BILKENT UNIVERSITY

CS342 - OPERATING SYSTEMS

PROJECT 2

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Section 1

REPORT

How Does the Code Work?

After executing the Makefile with make command, in order to run the code, one of the following two formats must be used.

> ./scheduler <N> <Bcount> <minB> <avgB> <minA> <avgA> <ALG>
> ./scheduler <N> <ALG> -f <inprefix>

If the first format is used, the mode variable is 1, otherwise it's 2.

First we must construct the shared buffer containing the runqueue which the threads are going to use to add their bursts. As runqueue, a queue data structure and proper functions of this structure such as retrieval and removal have been implemented.

If the first mode is used, the S thread and W threads are created. S thread waits whenever there is no burst node in the runqueue on shared_buf -> cond_hasburst conditional variable. While adding a burst into the runqueue, this conditional variable is signalled so that the S thread will be aware that there has been an addition to the runqueue, so the runqueue is no longer empty and it can simulate this burst by sleeping.

Every operation that is made in the runqueue such as addition, removal, and searching requires the mutex_lock. In order to prevent more than one thread from being able to change something in the runqueue, there is pthread_mutex_t mutex_queue variable. This variable assures that only one thread can execute their critical part in which they do addition, removal, or search operations on the shared runqueue structure.

Every W thread uses the generate_burst function which generates the bursts according to the instructions and adds them to the runqueue. In order to generate a sequence of cpu bursts one-by-one, the length of each burst is random and exponentially distributed with mean avgB. To correctly generate these lengths, the CDF (cumulative distribution function) of the exponential distribution is taken, and when we solve it to find X, the following result is obtained.

```
    X = -1/lambda * ln(1 - R). => Where R is a value between 0
and 1.
```

We are genereting random values between 0 and 1 with
> (double) rand() / (double) RAND_MAX

code, and checking if X is less than minB. If it is, the random value is generated again until it is not less than minB.

The same operation is done when the w thread is generated. The w threads as much as the generated random exponentially distributed value with mean avgA. Having finished their sleeping, they start generating bursts, after generating every burst, they sleep again as they did when they were first created. After generating Bcount bursts, they are finished.

If the second mode is used, the w threads get the information about sleeping and burst length from files. The general file name is given in the <inprefix> and the threads add -thread_index.txt to the end of this prefix. The files are in the form of

<div align="center">
first_sleeping_time
sleeping_length burst_length
sleeping_length burst_length
…
</div>

the first_sleeping_time is the time that every thread will sleep when they are created. Sleeping_length is the amount that the threads will sleep after they created and added their burst which has length burst_length.

The S thread runs the s_thread_func which executes the bursts according to the specified algorithm. Whenever there is no node in the runqueue, it waits for an item to be added.

In the FCFS (first come first serve) algorithm, the burst that is added to the queue first is executed.

In the SJF (shortest job first) algorithm, the runqueue is searched for the shortest burst length. The burst that has the shortest burst length is selected, however, the order of the bursts in a thread is not changed. In other words, for example, if there are only three bursts which are all of thread 3 and the third burst has the shortest burst length, even though it is the shortest burst, the first burst is executed, and then the second, and lastly the third. Therefore, order of the threads is maintained.

In the PRIO (priority) mode, the burst that has the biggest priority (lowest thread index) has the priority, and is executed first. For instance, if there are 3 bursts of thread 1, 5 bursts of thread 2, 1 burst of thread 4, and no new bursts, the 3 bursts of thread 1 are executed, and 5 bursts of thread 2 are executed and the last burst of thread 4 is executed.

In the VRUNTIME algorithm, each thread has virtual runtime which they can achieve their virtual runtime from the array vruntime_info. The first thread (with index 1) can reach their virtual runtime from vruntime_info[0], etc. After executing a burst of a thread, their virtual runtime is incremented by $t(0.7 + 0.3i)$ where t is the burst_length, i is the index of the thread. While selecting burst, the burst of the

thread that has the smallest virtual runtime is selected for execution. We do not reorder the bursts, therefore, they are served in the order they are added to the runqueue. If the virtual runtime of the bursts are the same, the threads that have higher priority are selected first.

When S thread executed a burst, it removes that node from the runqueue. Therefore as S thread executes a burst, the size of the runqueue gets smaller. This is done with the runqueue_remove() method.

Experiments

In order to make the experiments more readable and understandable, the N and Bcount will not be huge numbers. Maximum 3 or 4 for N and maximum 5-6 for Bcount will be sufficient to test the code. That way, we can do more tests, and generate more reliable results.

1 - FCFS

N = 3, Bcount = 3, minB = 500, avgB = 200, minA = 600, avgA = 300

Result:

Thread 3, 2, 1 are created. Thread 3 is sleeping for 940 ms, thread 2 for 645 ms, thread 1 for 642 ms.

Thread 1 is awakened first, it is in critical section, it added burst #1 with length 575 ms, at time 643 ms. Sleeping for 810 ms.

An item is added to runqueue, S thread is awakened. S thread is executing the burst #1 of thread #1, at time 643. It will sleep for 575 ms.
Thread #2 added burst #1, length 854 ms, at time 646 ms. Sleeping for 727ms.
Thread #3 added burst #1, length 806 ms, at time 941 ms. Sleeping for 682ms.
S thread finished executing burst #1 of thread #1. Burst #1 of thread #2 is selected, because it has come earlier.
S thread is executing burst #1 of thread #2, at time 1219, sleeping for 845 ms.
Thread #2 added burst #2, length 588 ms, at time 1375 ms. Sleeping for 1588 ms.
Thread #1 added burst #2, length 1234 ms, at time 1454 ms. Sleeping for 1131 ms.
Thread #3 added burst #2, length 952 ms, at time 1625 ms. Sleeping foe 1638 ms.
S thread executed burst #1 of thread #2. S thread is executing burst #1 of thread #3 at time 2074. Sleeping for 806 ms.
Thread #1 added burst #3, length 676 ms, at time 2587 ms. Sleeping for 888 ms.
S thread executed #1 of thread #3. S thread is executing burst #2 of thread #2, at time 2882 ms. Sleeping for 588 ms.
Thread #2 added burst #3, length 709 ms, at time 2964 ms. Sleeping for 650 ms.

Thread #3 added burst #3, length 538 ms, at time 3264 ms. Sleeping for 928 ms.

No more bursts left to add the runqueue.

S thread executed burst #2 of thread #2.
S thread is executing burst #2 of thread #1, at time 3471 ms. Sleeping for 1234 ms.
Executed.
S thread is executing burst #2 of thread #3, at time 4706 ms. Sleeping for 952 ms.
Executed.
S thread is executing burst #3 of thread 1, at time 5659 ms. Sleeping for 676 ms.
Executed.
S thread is executing burst #3 of thread 2, at time 6335 ms. Sleeping for 709 ms.
Executed
S thread is executing burst #3 of thread 3, at time 7046 ms. Sleeping for 538 ms.
Executed.

Program finished.

Real output of the code can be seen below.

As can be seen, the selection is made correctly by the S thread. The first coming to the queue is served first.

	Arrival Time	Execution Start Time
1-1	643	643
2-1	646	1219
3-1	941	2074
2-2	1375	2882
1-2	1454	3471
3-2	1625	4706
1-3	2587	5659
2-3	2964	6335
3-3	3264	7046

i-j notation means the j'th burst of the i'th thread. For instance, 2-3 means that it is the third burst of the thread 2.

