OS Assignment 3

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Simulation of Scheduling Algorithms

1. FCFS
2. SJF
3. SJF with pre-emption(SRTF)
4. Priority with ageing
5. Priority with ageing and pre-emption
6. Round Robin
7. Multi-Level queue with priority, ageing, and pre-emption
8. Multi-Level Feedback queue with priority, ageing, and pre-emption

Note

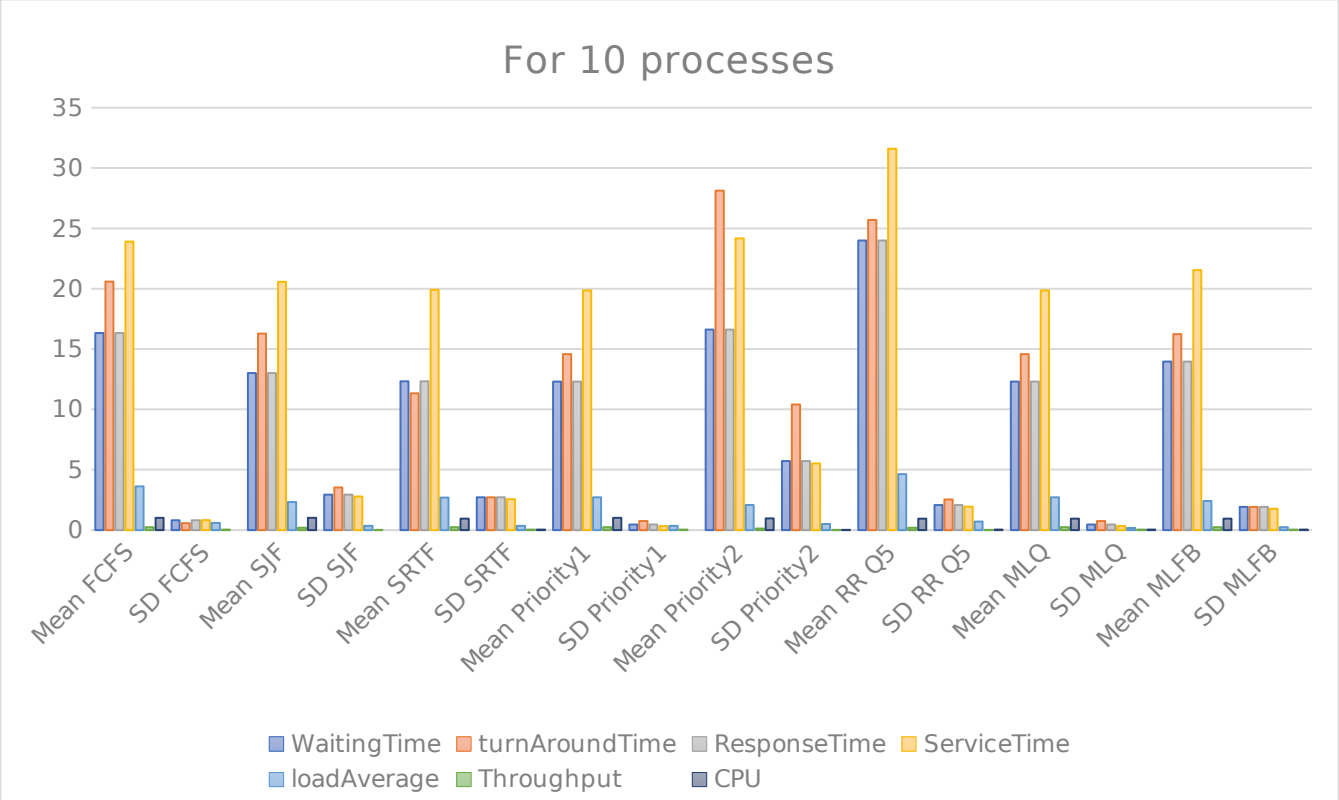
Context switch overhead of 1 clock has been added to all pre-emptive algorithms

