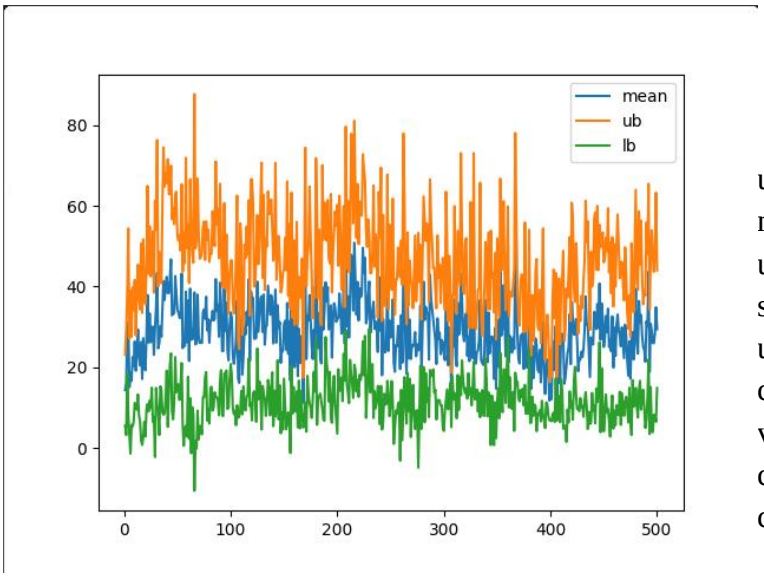
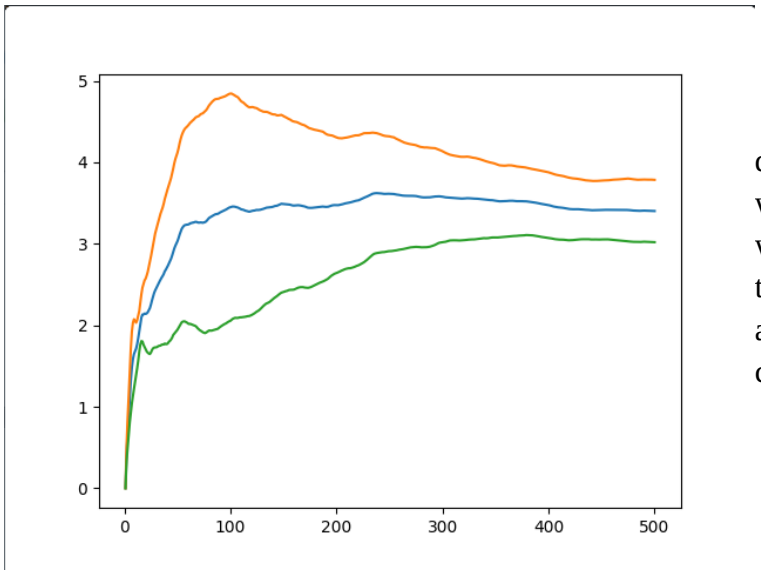
0.8 Utilization, 10 Run



Unlike the W plots of the 0.6 and 0.7 utilization, the warmup period is much more visible even in the 10 run case of 0.8 utilization. This can be the result of system getting more crowded in high utilization. Approximately after 100th customer graph is more stable and error value is less. Therefore we used 100 customers for second phase. Value converges around 30.



In the L plot there is a much more different result than the previous ones. The warmup period is much longer in this case with around 300 customers. This could be the result of the system getting crowded and less stable in the beginning. Value converges around 3.2

