CSC 591 IOT Analytics
Task 3 Statistical estimation of performance metrics
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Implementation

The flow of the project is as below:

Input: The code asks for mean arrival time, mean orbital time, service time and buffer size. It takes 51000 customers into consideration. First arrival is assumed to be at 2.

a) First arrival has ID 1.
b) The following metrics are recorded:
   i) First Arrival time
   ii) First retransmission time
   iii) When the activity gets in the queue
   iv) When the activity is serviced
c) T is calculated as When activity is serviced-First arrival time.
d) D is calculated as when activity gets in queue-first retransmission time.
e) Batch Means is done on T and D respectively and standard deviation of both is calculated to finally get the 95% Confidence Interval of means of T and D.
f) 95th percentiles $(x_{0.95,i})$ of each batch is then calculated for T and D to finally get the standard deviation and 95% Confidence Interval Of 95th Percentiles of T and D.

Output:

a) Mean, Standard deviation, and Confidence Interval of mean of T.
b) Mean, Standard deviation, and Confidence Interval of mean of D.
c) Mean, Standard deviation, and Confidence Interval of 95th percentile of T.
d) Mean, Standard deviation, and Confidence Interval of 95th percentile of D.
e) Output1.xlxs records CLA,CLS, CLR, Queue state and output2.xlxs records all the metrics mentioned in point (b) above.

Sample Ouptut

```
<terminated> vjaswan_IOT_P1T3 [Java Application] /Library/Java/JavaVirtualMachines/jdk-10.0.2.jdk/Contents/Home/bin/java (Oct 13, 2018, 12:37:57 PM)
Enter Mean Arrival Time
6
Enter Mean Orbitting Time
5
Enter Service Time
5
Enter Buffer Size
5
Simulation Completed
Details of T
SuperMean:17.01149127351956 SD:3.5495406181090843 CI:[16.02760881098405,17.995373736055072]
Details of D
SuperMean:3.329949481085971 SD:2.4424759612232307 CI:[2.6529296855800686,4.006969276591874]
Details of T_95
SuperMean:44.704503163554676 SD:14.663361751620792 CI:[40.640026651966174,48.76897967514318]
Details of D_95
SuperMean:21.498922539670627 SD:14.239559074789534 CI:[17.5519181367777,25.445926942563553]
```

Results

Part 1: Vary the service time as follows: 2,2.5,3,3.5,4,5.5. For each value obtain the statistics:

a. Mean and 95th percentile, and confidence intervals of T.

b. Mean and 95th percentile and confidence intervals of D.

Graph your results, and comment on your results.

Results:

The following data has been obtained for mean, 95th percentile and CI of T.