Observations

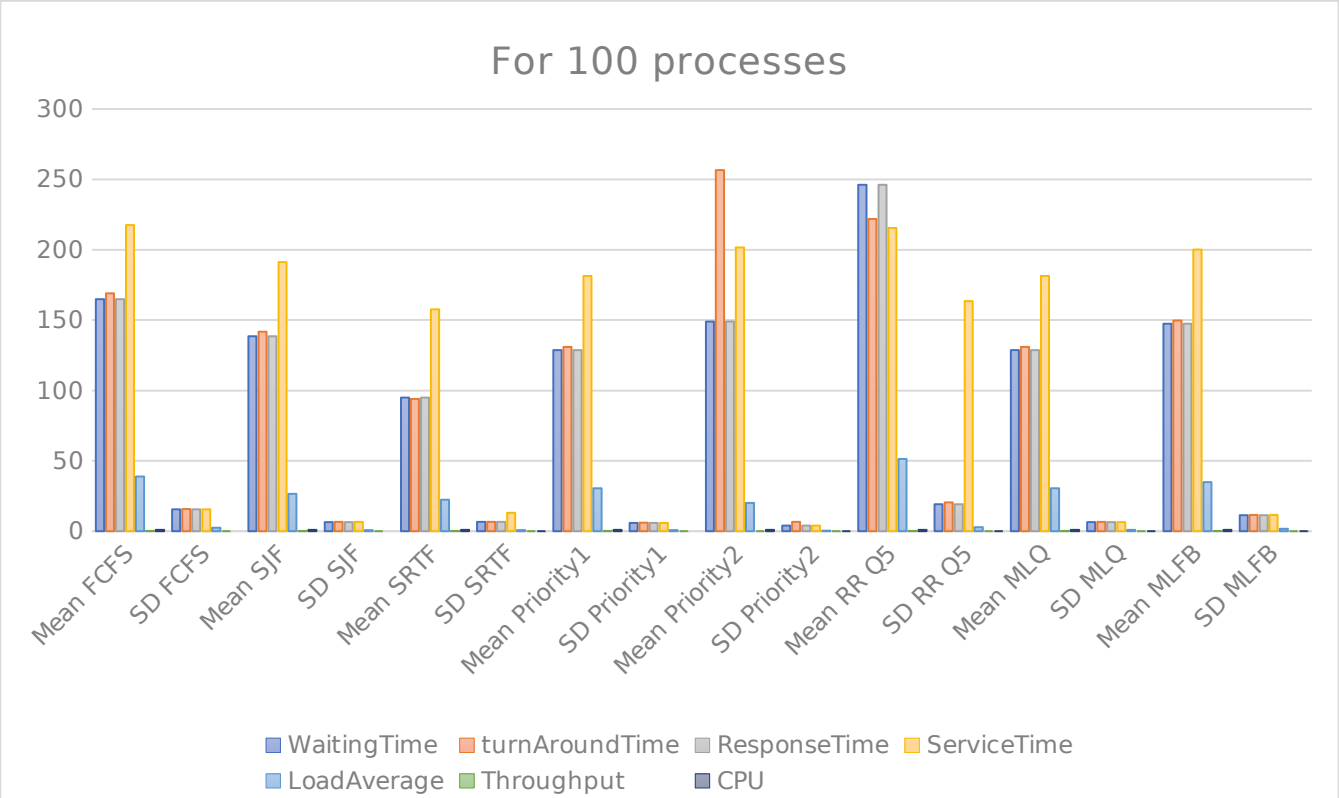
1. SRTF has best performance, and it truly shines if number of processes is high, (context switch overhead is averaged out).
2. Priority with pre-emption has high turnaround time due to starvation. Even with ageing, once lot of processes are at their lowest/highest priority, it behaves like FCFS
3. ML queues have pretty decent performance, with variable workloads.
4. Algorithms with pre-emption are better under heavy workloads (context switch overheads are averaged out)
5. Algorithms without pre-emption are okay at low workloads
6. Pre-emptive algorithms perform bad when lot of processes have same/similar priorities, as scheduler keeps on switching between two tasks that are ageing in same manner
7. RR has worst performance, but if process is interactive, it will probably perform fine
8. Performance of RR improves on increasing quanta size, but after certain max quanta size, it behaves like FCFS