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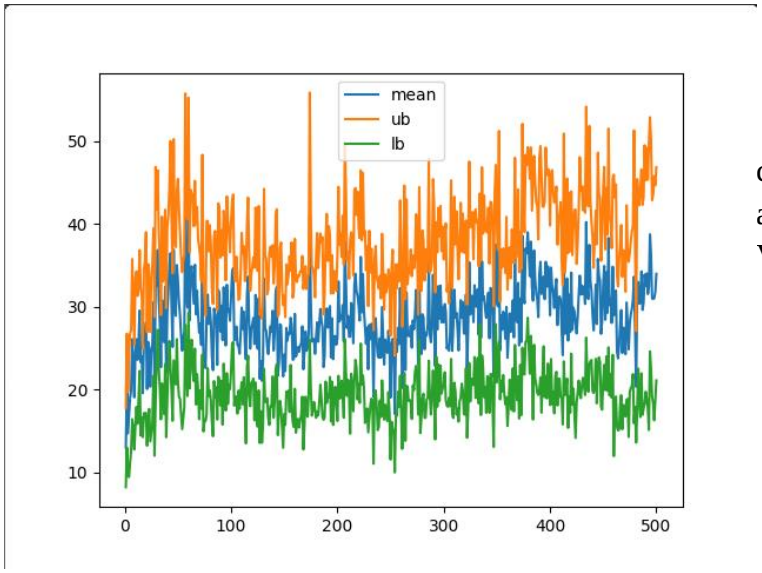
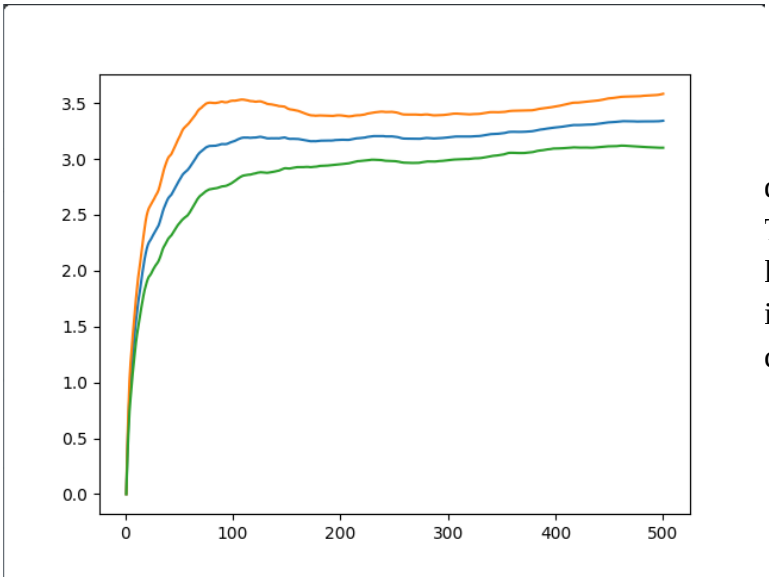
Student Numbers: 2019400234, 2019400057

0.8 Utilization, 30 Run



Warmup period is seen better here compared to 10 runs. We can say that around 100th customer graph is stable. Value converges around 30 again.



In the L plot however there is huge difference between 30 and 10 run cases. They show similar warm up periods by looking at the average but the confidence intervals are much narrower. Value converges around 3.2 again.

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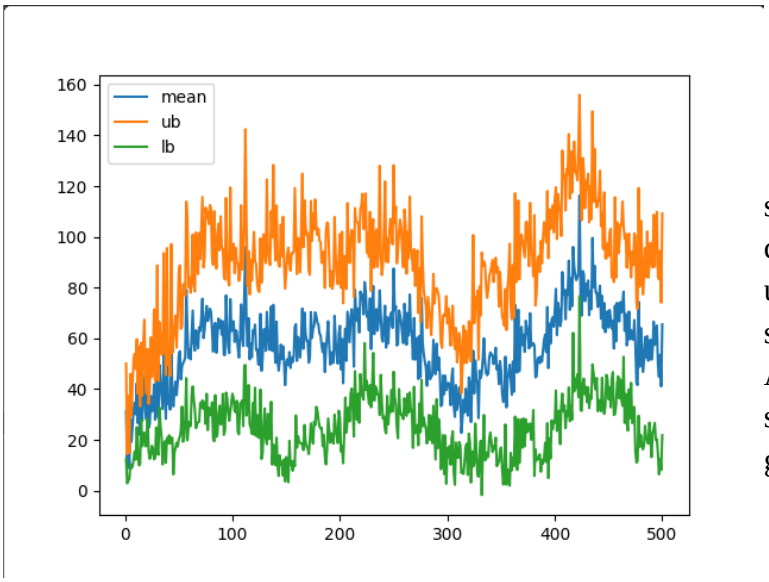
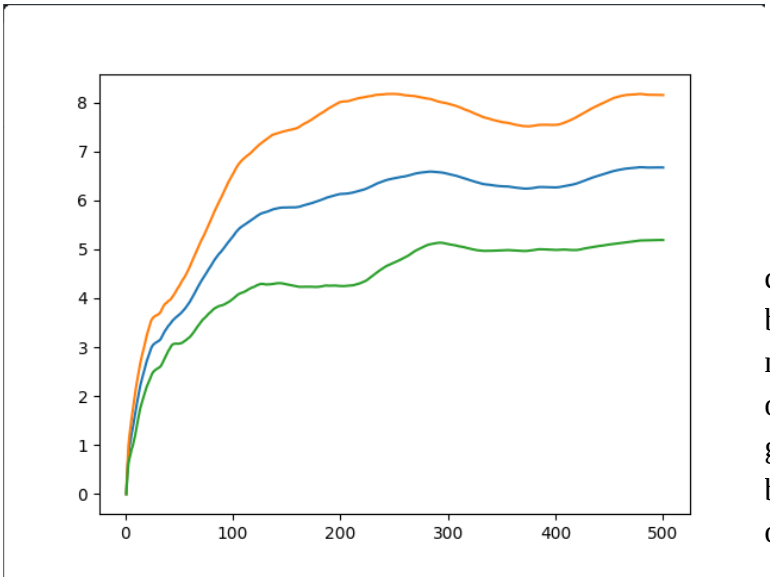
0.9 Utilization, 10 Run