In order to calculate total waiting time we will subtract the arrival time of the burst from the time that S thread starts executing that burst:

Waiting Time of the burst 1-1:   643 - 632 = 0
Waiting Time of the burst 2-1:   1219 - 646 = 573
Waiting Time of the burst 3-1:   2074 - 941 = 1133
Waiting Time of the burst 2-2:   2882 - 1375 = 1507
Waiting Time of the burst 1-2:   3471 - 1454 = 2017
Waiting Time of the burst 3-2:   4706 - 1625 = 3081
Waiting Time of the burst 1-3:   5659 - 2587 = 3072
Waiting Time of the burst 2-3:   6335 - 2964 = 3371
Waiting Time of the burst 3-3:   7046 - 3264 = 3782

Total waiting time = 18536 ms
Average waiting time = 18536/9 = 2059.56

2 - SJF

N = 3, Bcount = 3, minB = 500, avgB = 200, minA = 600, avgA = 300

```
Creating S_thread.
Creating W_thread_1.
Creating W_thread_2.
Creating W_thread_3.
Thread 2 is created, sleeping for 1094.883034 ms
Thread 1 is created, sleeping for 789.276270 ms
S-THREAD Created.
S Thread is waiting for an item to be added to the runqueue
Thread 3 is created, sleeping for 1030.331798 ms
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #1, length=805.206090 At time: 790
Thread index: 1, after adding, sleeping for 772.945874 ms
An item is added to the runqueue, S Thread is awaken

Next burst info: thid: 1, bid: 1
S Thread is executing Thread index:1 , Burst index:1, Length:805.206090, at time
 790
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #1, length=531.022428 At time: 1035
Thread index: 3, after adding, sleeping for 946.106787 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #1, length=528.680685 At time: 1096
Thread index: 2, after adding, sleeping for 1526.273467 ms
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #2, length=721.131023 At time: 1564
Thread index: 1, after adding, sleeping for 979.298354 ms
S Thread has executed Thread index:1 , Burst index:1, Length:805.206090

Next burst info: thid: 2, bid: 1
S Thread is executing Thread index:2 , Burst index:1, Length:528.680685, at time
 1596
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #2, length=590.541034 At time: 1982
Thread index: 3, after adding, sleeping for 1718.489163 ms
S Thread has executed Thread index:2 , Burst index:1, Length:528.680685

Next burst info: thid: 3, bid: 1
S Thread is executing Thread index:3 , Burst index:1, Length:531.022428, at time
 2125
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #3, length=548.458080 At time: 2544
Thread index: 1, after adding, sleeping for 870.650132 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #2, length=570.239142 At time: 2623
Thread index: 2, after adding, sleeping for 1096.452424 ms
S Thread has executed Thread index:3 , Burst index:1, Length:531.022428

Next burst info: thid: 1, bid: 3
S Thread is executing Thread index:1 , Burst index:3, Length:548.458080, at time
 2656
S Thread has executed Thread index:1 , Burst index:3, Length:548.458080

Next burst info: thid: 2, bid: 2
S Thread is executing Thread index:2 , Burst index:2, Length:570.239142, at time 3206
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #3, length=580.876693 At time: 3701
Thread index: 3, after adding, sleeping for 1490.827877 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #3, length=607.383739 At time: 3721
Thread index: 2, after adding, sleeping for 622.142688 ms
```

```
S Thread has executed Thread index:2 , Burst index:2, Length:570.239142

Next burst info: thid: 3, bid: 2
S Thread is executing Thread index:3 , Burst index:2, Length:590.541034, at time 3777
S Thread has executed Thread index:3 , Burst index:2, Length:590.541034

Next burst info: thid: 3, bid: 3
S Thread is executing Thread index:3 , Burst index:3, Length:580.876693, at time 4368
S Thread has executed Thread index:3 , Burst index:3, Length:580.876693

Next burst info: thid: 2, bid: 3
S Thread is executing Thread index:2 , Burst index:3, Length:607.383739, at time 4949
S Thread has executed Thread index:2 , Burst index:3, Length:607.383739

Next burst info: thid: 1, bid: 2
S Thread is executing Thread index:1 , Burst index:2, Length:721.131023, at time 5557
S Thread has executed Thread index:1 , Burst index:2, Length:721.131023

Program Finished. Runqueue information
```

Actual result can be seen above. To simplify reading, the table can be examined.

	Arrival Time	Burst Length	Execution Start Time	Waiting Time
1-1	790	805	790	0
3-1	1035	531	2125	1090
2-1	1096	528	1596	500
1-2	1564	721	5557	3993
3-2	1982	590	3777	1795
1-3	2544	548	2656	112
2-2	2623	570	3206	583
3-3	3701	580	4368	667
2-3	3721	607	4949	1228

Total waiting time = 9968. This is approximately the half of the waiting time that is gotten from the FCFS algorithm.

Average waiting time = 9968 / 9 = 1107.56

Explanation:

The first burst is immediately executed. While it has been executed, T3B1 (531), T2B1 (528), T1B2 (721) (Thread i, burst j) (burst length) added to the runqueue. The burst having the shortest burst length among these 3 bursts is **T2B1** (528 ms) and is executed. While it has been executed, T3B2 is added to the runqueue.

The runqueue has T3B1 (531), T1B2 (721), T3B2 (590). The burst having the shortest burst length is **T3B1** (531 ms) and is executed. While executing, T1B3, T2B2 have been added to the runqueue.

The runqueue has T1B2 (721), T3B2 (590), T1B3 (548), T2B2 (570). The burst having the shortest burst length is **T1B3** (548ms) and is executed.

While being executed, there is no burst newly arrived. The shortest burst is **T2B2**(570) and is executed.

While being executed, T3B3(580), T2B3(607) have been added to the queue.

The runqueue has T1B2(721), T3B2(590), T3B3(580), T2B3(607).

The shortest is T3B3, however, we can not reorder the thread's bursts, therefore **T3B2** is executed.

Next shortest is **T3B3** and is executed.

Next shortest is **T2B3** and is executed.

Next shortest is **T1B2** and is executed.

Program finished.

3 - PRIO

N = 3, Bcount = 3, minB = 500, avgB = 200, minA = 600, avgA = 300

```
Creating S_thread.
Creating W_thread_1.
Creating W_thread_2.
S-THREAD Created.
S Thread is waiting for an item to be added to the runqueue
Creating W_thread_3.
Thread 2 is created, sleeping for 703.682908 ms
Thread 1 is created, sleeping for 1024.711395 ms
Thread 3 is created, sleeping for 892.872400 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #1, length=637.147752 At time: 705
Thread index: 2, after adding, sleeping for 996.428197 ms
An item is added to the runqueue, S Thread is awaken

Next burst info: thid: 2, bid: 1
S  Ubuntu Software   Thread index:2 , Burst index:1, Length:637.147752, at time
: 705
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #1, length=1300.897011 At time: 894
Thread index: 3, after adding, sleeping for 1211.588528 ms
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #1, length=504.987098 At time: 1026
Thread index: 1, after adding, sleeping for 645.823764 ms
S Thread has executed Thread index:2 , Burst index:1, Length:637.147752

Next burst info: thid: 1, bid: 1
S Thread is executing Thread index:1 , Burst index:1, Length:504.987098, at time
: 1343
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #2, length=742.128701 At time: 1672
Thread index: 1, after adding, sleeping for 950.430559 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #2, length=677.510313 At time: 1702
Thread index: 2, after adding, sleeping for 913.007919 ms
S Thread has executed Thread index:1 , Burst index:1, Length:504.987098

Next burst info: thid: 1, bid: 2
S Thread is executing Thread index:1 , Burst index:2, Length:742.128701, at time
: 1849
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #2, length=1102.707490 At time: 2106
Thread index: 3, after adding, sleeping for 765.105430 ms
S Thread has executed Thread index:1 , Burst index:2, Length:742.128701

Next burst info: thid: 2, bid: 2
S Thread is executing Thread index:2 , Burst index:2, Length:677.510313, at time: 2592
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #3, length=649.248709 At time: 2616
Thread index: 2, after adding, sleeping for 1210.925327 ms
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #3, length=934.594465 At time: 2623
Thread index: 1, after adding, sleeping for 874.138929 ms
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #3, length=1055.377298 At time: 2872
Thread index: 3, after adding, sleeping for 1215.248323 ms
S Thread has executed Thread index:2 , Burst index:2, Length:677.510313

Next burst info: thid: 1, bid: 3
S Thread is executing Thread index:1 , Burst index:3, Length:934.594465, at time: 3270
S Thread has executed Thread index:1 , Burst index:3, Length:934.594465
```

```
Next burst info: thid: 1, bid: 3
S Thread is executing Thread index:1 , Burst index:3, Length:934.594465, at time: 3270
S Thread has executed Thread index:1 , Burst index:3, Length:934.594465

Next burst info: thid: 2, bid: 3
S Thread is executing Thread index:2 , Burst index:3, Length:649.248709, at time: 4205
S Thread has executed Thread index:2 , Burst index:3, Length:649.248709

Next burst info: thid: 3, bid: 1
S Thread is executing Thread index:3 , Burst index:1, Length:1300.897011, at time: 4855
S Thread has executed Thread index:3 , Burst index:1, Length:1300.897011

Next burst info: thid: 3, bid: 2
S Thread is executing Thread index:3 , Burst index:2, Length:1102.707490, at time: 6156
S Thread has executed Thread index:3 , Burst index:2, Length:1102.707490

Next burst info: thid: 3, bid: 3
S Thread is executing Thread index:3 , Burst index:3, Length:1055.377298, at time: 7260
S Thread has executed Thread index:3 , Burst index:3, Length:1055.377298


Program Finished. Runqueue information
```