Graphs

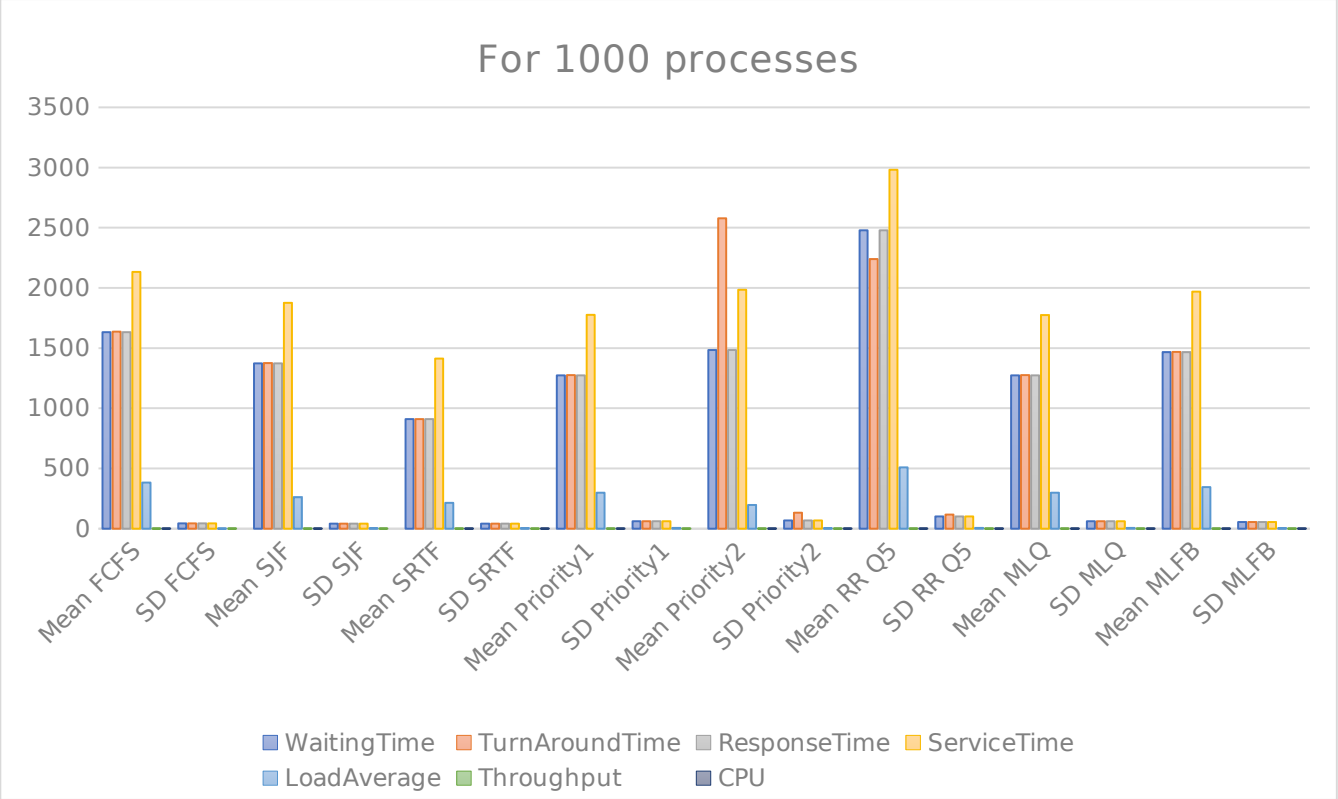
1. For 10 Processes



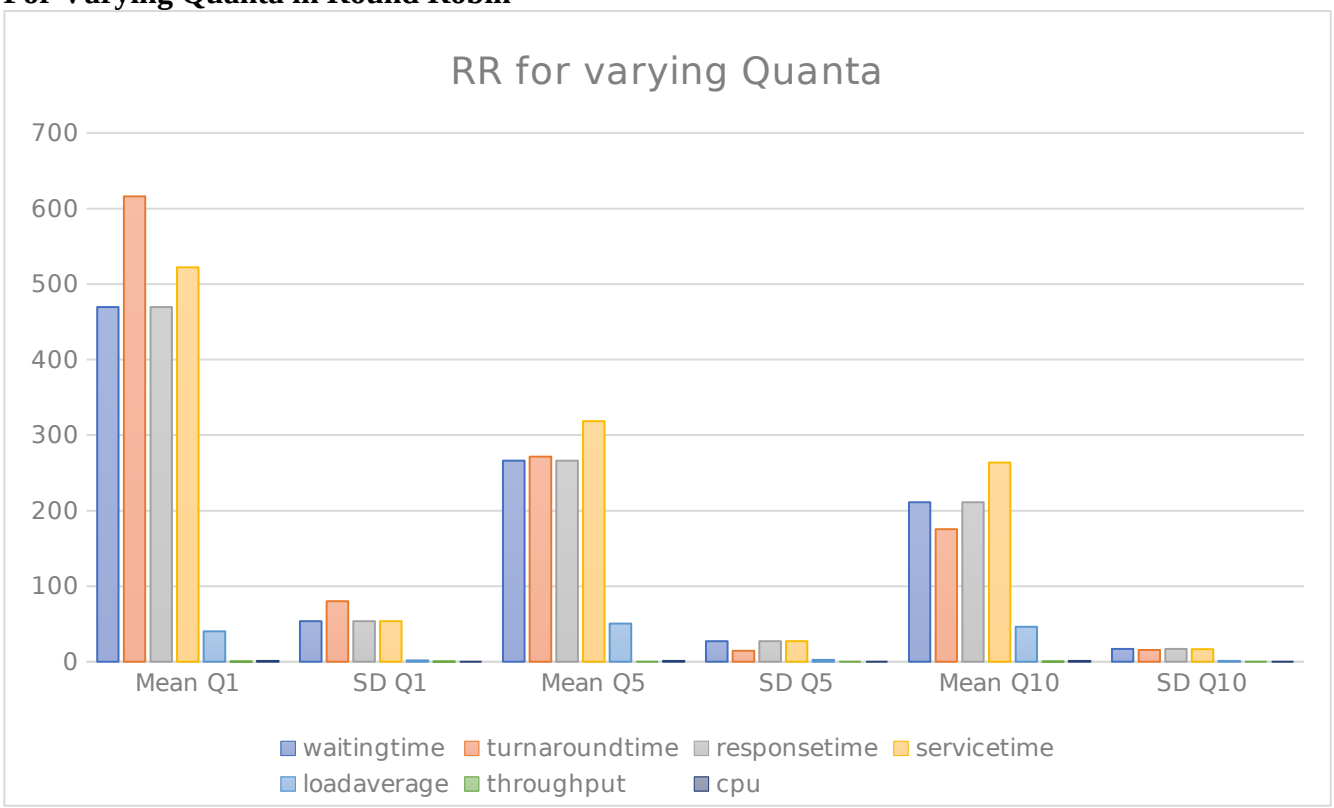
2. For 100 Processes



3. **For 1000 Processes**



4. **For Varying Quanta in Round Robin**



5.