In the 0.9 utilization the system's stability is far less. There is no consistency like it was in the previous utilizations. There is no clear evidence showing the warm up period is over. At some periods ensemble average of sojourn time is 40 but after this period graph sees 80 at some interval.



The results on L plot is a bit more consistent with a little bit stability has been reached at the and but it is still not certain that warm up period is over or not. However, after 300th customer graph converges on 6.2 approximately but this graph is not consistent as others.

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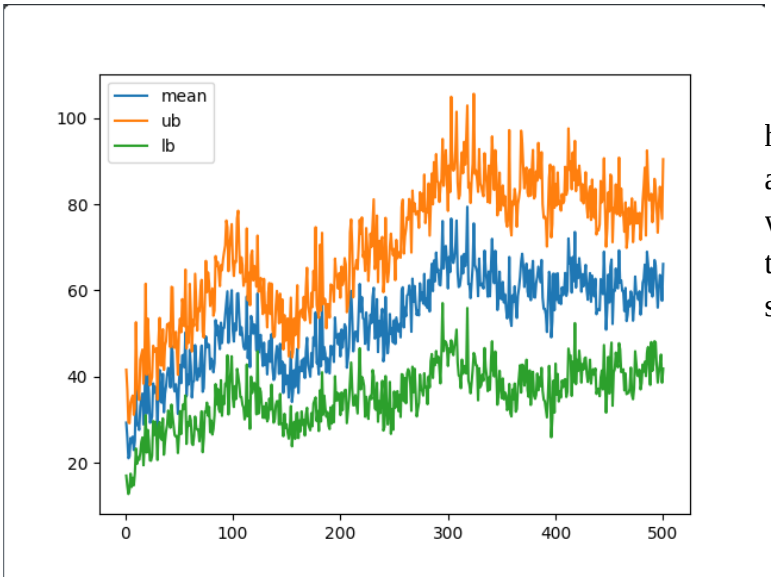
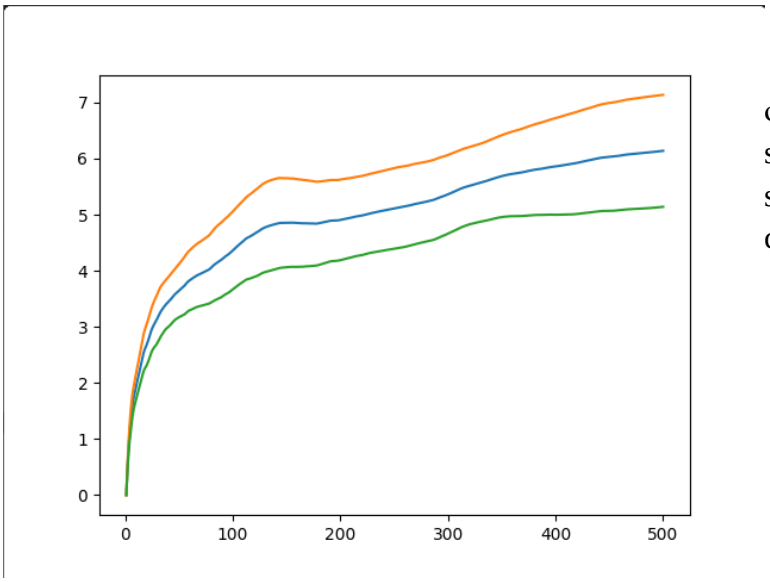
0.9 Utilization, 30 Run



In the 30 case result it very different, however. The system shows stability after around 300 customers. Before that the waiting times are increasing because of the initial empty state. But it reaches its steady state condition after that period.