	Arrival Time	Burst Length	Execution Start Time	Waiting Time
2-1	705	637	705	0
3-1	894	1300	4855	3961
1-1	1026	504	1343	317
1-2	1672	721	1849	177
2-2	1702	677	2592	890
3-2	2106	1102	6156	4050
2-3	2616	649	4205	1589
1-3	2623	934	3270	647
3-3	2872	1055	7260	4388

Total Waiting Time = 16019
Average Waiting Time = 1779.89

When we look at the waiting times, the waiting time of the bursts that belong to the threads with higher priority is considerably low. However, some bursts of the threads having lower priority may never be executed if the higher priority bursts keep coming.

Explanation:

First, T2 added B1, length 637, at time 705.
Only item is it, S thread executes it. While executing, T3B1 length 1300 added at time 894. T1B1 length 504 added at time 1026.

T2B1 executed. Biggest priority is T1B1, it is executed at time 1343. While being executed, T1B2 added at time 1672, T2B2 added at 1702.

S thread executed T1B1. Biggest priority is of T1B2 and is executed at time 1849. While being executed, T3B2 was added in 2106.
The next biggest priority is of T2B2, and is executed at time 2592. While being executed, T2B3, T1B3, T3B3 have been added to the queue.

Next biggest priority is T1B3, T2B3, T3B1, T3B2, T3B3. This sequence is executed.

4 - VRUNTIME

N = 3, Bcount = 3, minB = 500, avgB = 200, minA = 600, avgA = 300

```
Creating S_thread.
Creating W_thread_1.
Creating W_thread_2.
Creating W_thread_3.
S-THREAD Created.
S Thread is waiting for an item to be added to the runqueue
Thread 1 is created, sleeping for 689.999771 ms
Thread 2 is created, sleeping for 705.772289 ms
Thread 3 is created, sleeping for 632.737210 ms
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #1, length=517.094664 At time: 634
Thread index: 3, after adding, sleeping for 737.911905 ms
An item is added to the runqueue, S Thread is awaken

Next burst info: thid: 3, bid: 1
S Thread is executing Thread index:3 , Burst index:1, Length:517.094664, At time
: 634
Thread index:1 is in critical section
T       dex:1 EXITTED the critical section
T Help  dex:1, has added burst #1, length=532.127366 At time: 690
Thread index: 1, after adding, sleeping for 639.891810 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #1, length=742.385810 At time: 707
Thread index: 2, after adding, sleeping for 685.858661 ms
S Thread has executed Thread index:3 , Burst index:1, Length:517.094664
vruntime[0] = 0.000000
vruntime[1] = 0.000000
vruntime[2] = 827.351462

Next burst info: thid: 1, bid: 1
S Thread is executing Thread index:1 , Burst index:1, Length:532.127366, At time
: 1151
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #2, length=624.330756 At time: 1331
Thread index: 1, after adding, sleeping for 723.377808 ms
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #2, length=580.466401 At time: 1372
Thread index: 3, after adding, sleeping for 794.504436 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #2, length=793.975062 At time: 1393
Thread index: 2, after adding, sleeping for 987.235280 ms
S Thread has executed Thread index:1 , Burst index:1, Length:532.127366
vruntime[0] = 532.127366
vruntime[1] = 0.000000
vruntime[2] = 827.351462

Next burst info: thid: 2, bid: 1
S Thread is executing Thread index:2 , Burst index:1, Length:742.385810, At time: 1684
Thread index:1 is in critical section
Thread index:1 EXITTED the critical section
Thread index:1, has added burst #3, length=517.195412 At time: 2055
Thread index: 1, after adding, sleeping for 822.931710 ms
Thread index:3 is in critical section
Thread index:3 EXITTED the critical section
Thread index:3, has added burst #3, length=518.441095 At time: 2167
Thread index: 3, after adding, sleeping for 794.441453 ms
Thread index:2 is in critical section
Thread index:2 EXITTED the critical section
Thread index:2, has added burst #3, length=505.019865 At time: 2381
Thread index: 2, after adding, sleeping for 734.905116 ms
S Thread has executed Thread index:2 , Burst index:1, Length:742.385810
vruntime[0] = 532.127366
vruntime[1] = 965.101553
vruntime[2] = 827.351462
```

```
Next burst info: thid: 3, bid: 2
S Thread is executing Thread index:3 , Burst index:2, Length:580.466401, At time: 3053
S Thread has executed Thread index:3 , Burst index:2, Length:580.466401
vruntime[0] = 1156.458122
vruntime[1] = 965.101553
vruntime[2] = 1756.097705

Next burst info: thid: 2, bid: 2
S Thread is executing Thread index:2 , Burst index:2, Length:793.975062, At time: 3634
S Thread has executed Thread index:2 , Burst index:2, Length:793.975062
vruntime[0] = 1156.458122
vruntime[1] = 1997.269134
vruntime[2] = 1756.097705

Next burst info: thid: 1, bid: 3
S Thread is executing Thread index:1 , Burst index:3, Length:517.195412, At time: 4429
S Thread has executed Thread index:1 , Burst index:3, Length:517.195412
vruntime[0] = 1673.653533
vruntime[1] = 1997.269134
vruntime[2] = 1756.097705

Next burst info: thid: 3, bid: 3
S Thread is executing Thread index:3 , Burst index:3, Length:518.441095, At time: 4947
S Thread has executed Thread index:3 , Burst index:3, Length:518.441095
vruntime[0] = 1673.653533
vruntime[1] = 1997.269134
vruntime[2] = 2585.603457

Next burst info: thid: 2, bid: 3
S Thread is executing Thread index:2 , Burst index:3, Length:505.019865, At time: 5466
S Thread has executed Thread index:2 , Burst index:3, Length:505.019865
vruntime[0] = 1673.653533
vruntime[1] = 2653.794959
vruntime[2] = 2585.603457


Program Finished. Runqueue information
```

	Arrival Time	Burst Length	Execution Start Time	Waiting Time
3-1	634	517	634	0
1-1	690	532	1151	461
2-1	707	742	1684	977
1-2	1331	624	2428	1097
3-2	1372	580	3053	1681
2-2	1393	793	3634	2141
1-3	2055	517	4429	2374
3-3	2167	518	4947	2780
2-3	2381	505	5466	3085

Total Waiting Time = 14596
Average Waiting Time = 1621.78

Explanation:

Current Vruntime Array = [0 , 0 , 0]

T3B1 has been added at time 634 and starts being executed.
 While T3B1 was being executed, T1B1 and T2B1 were added to the queue.
After the execution of T3B1,

Current Vruntime Array = [0 , 0 , 827]

The first smallest virtual run time is 0 belonging to the thread 1. Therefore T1B1
starts being executed.
While T1B1 was being executed, T1B2, T3B2, T2B2 were added to the queue.
After the execution of T1B1,

Current Vruntime Array = [532 , 0 , 827]

Next burst is T2B1, while T2B1 was being executed, T1B3, T3B3, T2B3 were added
to the queue.