Data

1. For 10 Processes

NumProc		10	Waiting Time	TAT	Response Tin	Service Time	load Average	Throughput	%CPU
FCFS		1	15.5	20	15.5	23.2	3.16	0.204	1
		2	17.1	20.7	17.1	24.79	4.27	0.25	1
		3	16.4	21.1	16.4	23.7	3.41	0.208	1
	Mean FCFS		16.333333333	20.6	16.333333333	23.896666667	3.6133333333	0.2206666667	1
	SD FCFS		0.8020806277	0.5567764363	0.8020806277	0.8130395644	0.5822656896	0.0254820198	0
SJF		1	14	17.5	14	21.7	2.37	0.169	1
		2	9.7	12.3	9.7	17.4	1.94	0.2	1
		3	15.3	19	15.3	22.6	2.63	0.172	1
	Mean SJF		13	16.266666667	13	20.566666667	2.3133333333	0.1803333333	1
	SD SJF		2.930870178	3.5161532011	2.930870178	2.7790885796	0.3484728588	0.0170977581	0
SRTF		1	13.2	12.2	13.2	20.9	2.69	0.204	0.918
		2	9.3	8.3	9.3	17	2.32	0.25	0.9
		3	14.5	13.5	14.5	21.79	3.02	0.208	0.979
	Mean SRTF		12.333333333	11.333333333	12.333333333	19.896666667	2.6766666667	0.2206666667	0.9323
	SD SRTF		2.7061657993	2.7061657993	2.7061657993	2.5477506419	0.3501904244	0.0254820198	0.0414
Priority		1	11.8	14.3	11.8	19.5	2.408	0.204	1
+ageing		2	12.4	14	12.4	20.1	3.1	0.25	1
		3	12.7	15.4	12.7	20	2.64	0.208	1
	Mean Priority1		12.3	14.566666667	12.3	19.866666667	2.716	0.2206666667	1
	SD Priority1		0.4582575695	0.7371114796	0.4582575695	0.3214550254	0.3522044861	0.0254820198	0
Priority		1	17	28.4	17	24.7	2.02	0.119	0.952
+ageing		2	10.7	17.6	10.7	18.4	1.62	0.15	0.94
+preemption		3	22.1	38.4	22.1	29.4	2.6	0.117	0.988
	Mean Priority2		16.6	28.133333333	16.6	24.166666667	2.08	0.1286666667	0.96
	SD Priority2		5.7105166141	10.402563787	5.7105166141	5.5193598663	0.4927473998	0.0185022521	0.025
Round Robin		1	21.7	23.4	21.7	29.4	3.94	0.181	0.927
Quanta = 5		2	24.6	25.29	24.6	32.29	5.34	0.217	0.913
		3	25.7	28.4	25.7	33.09	4.607	0.178	0.982
	Mean RR Q5		24	25.696666667	24	31.593333333	4.629	0.192	0.9407
	SD RR Q5		2.066397832	2.5246847988	2.066397832	1.9411422754	0.7002592377	0.0217025344	0.0365
Multi level		1	11.8	14.3	11.8	19.5	2.89	0.204	0.935
Queue		2	12.4	14	12.4	20.1	2.6	0.25	0.915
+ageing		3	12.7	15.4	12.7	20	2.64	0.208	0.979
+preemption	Mean MLQ		12.3	14.566666667	12.3	19.866666667	2.71	0.2206666667	0.943
	SD MLQ		0.4582575695	0.7371114796	0.4582575695	0.3214550254	0.1571623365	0.0254820198	0.0327
ML feedback		1	11.8	14.3	11.8	19.5	2.64	0.204	0.935
+ageing		2	14.7	16.29	14.7	22.4	2.18	0.25	0.935
+preemption		3	15.4	18.1	15.4	22.7	2.39	0.208	0.979
	Mean MLFB		13.966666667	16.23	13.966666667	21.533333333	2.4033333333	0.2206666667	0.9497
	SD MLFB		1.9087517736	1.9007103935	1.9087517736	1.7672954856	0.2302896727	0.0254820198	0.0254

