COMPENG 4DK4 LAB1

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# Experiment

2.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Service Time | Arrival Rate | Utilization | Fraction Served | Mean Number in system | Mean delay |
| 5 | 0.012357 | 0.061776 | 1.000000 | 0.063811 | 5.164663 |
| 5 | 0.024288 | 0.121424 | 1.000000 | 0.129816 | 5.345559 |
| 5 | 0.041819 | 0.209069 | 1.000000 | 0.236706 | 5.660967 |
| 5 | 0.062058 | 0.310251 | 1.000000 | 0.380048 | 6.124837 |
| 5 | 0.120962 | 0.604734 | 1.000000 | 1.067651 | 8.827442 |
| 5 | 0.133979 | 0.669813 | 1.000000 | 1.349778 | 10.075782 |
| 5 | 0.146497 | 0.732395 | 1.000000 | 1.735676 | 11.849313 |
| 5 | 0.147549 | 0.737654 | 1.000000 | 1.775807 | 12.036858 |
| 5 | 0.156446 | 0.782133 | 1.000000 | 2.187385 | 13.983462 |
| 5 | 0.174924 | 0.874510 | 1.000000 | 3.920923 | 22.417832 |
| 5 | 0.187101 | 0.935390 | 1.000000 | 7.693819 | 41.126253 |

Plot:



Justification:

As we obtained from the simulation plot, the mean delay axis intercept time at low arrival rate values (below 0.1 arrival rate) has a value around 6.0 and an overall of 10.0. As the arrival rate starts increasing and approaching the allowed maximum 0.2, we can obtain the plot is showing an exponential growth very fast when the arrival rate is over around 0.16 and approaching the infinity mean delay time where the vertical asymptote is 0.2.

This shape of the mean delay curve can reflect how the single server queue system handle customers under different arrival rates when the service time is constant (5). It can help better design the system by simulating the customers arrival rates to know the system capability. From this curve, we can find for this system, to allow customers have a low mean delay, the ideal arrival rate should lower than 0.16.

3. When the product of arrival rate and service time is greater than 1, set the arrival rate to 0.201, the following experiments are shown below.A black background with white text

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When the arrival rate is slightly greater than 1/5=0.2, as we can see from those pictures, the fraction served is no longer equal to 1 which means there are unserved customers in the system and that can also be proved from the total arrived customers is larger than the customers served.

And as we increased the run length of customers, we can see the unserved customers is increased as well. Moreover, the mean number in system and mean delay are both increasing. Why this happen is due to as we increased the total customers, the system don’t have sufficient service time to serve the customers, so when the arrival rate and service time is not changing, a portion of total customers will always be unserved which that is why the Expression 1 is necessary.

What’s more, we can calculate the mean customer interarrival time by the formula 1/ARRIVAL\_RATE which is equal to 1/0.201 = 4.975s. And we know the service time is 5s. So for every 5s, a portion of 0.025s customers of the total will not be served.

4.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Service Time | Arrival Rate | Utilization | Fraction Served | Mean Number in system | Mean delay |
| 20 | 0.005000 | 0.099988 | 1.000000 | 0.105543 | 21.111172 |
| 20 | 0.010000 | 0.199975 | 1.000000 | 0.224973 | 22.500111 |
| 20 | 0.015000 | 0.299963 | 1.000000 | 0.364248 | 24.286199 |
| 20 | 0.020000 | 0.400041 | 1.000000 | 0.533400 | 26.667268 |
| 20 | 0.025000 | 0.500052 | 1.000000 | 0.750143 | 30.002620 |
| 20 | 0.030000 | 0.599965 | 1.000000 | 1.050103 | 35.005474 |
| 20 | 0.035000 | 0.699998 | 1.000000 | 1.516764 | 43.336238 |
| 20 | 0.037000 | 0.739909 | 1.000000 | 1.793478 | 48.478362 |
| 20 | 0.040000 | 0.799936 | 1.000000 | 2.396674 | 59.921610 |
| 20 | 0.045000 | 0.899957 | 1.000000 | 4.956088 | 110.140507 |



(Exp 2)



(Exp 4)

As we can see from the above two plots, the second one is the plot where the service time is equal to 20 while arrival rate is within a suitable range, the average of the mean delay in exp4 is around 40. Compared to the mean delay 10 in exp2, an assumption can be made under the same customers served, when the service time is longer, the mean delay will be longer than before. And the increase of the service time could be proportional lead to the increase of the mean delay which is 4 times in this case. But the overall shape of the curve should look similar.

5.

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Description automatically generated, by applying this formula where , the analytic result for parts2 and 4 are shown below.

|  |  |  |  |
| --- | --- | --- | --- |
| Mean delay(parts2) | Analytic Result | Mean delay(parts4) | Analytic Result |
| 5.164663 | 5.164634439 | 21.111172 | 21.11111111 |
| 5.345559 | 5.345565471 | 22.500111 | 22.5 |
| 5.660967 | 5.66093589 | 24.286199 | 24.28571429 |
| 6.124837 | 6.124711835 | 26.667268 | 26.66666667 |
| 6.346308 | 6.346153846 | 30.00262 | 30 |
| 6.666862 | 6.666666667 | 35.005474 | 35 |
| 8.827442 | 8.826071004 | 43.336238 | 43.33333333 |
| 10.075782 | 10.07334787 | 48.478362 | 48.46153846 |
| 13.983462 | 13.98000184 | 59.92161 | 60 |
| 22.417832 | 22.43938427 | 110.140507 | 110 |

From the tables, we can compare the simulation and analytic results are very close to each other, which can further prove this formula is correct.

6.