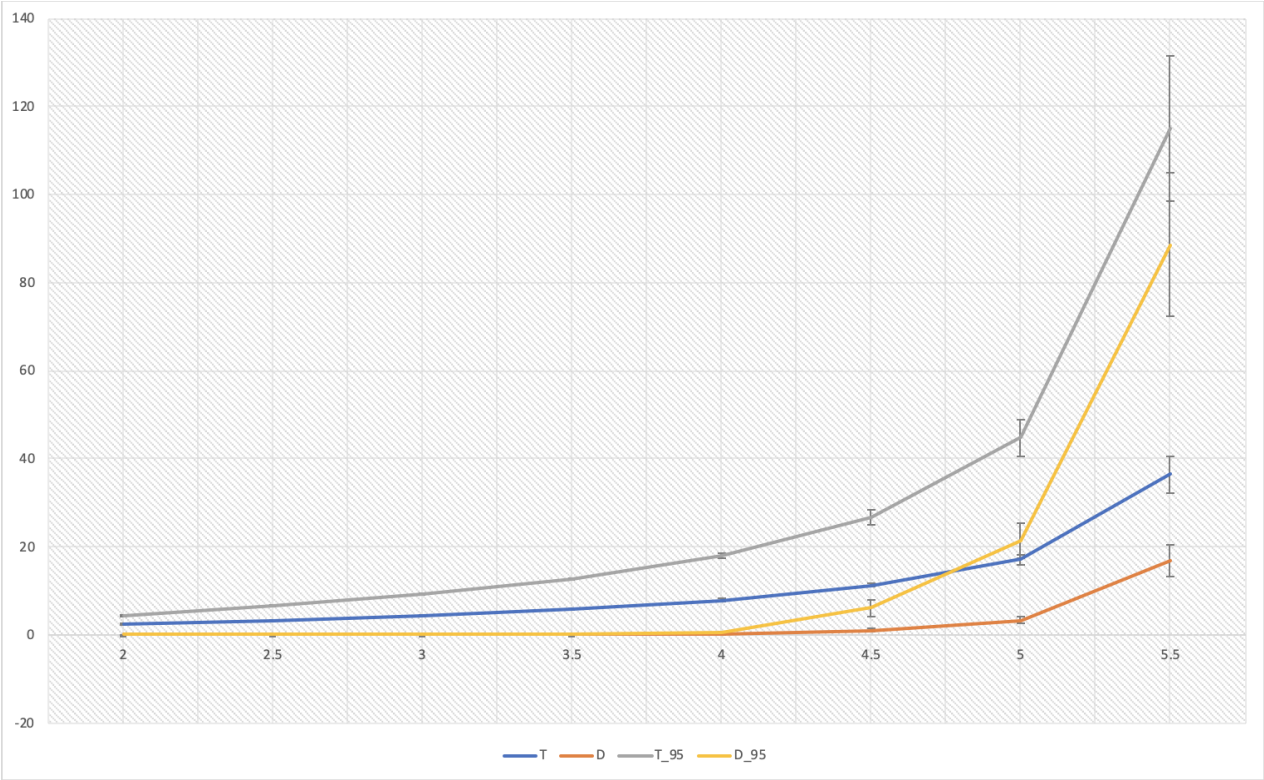
Service Time	T	SD	CI Lower	CI Upper	T_95	T_95 SD	T95 CI Lower	T95 CI Upper
2	2.446435941	0.069234112	2.427245	2.465627	4.452202	0.290563599	4.371661996	4.532742237
2.5	3.316513015	0.109411036	3.286186	3.34684	6.491072	0.408843665	6.377746168	6.604397533
3	4.392931537	0.177808865	4.343645	4.442218	9.083655	0.666676777	8.898861801	9.26844855
3.5	5.783253687	0.29864701	5.700473	5.866034	12.57518	1.087489608	12.27374824	12.87662172
4	7.89846253	0.714959931	7.700286	8.096639	17.95292	2.193921338	17.34479668	18.56104462
4.5	11.19363404	1.534494207	10.76829	11.61897	26.81544	6.067349763	25.13365568	28.49722278
5	17.01149127	3.549540618	16.02761	17.99537	44.7045	14.66336175	40.64002665	48.76897968
5.5	36.41710712	14.90421272	32.28587	40.54834	114.9116	59.45849495	98.43050834	131.3926162

The following data has been obtained for mean, 95th percentile and CI of D.

Service Time	D	SD	CI Lower	CI Upper	D_95	D_95 SD	D_95 CI Lower	D_95 CI Upper
2	7.02E-05	3.45E-04	-2.55E-05	1.66E-04	0	0	0	0
2.5	0.00302038	0.005743411	0.001428388	0.00461237	0	0	0	0
3	0.01854013	0.016574247	0.013945983	0.02313428	0	0	0	0
3.5	0.061454981	0.047291964	0.048346317	0.07456364	0	0	0	0
4	0.314211458	0.253739931	0.243878337	0.38454458	0.439733	1.414637	0.047615576	0.831850276
4.5	1.060600057	0.768162097	0.847676387	1.27352373	6.012381	6.164966	4.30353923	7.721221838
5	3.329949481	2.442475961	2.652929686	4.00696928	21.49892	14.23956	17.55191814	25.44592694
5.5	16.86776097	13.18533445	13.21297272	20.5225492	88.51205	58.98011	72.16360384	104.8605059

Plots and Inference:

Both the tables above have been plotted in a single graph.