The L plot doesn’t agree with the results of the W plot. The system hasn’t stabilized even at the end of the simulation, and the average customer count is still increasing steadily.

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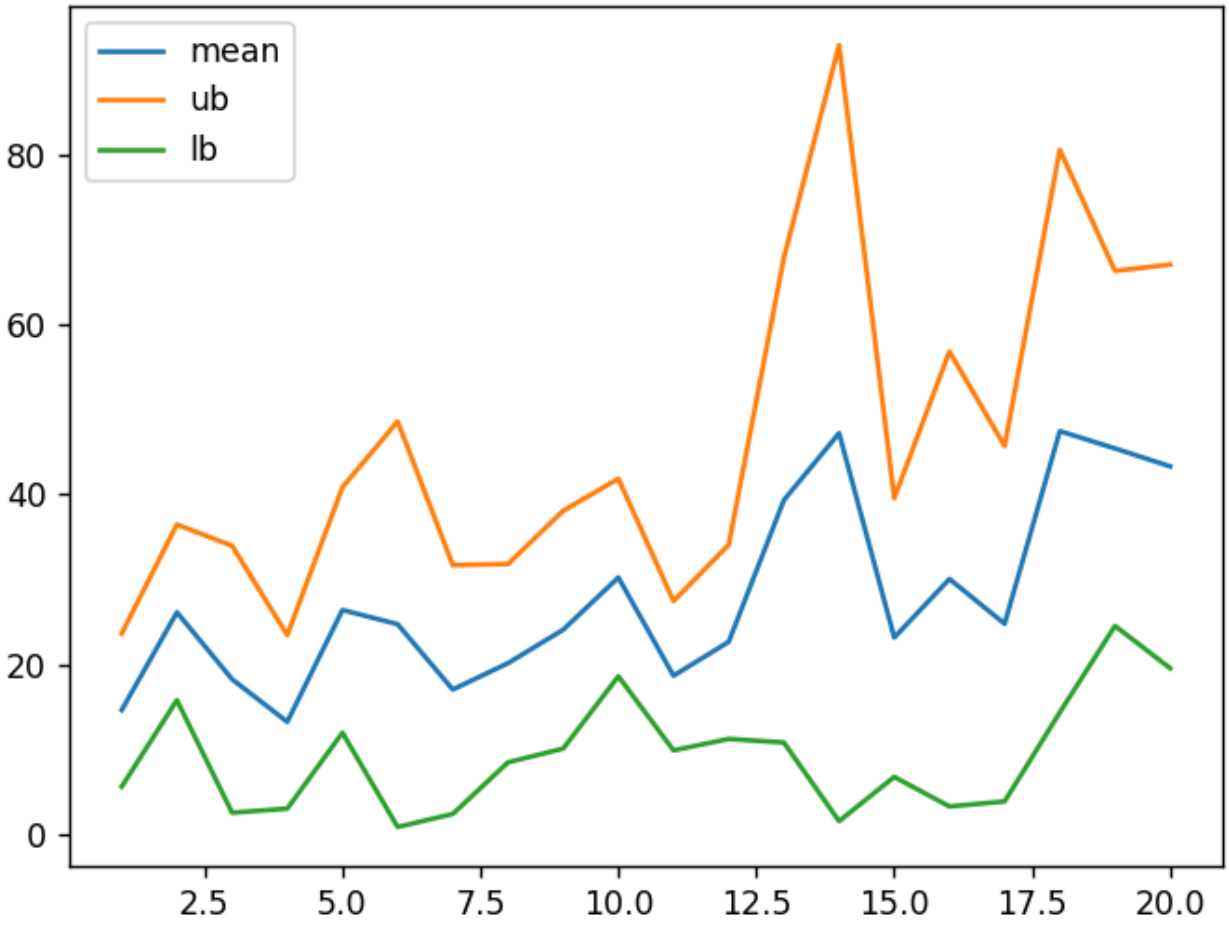

From this graph we see that, sojourn times are less at the beginning. The actual value in the first phase around 30, but we can clearly see that values are not close to 30.