After the execution of T2B1,

Current Vruntime Array = [532 , 965 , 827]

The smallest virtual runtime belongs to the Thread #1, T1B2 is selected for
execution. After T1B2's execution,

Current Vruntime Array = [1156 , 965 , 827]

The smallest virtual run time belongs to the third thread, T3B2 is selected for
execution. After T3B2's execution,

Current Vruntime Array = [1156 , 965 , 1756]

The smallest virtual run time belongs to the second thread, T2B2 is selected for
execution. After T2B2's execution,

Current Vruntime Array = [1156 , 1997 , 1756]

T1B3 is selected for execution. After T1B3's execution,

Current Vruntime Array = [1673, 1997 , 1756]
Smallest virtual runtime belongs to the thread 1, but no T1 burst left, T3B3 selected, and after its execution T2B3 is selected.

More Tests:

In order to conduct the experiments in a much faster manner, the code is automated so that it will calculate the waiting time of every burst.
When you run the code, every arrival time and execution start time of the bursts will be printed out to the console at the end of the program execution.

Effect of Thread count to the waiting time when the mode is FCFS
(N will change):

N = 3 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 1, Burst index: 1, Arrival Time: 621, Exe Start time: 621, Waiting Time: 0
Thread Index: 3, Burst index: 1, Arrival Time: 672, Exe Start time: 1156, Waiting Time: 484
Thread Index: 2, Burst index: 1, Arrival Time: 858, Exe Start time: 1835, Waiting Time: 977
Thread Index: 3, Burst index: 2, Arrival Time: 1467, Exe Start time: 3116, Waiting Time: 1649
Thread Index: 2, Burst index: 2, Arrival Time: 1628, Exe Start time: 3767, Waiting Time: 2139
Thread Index: 1, Burst index: 2, Arrival Time: 1655, Exe Start time: 4308, Waiting Time: 2653
Thread Index: 3, Burst index: 3, Arrival Time: 2094, Exe Start time: 4870, Waiting Time: 2776
Thread Index: 2, Burst index: 3, Arrival Time: 2271, Exe Start time: 5476, Waiting Time: 3205
Thread Index: 3, Burst index: 4, Arrival Time: 2743, Exe Start time: 6413, Waiting Time: 3670
Thread Index: 1, Burst index: 3, Arrival Time: 2788, Exe Start time: 7102, Waiting Time: 4314
Thread Index: 2, Burst index: 4, Arrival Time: 3170, Exe Start time: 7693, Waiting Time: 4523
Thread Index: 3, Burst index: 5, Arrival Time: 3417, Exe Start time: 8588, Waiting Time: 5171
Thread Index: 1, Burst index: 4, Arrival Time: 3705, Exe Start time: 9185, Waiting Time: 5480
Thread Index: 2, Burst index: 5, Arrival Time: 3966, Exe Start time: 10168, Waiting Time: 6202
Thread Index: 1, Burst index: 5, Arrival Time: 4775, Exe Start time: 10823, Waiting Time: 6048

Average waiting time: 3286.066667

N = 5 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 3, Burst index: 1, Arrival Time: 613, Exe Start time: 614, Waiting Time: 1
Thread Index: 1, Burst index: 1, Arrival Time: 630, Exe Start time: 1184, Waiting Time: 554
Thread Index: 5, Burst index: 1, Arrival Time: 707, Exe Start time: 2482, Waiting Time: 1775
Thread Index: 4, Burst index: 1, Arrival Time: 780, Exe Start time: 3504, Waiting Time: 2724
Thread Index: 2, Burst index: 1, Arrival Time: 1012, Exe Start time: 4139, Waiting Time: 3127
Thread Index: 5, Burst index: 2, Arrival Time: 1347, Exe Start time: 4641, Waiting Time: 3294
Thread Index: 1, Burst index: 2, Arrival Time: 1430, Exe Start time: 5182, Waiting Time: 3752
Thread Index: 3, Burst index: 2, Arrival Time: 1481, Exe Start time: 5736, Waiting Time: 4255
Thread Index: 2, Burst index: 2, Arrival Time: 1708, Exe Start time: 7051, Waiting Time: 5343
Thread Index: 4, Burst index: 2, Arrival Time: 1790, Exe Start time: 7603, Waiting Time: 5813
Thread Index: 3, Burst index: 3, Arrival Time: 2109, Exe Start time: 8151, Waiting Time: 6042
Thread Index: 1, Burst index: 3, Arrival Time: 2325, Exe Start time: 8759, Waiting Time: 6434
Thread Index: 5, Burst index: 3, Arrival Time: 2373, Exe Start time: 9415, Waiting Time: 7042
Thread Index: 2, Burst index: 3, Arrival Time: 2635, Exe Start time: 10452, Waiting Time: 7817
Thread Index: 4, Burst index: 3, Arrival Time: 2660, Exe Start time: 11016, Waiting Time: 8356
Thread Index: 3, Burst index: 4, Arrival Time: 2764, Exe Start time: 11629, Waiting Time: 8865
Thread Index: 5, Burst index: 4, Arrival Time: 2982, Exe Start time: 12232, Waiting Time: 9250

Thread Index: 1, Burst index: 4, Arrival Time: 3170, Exe Start time: 12972, Waiting Time: 9802
Thread Index: 3, Burst index: 5, Arrival Time: 3662, Exe Start time: 13614, Waiting Time: 9952
Thread Index: 1, Burst index: 5, Arrival Time: 3894, Exe Start time: 14195, Waiting Time: 10301
Thread Index: 2, Burst index: 4, Arrival Time: 3943, Exe Start time: 14763, Waiting Time: 10820
Thread Index: 5, Burst index: 5, Arrival Time: 4052, Exe Start time: 15280, Waiting Time: 11228
Thread Index: 2, Burst index: 5, Arrival Time: 4545, Exe Start time: 15875, Waiting Time: 11330
Thread Index: 4, Burst index: 4, Arrival Time: 4758, Exe Start time: 16437, Waiting Time: 11679
Thread Index: 4, Burst index: 5, Arrival Time: 5750, Exe Start time: 16943, Waiting Time: 11193