Some of the inferences from the graph are

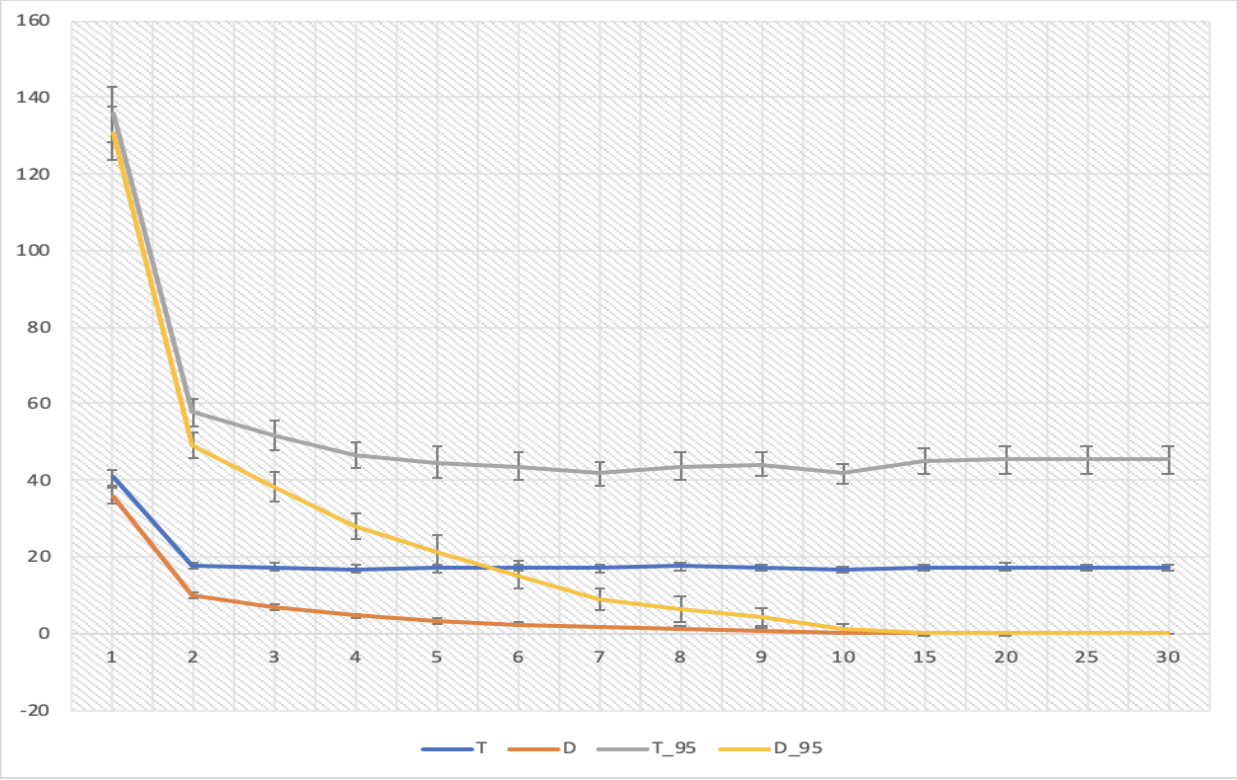
1) The response time and orbit time are increasing exponentially with respect to the service time which aligns with the fact that as service time increases, more requests spend time orbiting. If the service time is smaller, requests get handled almost immediately and have low orbital time. As service time increases, buffer stays full causing an increase in orbit time and eventually service time .
2) The values of 95th percentiles are larger because they record an overall higher value as compared to the mean values.
3) T is greater than D and T_95 is greater than D_95 because T which is the service time accounts for the orbit time, time spent in buffer and the service time whereas D which is the orbit time only accounts for the time spent orbiting.
4) As the values of all our metrics increase, the confidence increases also increases which aligns with the fact that our spread is increasing as more number of requests are being sent to orbit.

Part 2: Investigate the effect of varying B on all the above statistics for s=5. Graph your results and comments on your findings.

Results:

Buffer Size	T	T CI Lower	D	D CI Lower	T95	T95 CI Lower	D95	D95 CI Lower
1	40.69243919	38.6143523	35.79243919	33.71718206	135.5590735	128.460351	130.5590735	123.460351
2	17.653872	16.83413718	9.948128419	9.183183143	57.69721767	54.22091924	48.98501822	45.61380857
3	17.33496001	16.42095687	6.931619324	6.116136981	51.85374501	48.08036383	38.28821868	34.59740763
4	16.88478915	15.99769977	4.57004693	3.891360508	46.39414039	43.01329511	28.05729797	24.81894849
5	17.01149127	16.02760881	3.329949481	2.652929686	44.70450316	40.64002665	21.49892254	17.55191814
6	17.07481773	16.27160378	2.349587969	1.84587454	43.56505522	39.96638423	15.19851688	11.64837094
7	16.98887107	16.10089775	1.606332626	1.20455793	41.90078799	38.83012748	8.9059475	5.941648379
8	17.47195733	16.42748821	1.301748224	0.851235527	43.65006695	40.11848002	6.221130619	2.965661689
9	17.28175608	16.37975317	0.939160954	0.594847855	44.18710434	40.98286948	4.368848799	1.917223799
10	16.63775248	15.85332145	0.375258852	0.186442403	41.67635026	39.21899802	1.182672813	-0.022875089
15	17.10857752	16.26462042	0.084647356	0.011095516	44.91843798	41.65567084	0.081536248	-0.073472228
20	17.23875281	16.24103486	0.001062715	-4.61E-04	45.39453672	41.69888691	0	0
25	17.22890683	16.24338944	0	0	45.39400226	41.70668238	0	0
30	17.22890683	16.24338944	0	0	45.39400226	41.70668238	0	0

Plots and Inference:



Some of the inferences from the graphs are:

1) Initially, when the buffer size is small, we see high values of all the metrics since all requests are being sent to orbit.
2) As buffer size increases, we see a dip in the values since the buffer is able to handle more requests simultaneously.
3) With increasing buffer size there is then a dip at buffer size 10, which becomes our optimal value.
4) After a point e.g. buffer size greater than 25-30, there everything is almost constant and orbital time comes down to 0 as requests get handled almost immediately because of the large size of the buffer.