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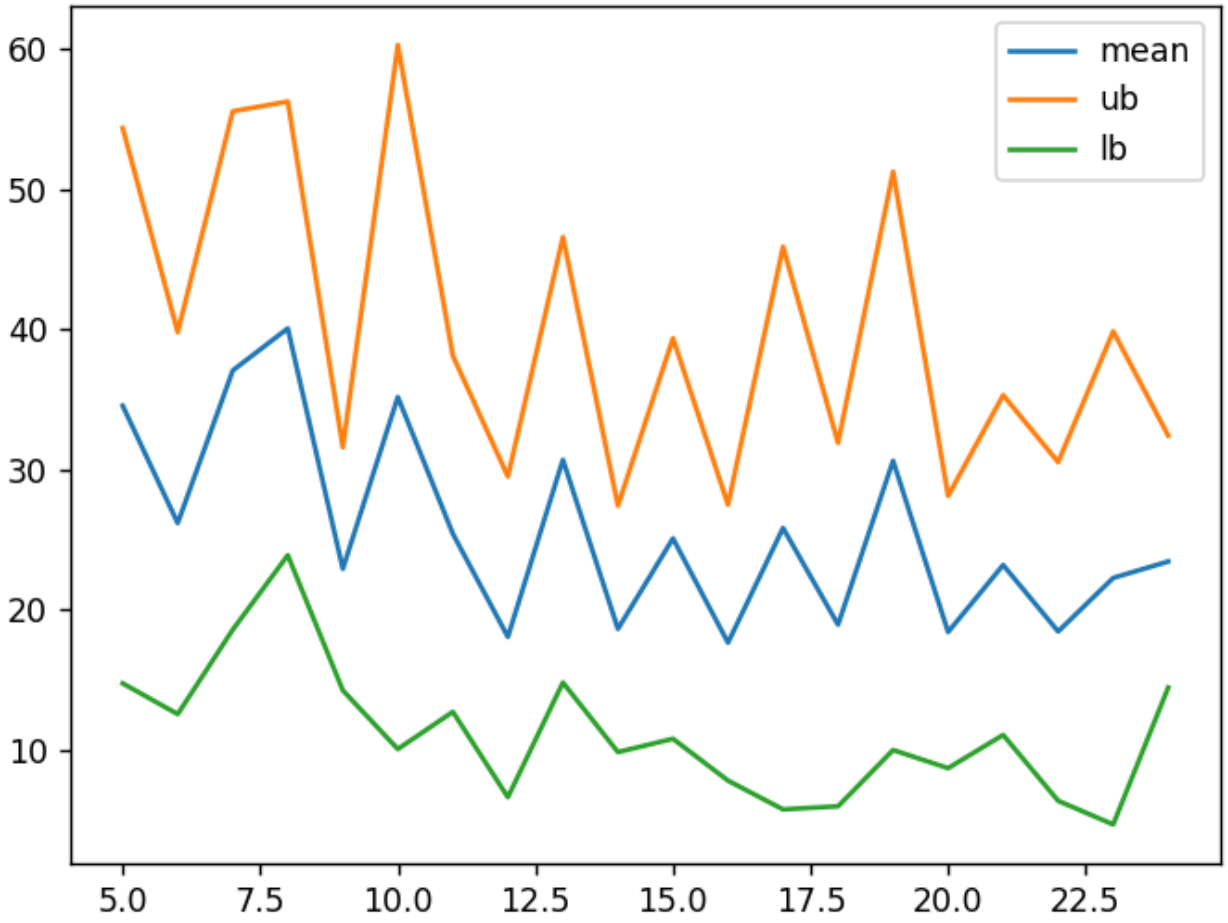

At this graph we see that, values are not liable to increase. At this utilization value we do not see completely full queue, so the full queue at the beginning causes greater sojourn times at the beginning. We removed first four customers to see better this result. If they are kept, 3 of them will not have waiting time and these means this graph does not have much difference with previous case. System generally does not have completely full queue or completely empty queue, so there must be a better option.