Average waiting time: 6829.960000

N = 7 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 6, Burst index: 1, Arrival Time: 650, Exe Start time: 650, Waiting Time: 0
Thread Index: 3, Burst index: 1, Arrival Time: 653, Exe Start time: 1152, Waiting Time: 499
Thread Index: 1, Burst index: 1, Arrival Time: 692, Exe Start time: 1654, Waiting Time: 962
Thread Index: 5, Burst index: 1, Arrival Time: 706, Exe Start time: 2342, Waiting Time: 1636
Thread Index: 2, Burst index: 1, Arrival Time: 707, Exe Start time: 2944, Waiting Time: 2237
Thread Index: 4, Burst index: 1, Arrival Time: 1026, Exe Start time: 3451, Waiting Time: 2425
Thread Index: 7, Burst index: 1, Arrival Time: 1030, Exe Start time: 4253, Waiting Time: 3223
Thread Index: 1, Burst index: 2, Arrival Time: 1305, Exe Start time: 4793, Waiting Time: 3488
Thread Index: 6, Burst index: 2, Arrival Time: 1327, Exe Start time: 5495, Waiting Time: 4168
Thread Index: 3, Burst index: 2, Arrival Time: 1359, Exe Start time: 6007, Waiting Time: 4648
Thread Index: 5, Burst index: 2, Arrival Time: 1394, Exe Start time: 6555, Waiting Time: 5161
Thread Index: 2, Burst index: 2, Arrival Time: 1694, Exe Start time: 7289, Waiting Time: 5595
Thread Index: 4, Burst index: 2, Arrival Time: 1747, Exe Start time: 8356, Waiting Time: 6609
Thread Index: 6, Burst index: 3, Arrival Time: 1958, Exe Start time: 8859, Waiting Time: 6901
Thread Index: 1, Burst index: 3, Arrival Time: 2043, Exe Start time: 9393, Waiting Time: 7350
Thread Index: 3, Burst index: 3, Arrival Time: 2097, Exe Start time: 9925, Waiting Time: 7828
Thread Index: 7, Burst index: 2, Arrival Time: 2102, Exe Start time: 10440, Waiting Time: 8338
Thread Index: 2, Burst index: 3, Arrival Time: 2370, Exe Start time: 11076, Waiting Time: 8706
Thread Index: 4, Burst index: 3, Arrival Time: 2415, Exe Start time: 11664, Waiting Time: 9249
Thread Index: 3, Burst index: 4, Arrival Time: 2709, Exe Start time: 12314, Waiting Time: 9605
Thread Index: 7, Burst index: 3, Arrival Time: 2921, Exe Start time: 13667, Waiting Time: 10746
Thread Index: 6, Burst index: 4, Arrival Time: 2939, Exe Start time: 14337, Waiting Time: 11398
Thread Index: 5, Burst index: 3, Arrival Time: 3138, Exe Start time: 15405, Waiting Time: 12267
Thread Index: 1, Burst index: 4, Arrival Time: 3281, Exe Start time: 15976, Waiting Time: 12695
Thread Index: 3, Burst index: 5, Arrival Time: 3356, Exe Start time: 17162, Waiting Time: 13806
Thread Index: 4, Burst index: 4, Arrival Time: 3387, Exe Start time: 17669, Waiting Time: 14282
Thread Index: 7, Burst index: 4, Arrival Time: 3544, Exe Start time: 18275, Waiting Time: 14731
Thread Index: 6, Burst index: 5, Arrival Time: 3715, Exe Start time: 19049, Waiting Time: 15334
Thread Index: 2, Burst index: 4, Arrival Time: 3785, Exe Start time: 19806, Waiting Time: 16021
Thread Index: 5, Burst index: 4, Arrival Time: 3866, Exe Start time: 20443, Waiting Time: 16577
Thread Index: 4, Burst index: 5, Arrival Time: 4044, Exe Start time: 21010, Waiting Time: 16966
Thread Index: 1, Burst index: 5, Arrival Time: 4269, Exe Start time: 21569, Waiting Time: 17300
Thread Index: 7, Burst index: 5, Arrival Time: 4495, Exe Start time: 22401, Waiting Time: 17906
Thread Index: 5, Burst index: 5, Arrival Time: 4578, Exe Start time: 23061, Waiting Time: 18483
Thread Index: 2, Burst index: 5, Arrival Time: 5357, Exe Start time: 23869, Waiting Time: 18512

Average waiting time: 9304.342857

**Effect of Thread count to the waiting time when the mode is SJF
(N will change):**

N = 3 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 1, Burst index: 1, Arrival Time: 637, Exe Start time: 637, Waiting Time: 0
Thread Index: 3, Burst index: 1, Arrival Time: 870, Exe Start time: 1146, Waiting Time: 276
Thread Index: 3, Burst index: 2, Arrival Time: 1591, Exe Start time: 1715, Waiting Time: 124
Thread Index: 1, Burst index: 2, Arrival Time: 1494, Exe Start time: 2232, Waiting Time: 738
Thread Index: 3, Burst index: 3, Arrival Time: 2269, Exe Start time: 2757, Waiting Time: 488
Thread Index: 3, Burst index: 4, Arrival Time: 3046, Exe Start time: 3444, Waiting Time: 398
Thread Index: 1, Burst index: 3, Arrival Time: 2932, Exe Start time: 4018, Waiting Time: 1086
Thread Index: 3, Burst index: 5, Arrival Time: 4475, Exe Start time: 4712, Waiting Time: 237
Thread Index: 1, Burst index: 4, Arrival Time: 4130, Exe Start time: 5417, Waiting Time: 1287
Thread Index: 2, Burst index: 5, Arrival Time: 5493, Exe Start time: 6222, Waiting Time: 729
Thread Index: 1, Burst index: 5, Arrival Time: 5089, Exe Start time: 6723, Waiting Time: 1634
Thread Index: 2, Burst index: 1, Arrival Time: 637, Exe Start time: 7585, Waiting Time: 6948
Thread Index: 2, Burst index: 2, Arrival Time: 1261, Exe Start time: 8551, Waiting Time: 7290
Thread Index: 2, Burst index: 3, Arrival Time: 2524, Exe Start time: 9229, Waiting Time: 6705
Thread Index: 2, Burst index: 4, Arrival Time: 3737, Exe Start time: 10026, Waiting Time: 6289

Average waiting time: 2281.933333

N = 5 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 1, Burst index: 1, Arrival Time: 647, Exe Start time: 647, Waiting Time: 0
Thread Index: 1, Burst index: 2, Arrival Time: 1322, Exe Start time: 1326, Waiting Time: 4
Thread Index: 4, Burst index: 1, Arrival Time: 1458, Exe Start time: 1878, Waiting Time: 420
Thread Index: 3, Burst index: 2, Arrival Time: 1920, Exe Start time: 2393, Waiting Time: 473
Thread Index: 2, Burst index: 2, Arrival Time: 2736, Exe Start time: 3008, Waiting Time: 272
Thread Index: 1, Burst index: 4, Arrival Time: 2702, Exe Start time: 3521, Waiting Time: 819
Thread Index: 3, Burst index: 4, Arrival Time: 3655, Exe Start time: 4042, Waiting Time: 387
Thread Index: 3, Burst index: 5, Arrival Time: 4261, Exe Start time: 4584, Waiting Time: 323
Thread Index: 2, Burst index: 4, Arrival Time: 4316, Exe Start time: 5102, Waiting Time: 786
Thread Index: 2, Burst index: 5, Arrival Time: 4988, Exe Start time: 5658, Waiting Time: 670
Thread Index: 4, Burst index: 3, Arrival Time: 4755, Exe Start time: 6206, Waiting Time: 1451
Thread Index: 5, Burst index: 1, Arrival Time: 1193, Exe Start time: 6816, Waiting Time: 5623
Thread Index: 5, Burst index: 4, Arrival Time: 3164, Exe Start time: 7456, Waiting Time: 4292
Thread Index: 3, Burst index: 1, Arrival Time: 654, Exe Start time: 8087, Waiting Time: 7433
Thread Index: 2, Burst index: 3, Arrival Time: 3659, Exe Start time: 8736, Waiting Time: 5077
Thread Index: 5, Burst index: 3, Arrival Time: 2532, Exe Start time: 9403, Waiting Time: 6871
Thread Index: 5, Burst index: 5, Arrival Time: 4021, Exe Start time: 10118, Waiting Time: 6097
Thread Index: 1, Burst index: 3, Arrival Time: 2001, Exe Start time: 10803, Waiting Time: 8802
Thread Index: 5, Burst index: 2, Arrival Time: 1870, Exe Start time: 11527, Waiting Time: 9657
Thread Index: 1, Burst index: 5, Arrival Time: 3522, Exe Start time: 12263, Waiting Time: 8741
Thread Index: 4, Burst index: 2, Arrival Time: 3748, Exe Start time: 13037, Waiting Time: 9289
Thread Index: 4, Burst index: 4, Arrival Time: 5506, Exe Start time: 13934, Waiting Time: 8428
Thread Index: 2, Burst index: 1, Arrival Time: 1963, Exe Start time: 14737, Waiting Time: 12774
Thread Index: 4, Burst index: 5, Arrival Time: 6585, Exe Start time: 15706, Waiting Time: 9121
Thread Index: 3, Burst index: 3, Arrival Time: 2603, Exe Start time: 17018, Waiting Time: 14415