2. For 100 Processes

NumProc	100	Waiting Time	TAT	Response Tin	Service Time	load Average	Throughput	%CPU
FCFS	1	149.02	153.11	149.02	201.66	36.26	0.243	1
	2	180.35	184.72	180.35	233.02	40.89	0.226	1
	3	165.22	169.35	165.22	217.82	39.81	0.24	1
	Mean FCFS	164.86333333	169.06	164.86333333	217.5	38.986666667	0.2363333333	1
	SD FCFS	15.668044975	15.806995287	15.668044975	15.682448788	2.4223198247	0.0090737717	0
SJF	1	138.89	141.97	138.89	191.53	27.18	0.195	1
	2	144.94	148.33	144.94	197.63	26.84	0.185	1
	3	131.8	134.94	131.8	184.41	25.59	0.194	1
	Mean SJF	138.54333333	141.74666667	138.54333333	191.19	26.536666667	0.1913333333	1
	SD SJF	6.5768558851	6.6977931689	6.5768558851	6.6165549949	0.8372773336	0.0055075705	0
SRTF	1	93.33	92.33	93.33	145.97	22.708	0.243	0.992
	2	102.38	101.389	102.389	155.07	23.27	0.227	0.995
	3	89.2	88.2	89.2	171.8	21.496	0.24	0.9951
	Mean SRTF	94.97	93.973	94.973	157.61333333	22.491333333	0.2366666667	0.99403
	SD SRTF	6.7413129285	6.7462594821	6.7462594821	13.101474472	0.9066296561	0.0085049005	0.00176
Priority	1	122.08	124.16	122.08	174.72	29.7	0.243	1
+ageing	2	133.61	135.99	133.61	186.28	30.36	0.227	1
	3	130.52	132.64	130.52	183.11	31.45	0.24	1
	Mean Priority1	128.73666667	130.93	128.73666667	181.37	30.503333333	0.2366666667	1
	SD Priority1	5.9682856277	6.0975650878	5.9682856277	5.9731984732	0.8837609028	0.0085049005	0
Priority	1	148.69	254.63	148.69	201.33	20.68	0.139	0.995
+ageing	2	153.17	263.94	153.17	205.86	19.68	0.128	0.997
+preemption	3	145.16	251.03	145.16	197.77	19.94	0.137	0.997
	Mean Priority2	149.00666667	256.53333333	149.00666667	201.65333333	20.1	0.1346666667	0.99633
	SD Priority2	4.0143783246	6.6621342927	4.0143783246	4.0546804231	0.5188448708	0.0058594653	0.00115
Round Robin	1	223.97	198.5	223.97	26.61	48.37	0.215	0.993
Quanta = 5	2	257.51	235.52	257.51	310.2	51.91	0.201	0.995
	3	257.2	232.02	257.09	309.8	53.92	0.209	0.9958
	Mean RR Q5	246.22666667	222.01333333	246.19	215.53666667	51.4	0.2083333333	0.9946
	SD RR Q5	19.275461949	20.438202791	19.244230304	163.61541502	2.8099288247	0.0070237692	0.00144
Multi level	1	121.54	123.62	121.54	174.17	29.57	0.243	0.992
Queue	2	134.11	136.5	134.11	186.8	30.48	0.227	0.995
+ageing	3	130.55	132.69	130.55	183.16	31.46	0.2409	0.9951
+preemption	Mean MLQ	128.73333333	130.93666667	128.73333333	181.37666667	30.503333333	0.2369666667	0.99403
	SD MLQ	6.4789222355	6.6165877409	6.4789222355	6.5011101616	0.9452160247	0.0086950177	0.00176
ML feedback	1	135.47	137.55	135.47	188.11	32.96	0.2433	0.9927
+ageing	2	158.41	160.8	158.41	211.1	36	0.227	0.995
+preemption	3	148.55	150.67	148.55	201.14	35.79	0.24	0.9951
	Mean MLFB	147.47666667	149.67333333	147.47666667	200.11666667	34.916666667	0.2367666667	0.99427
	SD MLFB	11.507603284	11.656999328	11.507603284	11.529112426	1.6977730512	0.0086176176	0.00136