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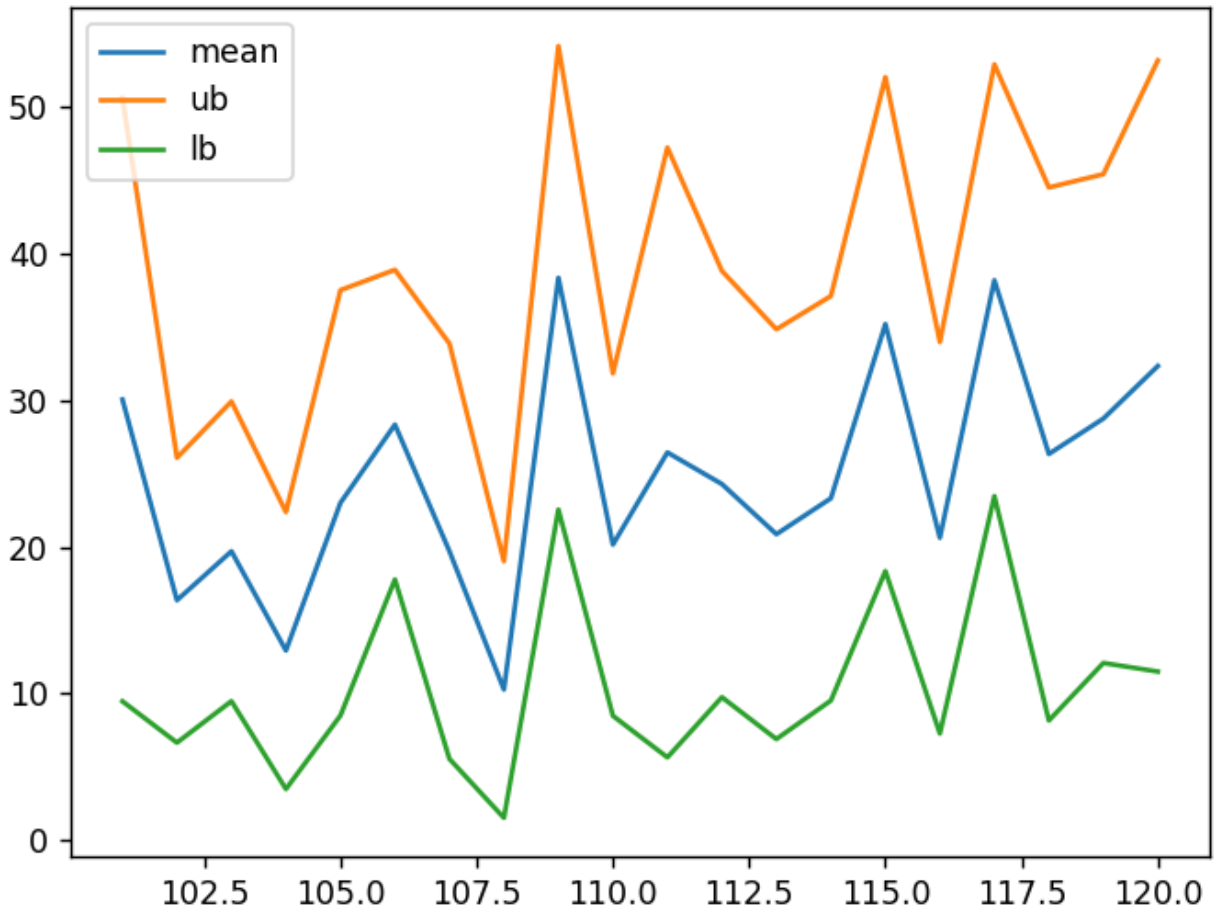

At the third graph, we see that, values are not close between them, but they are not seemed as increasing and decreasing continually as the previous graphs. The values around 25-30. In this case, we did not plot the first 100 customers' statistic and took 20 customers' stats after these 100. This graph shows the best option is removing warmup between all three cases instead of full queue or empty queue beginning.

NOTE: To get phase 2 graphs exactly, one should convert phase 1 part to comment and run all three parts of phase 2 at same program run. On the other words, 27-186 lines are phase 1 which should be commented to get phase 2 graphs.