Average waiting time: 4889.000000

N = 7 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 2, Burst index: 1, Arrival Time: 723, Exe Start time: 723, Waiting Time: 0
Thread Index: 3, Burst index: 1, Arrival Time: 897, Exe Start time: 1333, Waiting Time: 436
Thread Index: 4, Burst index: 1, Arrival Time: 937, Exe Start time: 1843, Waiting Time: 906
Thread Index: 6, Burst index: 2, Arrival Time: 1885, Exe Start time: 2353, Waiting Time: 468
Thread Index: 7, Burst index: 1, Arrival Time: 906, Exe Start time: 2875, Waiting Time: 1969
Thread Index: 6, Burst index: 3, Arrival Time: 3166, Exe Start time: 3434, Waiting Time: 268
Thread Index: 2, Burst index: 3, Arrival Time: 3170, Exe Start time: 3942, Waiting Time: 772
Thread Index: 4, Burst index: 4, Arrival Time: 4001, Exe Start time: 4463, Waiting Time: 462
Thread Index: 7, Burst index: 5, Arrival Time: 4077, Exe Start time: 4969, Waiting Time: 892
Thread Index: 2, Burst index: 4, Arrival Time: 4771, Exe Start time: 5486, Waiting Time: 715
Thread Index: 4, Burst index: 5, Arrival Time: 4725, Exe Start time: 6018, Waiting Time: 1293
Thread Index: 1, Burst index: 5, Arrival Time: 4215, Exe Start time: 6557, Waiting Time: 2342
Thread Index: 2, Burst index: 5, Arrival Time: 5423, Exe Start time: 7100, Waiting Time: 1677
Thread Index: 3, Burst index: 5, Arrival Time: 3803, Exe Start time: 7662, Waiting Time: 3859
Thread Index: 7, Burst index: 2, Arrival Time: 1610, Exe Start time: 8228, Waiting Time: 6618
Thread Index: 6, Burst index: 5, Arrival Time: 4471, Exe Start time: 8804, Waiting Time: 4333
Thread Index: 1, Burst index: 1, Arrival Time: 936, Exe Start time: 9382, Waiting Time: 8446
Thread Index: 1, Burst index: 2, Arrival Time: 1727, Exe Start time: 9980, Waiting Time: 8253
Thread Index: 1, Burst index: 3, Arrival Time: 2726, Exe Start time: 10601, Waiting Time: 7875
Thread Index: 2, Burst index: 2, Arrival Time: 1331, Exe Start time: 11225, Waiting Time: 9894
Thread Index: 3, Burst index: 3, Arrival Time: 2241, Exe Start time: 11849, Waiting Time: 9608
Thread Index: 4, Burst index: 3, Arrival Time: 2913, Exe Start time: 12477, Waiting Time: 9564
Thread Index: 6, Burst index: 1, Arrival Time: 900, Exe Start time: 13107, Waiting Time: 12207
Thread Index: 6, Burst index: 4, Arrival Time: 3844, Exe Start time: 13751, Waiting Time: 9907
Thread Index: 3, Burst index: 4, Arrival Time: 2917, Exe Start time: 14413, Waiting Time: 11496
Thread Index: 5, Burst index: 2, Arrival Time: 1703, Exe Start time: 15096, Waiting Time: 13393
Thread Index: 5, Burst index: 3, Arrival Time: 2341, Exe Start time: 15781, Waiting Time: 13440
Thread Index: 3, Burst index: 2, Arrival Time: 1567, Exe Start time: 16446, Waiting Time: 14879
Thread Index: 1, Burst index: 4, Arrival Time: 3478, Exe Start time: 17141, Waiting Time: 13663
Thread Index: 7, Burst index: 3, Arrival Time: 2549, Exe Start time: 17838, Waiting Time: 15289
Thread Index: 5, Burst index: 1, Arrival Time: 1005, Exe Start time: 18593, Waiting Time: 17588
Thread Index: 4, Burst index: 2, Arrival Time: 2207, Exe Start time: 19385, Waiting Time: 17178
Thread Index: 7, Burst index: 4, Arrival Time: 3227, Exe Start time: 20379, Waiting Time: 17152
Thread Index: 5, Burst index: 4, Arrival Time: 3215, Exe Start time: 21428, Waiting Time: 18213
Thread Index: 5, Burst index: 5, Arrival Time: 4576, Exe Start time: 22721, Waiting Time: 18145

Average waiting time: 7805.714286

Effect of Thread count to the waiting time when the mode is PRIO (N will change):

N = 3 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 1, Burst index: 1, Arrival Time: 646, Exe Start time: 647, Waiting Time: 1
Thread Index: 2, Burst index: 1, Arrival Time: 659, Exe Start time: 1317, Waiting Time: 658
Thread Index: 1, Burst index: 2, Arrival Time: 1630, Exe Start time: 1924, Waiting Time: 294
Thread Index: 1, Burst index: 3, Arrival Time: 2290, Exe Start time: 2450, Waiting Time: 160
Thread Index: 1, Burst index: 4, Arrival Time: 2958, Exe Start time: 3019, Waiting Time: 61
Thread Index: 2, Burst index: 2, Arrival Time: 1572, Exe Start time: 3701, Waiting Time: 2129
Thread Index: 1, Burst index: 5, Arrival Time: 3728, Exe Start time: 4316, Waiting Time: 588
Thread Index: 2, Burst index: 3, Arrival Time: 2907, Exe Start time: 4829, Waiting Time: 1922
Thread Index: 2, Burst index: 4, Arrival Time: 3518, Exe Start time: 5396, Waiting Time: 1878
Thread Index: 2, Burst index: 5, Arrival Time: 4409, Exe Start time: 5902, Waiting Time: 1493
Thread Index: 3, Burst index: 1, Arrival Time: 842, Exe Start time: 6482, Waiting Time: 5640
Thread Index: 3, Burst index: 2, Arrival Time: 1509, Exe Start time: 6993, Waiting Time: 5484
Thread Index: 3, Burst index: 3, Arrival Time: 2277, Exe Start time: 7547, Waiting Time: 5270
Thread Index: 3, Burst index: 4, Arrival Time: 3174, Exe Start time: 8682, Waiting Time: 5508
Thread Index: 3, Burst index: 5, Arrival Time: 4334, Exe Start time: 9310, Waiting Time: 4976