3. For 1000 Processes

NumProc		1000	Waiting Time	TAT	Response Tin	Service Time	load Average	Throughput	%CPU
FCFS		1	1659.296	1663.629	1659.296	2161.766	382.59	0.2305	1
		2	1654.35	1658.678	1654.35	2156.94	382.422	0.2311	1
		3	1580.519	1584.64	1580.51	2083.058	383.156	0.2424	1
	Mean FCFS		1631.3883333	1635.649	1631.3853333	2133.9213333	382.72266667	0.2346666667	1
	SD FCFS		44.123491865	44.244396945	44.12867985	44.114981325	0.3845638222	0.0067039789	0
SJF		1	1397.53	1400.86	1397.53	1900	261.85	0.187	1
		2	1394.65	1397.978	1394.65	1897.2399	261.907	0.1877	1
		3	1325.16	1328.29	1325.16	1827.7	258.61	0.19516	1
	Mean SJF		1372.4466667	1375.7093333	1372.4466667	1874.9799667	260.789	0.1899533333	1
	SD SJF		40.976764554	41.091621547	40.976764554	40.968902524	1.8872845572	0.0045226688	0
SRTF		1	932.49	931.49	932.49	1434.96	215	0.2305	0.99907
		2	932.74	931.74	932.74	1435.323	215.66	0.2312	0.999075
		3	863.629	862.629	863.629	1366.167	209.41	0.24248	0.999515
	Mean SRTF		909.61966667	908.61966667	909.61966667	1412.15	213.35666667	0.2347266667	0.99922
	SD SRTF		39.82928182	39.82928182	39.82928182	39.822859754	3.4338074106	0.0067236994	0.000255
Priority		1	1317.6	1319.93	1317.6	1820.077	303.8	0.2305	1
+ageing		2	1295.416	1297.738	1295.41	1798.41	299.518	0.2312	1
		3	1204.173	1206.296	1204.173	1706.713	291.991	0.242483	1
	Mean Priority1		1272.3963333	1274.6546667	1272.3943333	1775.0666667	298.43633333	0.2347276667	1
	SD Priority1		60.115304809	60.23123523	60.114156123	60.179170253	5.9783461202	0.0067254291	0
Priority		1	1527.68	2661.67	1527.68	2030.15	199.17	0.1303	0.9994
+ageing		2	1514.593	2647.375	1514.593	2017.6	198.089	0.1307	0.99947
+preemption		3	1405.381	2427.364	1405.381	1907.921	193.952	0.138	0.999724
	Mean Priority2		1482.5513333	2578.803	1482.5513333	1985.2236667	197.07033333	0.133	0.999531
	SD Priority2		67.151043568	131.3446413	67.151043568	67.23951465	2.754113711	0.0043347434	0.00017
Round Robin		1	2502.186	2261.688	2502.186	3004.65	505.185	0.2018	0.99919
Quanta = 5		2	2566.57	2344.68	2566.57	3069.158	515.68	0.2009	0.999196
		3	2368.38	2113.645	2368.384	2870.923	505.416	0.2134	0.999573
	Mean RR Q5		2479.0453333	2240.0043333	2479.0466667	2981.577	508.76033333	0.2053666667	0.99932
	SD RR Q5		101.10112198	117.0338791	101.09893278	101.11157848	5.9937200747	0.0069716091	0.000219
Multi level		1	1317.605	1319.938	1317.605	1820.076	303.805	0.2305	0.999078
Queue		2	1295.82	1297.82	1295.508	1798.09	299.539	0.2312	0.999075
+ageing		3	1204.14	1206.262	1204.14	1706.68	291.983	0.242483	0.999515
+preemption	Mean MLQ		1272.5216667	1274.6733333	1272.4176667	1774.9486667	298.44233333	0.2347276667	0.999223
	SD MLQ		60.213667953	60.269265611	60.153546665	60.135714724	5.9868129529	0.0067254291	0.000253
ML feedback		1	1510.96	1513.3	1510.96	2013.43	348.389	0.2305	0.99907
+ageing		2	1481.17	1483.49	1481.17	1983.76	342.468	0.2312	0.999075
+preemption		3	1405.125	1407.246	1405.125	1907.663	340.718	0.24248	0.999515
	Mean MLFB		1465.7516667	1468.012	1465.7516667	1968.2843333	343.85833333	0.2347266667	0.99922
	SD MLFB		54.57614459	54.694964046	54.57614459	54.555355066	4.0200535237	0.0067236994	0.000255

4. For Round Robin with varying quanta

Num = 100		**Waiting Time**	**TAT**	**Response Tin**	**Service Time**	**load Average**	**Throughput**	**%CPU**
RR	1	523.89	697.47	523.89	576.89	41.84	0.0798	0.9976
Q = 1	2	468.07	613.729	468.07	520.76	40.667	0.8688	0.99913
	3	416.51	537.05	416.51	469.239	38.601	0.0926	0.996
Mean Q1		469.49	616.083	469.49	522.29633333	40.369333333	0.3470666667	0.9975766667
SD q10		53.704081782	80.235902731	53.704081782	53.84194174	1.6398885125	0.4518796447	0.0015651305

Num = 100	10	Waiting Time	TAT	Response Tim	Service Time	load Average	Throughput	%CPU
RR	1	287.22	268.48	287.22	339.57	51.289	0.1785	0.9946
Q = 5	2	275.89	258.83	275.89	328.57	52.552	0.19	0.998
	3	235.24	287.119	235.24	287.97	47.716	0.20284	0.99188
Mean Q5		266.11666667	271.47633333	266.11666667	318.70333333	50.519	0.1904466667	0.9948266667
SD Q5		27.333470935	14.380555981	27.333470935	27.17817752	2.5082661342	0.0121761461	0.0030662898

Num = 100	10	Waiting Time	TAT	Response Tim	Service Time	load Average	Throughput	%CPU
RR	1	227.21	189.78	227.21	279.21	46.751	0.2057	0.99382
Q = 10	2	213.35	177.91	213.35	266.02	47.305	0.2217	0.9978
	3	193.27	159.28	193.27	246	45.051	0.233	0.996
Mean Q10		211.27666667	175.65666667	211.27666667	263.74333333	46.369	0.2201333333	0.9958733333
SD Q10		17.064727754	15.374349851	17.064727754	16.721645653	1.1745518294	0.0137172641	0.0019930212