Average waiting time: 2404.133333

N = 5 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 2, Burst index: 1, Arrival Time: 628, Exe Start time: 628, Waiting Time: 0
Thread Index: 1, Burst index: 1, Arrival Time: 724, Exe Start time: 1710, Waiting Time: 986
Thread Index: 1, Burst index: 2, Arrival Time: 1421, Exe Start time: 2394, Waiting Time: 973
Thread Index: 1, Burst index: 3, Arrival Time: 2260, Exe Start time: 2913, Waiting Time: 653
Thread Index: 1, Burst index: 4, Arrival Time: 3184, Exe Start time: 3825, Waiting Time: 641
Thread Index: 1, Burst index: 5, Arrival Time: 4063, Exe Start time: 4367, Waiting Time: 304
Thread Index: 2, Burst index: 2, Arrival Time: 1337, Exe Start time: 5115, Waiting Time: 3778
Thread Index: 2, Burst index: 3, Arrival Time: 1973, Exe Start time: 5916, Waiting Time: 3943
Thread Index: 2, Burst index: 4, Arrival Time: 3454, Exe Start time: 7014, Waiting Time: 3560
Thread Index: 2, Burst index: 5, Arrival Time: 4871, Exe Start time: 7655, Waiting Time: 2784
Thread Index: 3, Burst index: 1, Arrival Time: 788, Exe Start time: 8465, Waiting Time: 7677
Thread Index: 3, Burst index: 2, Arrival Time: 1459, Exe Start time: 9028, Waiting Time: 7569
Thread Index: 3, Burst index: 3, Arrival Time: 2080, Exe Start time: 9552, Waiting Time: 7472
Thread Index: 3, Burst index: 4, Arrival Time: 3698, Exe Start time: 10110, Waiting Time: 6412
Thread Index: 3, Burst index: 5, Arrival Time: 4485, Exe Start time: 10638, Waiting Time: 6153
Thread Index: 4, Burst index: 1, Arrival Time: 790, Exe Start time: 11620, Waiting Time: 10830
Thread Index: 4, Burst index: 2, Arrival Time: 1441, Exe Start time: 12296, Waiting Time: 10855
Thread Index: 4, Burst index: 3, Arrival Time: 2286, Exe Start time: 12829, Waiting Time: 10543
Thread Index: 4, Burst index: 4, Arrival Time: 3673, Exe Start time: 13462, Waiting Time: 9789
Thread Index: 4, Burst index: 5, Arrival Time: 5138, Exe Start time: 14266, Waiting Time: 9128
Thread Index: 5, Burst index: 1, Arrival Time: 790, Exe Start time: 14810, Waiting Time: 14020
Thread Index: 5, Burst index: 2, Arrival Time: 1841, Exe Start time: 15664, Waiting Time: 13823
Thread Index: 5, Burst index: 3, Arrival Time: 2815, Exe Start time: 16173, Waiting Time: 13358
Thread Index: 5, Burst index: 4, Arrival Time: 3551, Exe Start time: 17078, Waiting Time: 13527
Thread Index: 5, Burst index: 5, Arrival Time: 4459, Exe Start time: 17687, Waiting Time: 13228

Average waiting time: 6880.240000

N = 7 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 5, Burst index: 1, Arrival Time: 622, Exe Start time: 622, Waiting Time: 0
Thread Index: 1, Burst index: 1, Arrival Time: 745, Exe Start time: 1156, Waiting Time: 411
Thread Index: 1, Burst index: 2, Arrival Time: 1495, Exe Start time: 1659, Waiting Time: 164
Thread Index: 2, Burst index: 1, Arrival Time: 1365, Exe Start time: 2375, Waiting Time: 1010
Thread Index: 1, Burst index: 3, Arrival Time: 2386, Exe Start time: 3068, Waiting Time: 682
Thread Index: 1, Burst index: 4, Arrival Time: 3374, Exe Start time: 3604, Waiting Time: 230
Thread Index: 2, Burst index: 2, Arrival Time: 2049, Exe Start time: 4190, Waiting Time: 2141
Thread Index: 1, Burst index: 5, Arrival Time: 4316, Exe Start time: 5039, Waiting Time: 723
Thread Index: 2, Burst index: 3, Arrival Time: 2853, Exe Start time: 5786, Waiting Time: 2933
Thread Index: 2, Burst index: 4, Arrival Time: 3709, Exe Start time: 6581, Waiting Time: 2872
Thread Index: 2, Burst index: 5, Arrival Time: 5231, Exe Start time: 7339, Waiting Time: 2108
Thread Index: 3, Burst index: 1, Arrival Time: 644, Exe Start time: 7960, Waiting Time: 7316
Thread Index: 3, Burst index: 2, Arrival Time: 1695, Exe Start time: 8515, Waiting Time: 6820
Thread Index: 3, Burst index: 3, Arrival Time: 2636, Exe Start time: 9132, Waiting Time: 6496
Thread Index: 3, Burst index: 4, Arrival Time: 3682, Exe Start time: 9644, Waiting Time: 5962
Thread Index: 3, Burst index: 5, Arrival Time: 4985, Exe Start time: 10195, Waiting Time: 5210
Thread Index: 4, Burst index: 1, Arrival Time: 771, Exe Start time: 10779, Waiting Time: 10008
Thread Index: 4, Burst index: 2, Arrival Time: 1377, Exe Start time: 11700, Waiting Time: 10323
Thread Index: 4, Burst index: 3, Arrival Time: 2258, Exe Start time: 12225, Waiting Time: 9967
Thread Index: 4, Burst index: 4, Arrival Time: 3111, Exe Start time: 13099, Waiting Time: 9988
Thread Index: 4, Burst index: 5, Arrival Time: 3749, Exe Start time: 13612, Waiting Time: 9863
Thread Index: 5, Burst index: 2, Arrival Time: 1435, Exe Start time: 14341, Waiting Time: 12906
Thread Index: 5, Burst index: 3, Arrival Time: 2206, Exe Start time: 15019, Waiting Time: 12813
Thread Index: 5, Burst index: 4, Arrival Time: 3242, Exe Start time: 16047, Waiting Time: 12805
Thread Index: 5, Burst index: 5, Arrival Time: 4712, Exe Start time: 16658, Waiting Time: 11946
Thread Index: 6, Burst index: 1, Arrival Time: 639, Exe Start time: 17204, Waiting Time: 16565
Thread Index: 6, Burst index: 2, Arrival Time: 1360, Exe Start time: 17898, Waiting Time: 16538
Thread Index: 6, Burst index: 3, Arrival Time: 2302, Exe Start time: 18479, Waiting Time: 16177
Thread Index: 6, Burst index: 4, Arrival Time: 3407, Exe Start time: 19036, Waiting Time: 15629
Thread Index: 6, Burst index: 5, Arrival Time: 4069, Exe Start time: 19868, Waiting Time: 15799
Thread Index: 7, Burst index: 1, Arrival Time: 662, Exe Start time: 20970, Waiting Time: 20308
Thread Index: 7, Burst index: 2, Arrival Time: 1358, Exe Start time: 21817, Waiting Time: 20459
Thread Index: 7, Burst index: 3, Arrival Time: 2076, Exe Start time: 22712, Waiting Time: 20636
Thread Index: 7, Burst index: 4, Arrival Time: 2713, Exe Start time: 23344, Waiting Time: 20631
Thread Index: 7, Burst index: 5, Arrival Time: 3372, Exe Start time: 24362, Waiting Time: 20990

Average waiting time: 9412.257143

Effect of Thread count to the waiting time when the mode is VRUNTIME (N will change):

N = 3 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 2, Burst index: 1, Arrival Time: 778, Exe Start time: 778, Waiting Time: 0
Thread Index: 1, Burst index: 1, Arrival Time: 789, Exe Start time: 1341, Waiting Time: 552
Thread Index: 3, Burst index: 1, Arrival Time: 1025, Exe Start time: 1886, Waiting Time: 861
Thread Index: 1, Burst index: 2, Arrival Time: 1970, Exe Start time: 2424, Waiting Time: 454
Thread Index: 2, Burst index: 2, Arrival Time: 1491, Exe Start time: 3089, Waiting Time: 1598
Thread Index: 3, Burst index: 2, Arrival Time: 1819, Exe Start time: 3744, Waiting Time: 1925
Thread Index: 1, Burst index: 3, Arrival Time: 2572, Exe Start time: 4384, Waiting Time: 1812
Thread Index: 2, Burst index: 3, Arrival Time: 2444, Exe Start time: 5006, Waiting Time: 2562
Thread Index: 1, Burst index: 4, Arrival Time: 3298, Exe Start time: 5546, Waiting Time: 2248
Thread Index: 3, Burst index: 3, Arrival Time: 2625, Exe Start time: 6118, Waiting Time: 3493
Thread Index: 2, Burst index: 4, Arrival Time: 3111, Exe Start time: 6885, Waiting Time: 3774
Thread Index: 1, Burst index: 5, Arrival Time: 3926, Exe Start time: 7940, Waiting Time: 4014
Thread Index: 3, Burst index: 4, Arrival Time: 3327, Exe Start time: 8558, Waiting Time: 5231
Thread Index: 2, Burst index: 5, Arrival Time: 3767, Exe Start time: 9146, Waiting Time: 5379
Thread Index: 3, Burst index: 5, Arrival Time: 4213, Exe Start time: 9689, Waiting Time: 5476

Average waiting time: 2625.266667

N = 5 Bcount = 5 minB = 500 avgB = 200 minA = 600 avgA = 300

Thread Index: 2, Burst index: 1, Arrival Time: 626, Exe Start time: 626, Waiting Time: 0
Thread Index: 1, Burst index: 1, Arrival Time: 931, Exe Start time: 1314, Waiting Time: 383
Thread Index: 3, Burst index: 1, Arrival Time: 869, Exe Start time: 1827, Waiting Time: 958
Thread Index: 4, Burst index: 1, Arrival Time: 1190, Exe Start time: 2346, Waiting Time: 1156
Thread Index: 5, Burst index: 1, Arrival Time: 628, Exe Start time: 2875, Waiting Time: 2247
Thread Index: 1, Burst index: 2, Arrival Time: 1741, Exe Start time: 3610, Waiting Time: 1869
Thread Index: 3, Burst index: 2, Arrival Time: 3397, Exe Start time: 4471, Waiting Time: 1074
Thread Index: 2, Burst index: 2, Arrival Time: 1359, Exe Start time: 5135, Waiting Time: 3776
Thread Index: 4, Burst index: 2, Arrival Time: 1980, Exe Start time: 5827, Waiting Time: 3847
Thread Index: 1, Burst index: 3, Arrival Time: 2377, Exe Start time: 6588, Waiting Time: 4211
Thread Index: 5, Burst index: 2, Arrival Time: 1262, Exe Start time: 7550, Waiting Time: 6288
Thread Index: 2, Burst index: 3, Arrival Time: 1992, Exe Start time: 8223, Waiting Time: 6231
Thread Index: 3, Burst index: 3, Arrival Time: 4114, Exe Start time: 9155, Waiting Time: 5041
Thread Index: 1, Burst index: 4, Arrival Time: 3237, Exe Start time: 9697, Waiting Time: 6460
Thread Index: 4, Burst index: 3, Arrival Time: 3064, Exe Start time: 10468, Waiting Time: 7404
Thread Index: 3, Burst index: 4, Arrival Time: 4736, Exe Start time: 11050, Waiting Time: 6314
Thread Index: 2, Burst index: 4, Arrival Time: 2604, Exe Start time: 11832, Waiting Time: 9228
Thread Index: 5, Burst index: 3, Arrival Time: 1981, Exe Start time: 12336, Waiting Time: 10355
Thread Index: 1, Burst index: 5, Arrival Time: 4227, Exe Start time: 13128, Waiting Time: 8901
Thread Index: 4, Burst index: 4, Arrival Time: 3701, Exe Start time: 13799, Waiting Time: 10098
Thread Index: 2, Burst index: 5, Arrival Time: 4044, Exe Start time: 14428, Waiting Time: 10384
Thread Index: 5, Burst index: 4, Arrival Time: 3136, Exe Start time: 15367, Waiting Time: 12231
Thread Index: 5, Burst index: 5, Arrival Time: 4175, Exe Start time: 16015, Waiting Time: 11840
Thread Index: 4, Burst index: 5, Arrival Time: 4677, Exe Start time: 16774, Waiting Time: 12097
Thread Index: 3, Burst index: 5, Arrival Time: 5683, Exe Start time: 17358, Waiting Time: 11675

Average waiting time: 6162.720000

Thread Index: 6, Burst index: 1, Arrival Time: 621, Exe Start time: 621, Waiting Time: 0
Thread Index: 1, Burst index: 1, Arrival Time: 632, Exe Start time: 1356, Waiting Time: 724
Thread Index: 2, Burst index: 1, Arrival Time: 973, Exe Start time: 1914, Waiting Time: 941
Thread Index: 3, Burst index: 1, Arrival Time: 919, Exe Start time: 2869, Waiting Time: 1950
Thread Index: 4, Burst index: 1, Arrival Time: 850, Exe Start time: 3411, Waiting Time: 2561
Thread Index: 5, Burst index: 1, Arrival Time: 1073, Exe Start time: 3955, Waiting Time: 2882
Thread Index: 7, Burst index: 1, Arrival Time: 944, Exe Start time: 4729, Waiting Time: 3785
Thread Index: 1, Burst index: 2, Arrival Time: 2020, Exe Start time: 5388, Waiting Time: 3368
Thread Index: 3, Burst index: 2, Arrival Time: 2686, Exe Start time: 5941, Waiting Time: 3255
Thread Index: 4, Burst index: 2, Arrival Time: 1450, Exe Start time: 6717, Waiting Time: 5267
Thread Index: 1, Burst index: 3, Arrival Time: 2855, Exe Start time: 7338, Waiting Time: 4483
Thread Index: 2, Burst index: 2, Arrival Time: 2285, Exe Start time: 7915, Waiting Time: 5630
Thread Index: 1, Burst index: 4, Arrival Time: 4241, Exe Start time: 8425, Waiting Time: 4184
Thread Index: 5, Burst index: 2, Arrival Time: 2197, Exe Start time: 8986, Waiting Time: 6789
Thread Index: 6, Burst index: 2, Arrival Time: 2032, Exe Start time: 9942, Waiting Time: 7910
Thread Index: 7, Burst index: 2, Arrival Time: 1546, Exe Start time: 10479, Waiting Time: 8933
Thread Index: 2, Burst index: 3, Arrival Time: 2887, Exe Start time: 11738, Waiting Time: 8851
Thread Index: 3, Burst index: 3, Arrival Time: 3362, Exe Start time: 12537, Waiting Time: 9175
Thread Index: 4, Burst index: 3, Arrival Time: 2480, Exe Start time: 13534, Waiting Time: 11054
Thread Index: 1, Burst index: 5, Arrival Time: 5340, Exe Start time: 14738, Waiting Time: 9398
Thread Index: 7, Burst index: 3, Arrival Time: 2648, Exe Start time: 15284, Waiting Time: 12636
Thread Index: 6, Burst index: 3, Arrival Time: 2862, Exe Start time: 16009, Waiting Time: 13147
Thread Index: 5, Burst index: 3, Arrival Time: 3312, Exe Start time: 17012, Waiting Time: 13700
Thread Index: 4, Burst index: 4, Arrival Time: 3354, Exe Start time: 17584, Waiting Time: 14230
Thread Index: 6, Burst index: 4, Arrival Time: 3909, Exe Start time: 18680, Waiting Time: 14771
Thread Index: 3, Burst index: 4, Arrival Time: 3986, Exe Start time: 19185, Waiting Time: 15199
Thread Index: 7, Burst index: 4, Arrival Time: 4052, Exe Start time: 19747, Waiting Time: 15695
Thread Index: 4, Burst index: 5, Arrival Time: 4070, Exe Start time: 20526, Waiting Time: 16456
Thread Index: 2, Burst index: 4, Arrival Time: 4203, Exe Start time: 21037, Waiting Time: 16834
Thread Index: 5, Burst index: 4, Arrival Time: 4239, Exe Start time: 21698, Waiting Time: 17459
Thread Index: 6, Burst index: 5, Arrival Time: 4685, Exe Start time: 22215, Waiting Time: 17530
Thread Index: 7, Burst index: 5, Arrival Time: 4808, Exe Start time: 23141, Waiting Time: 18333
Thread Index: 3, Burst index: 5, Arrival Time: 4903, Exe Start time: 23734, Waiting Time: 18831
Thread Index: 2, Burst index: 5, Arrival Time: 5517, Exe Start time: 24300, Waiting Time: 18783
Thread Index: 5, Burst index: 5, Arrival Time: 5682, Exe Start time: 25145, Waiting Time: 19463

Average waiting time: 9834.485714

As can be seen from the results, the increase in the thread count makes the average waiting time increase exponentially. The best performance is seen from the SJF algorithm. The other algorithms perform similar results when these inputs are given.

When Bcount is greater, effect of minB

N = 8 Bcount = 40 minB = 500 avgB = 300 minA = 600 avgA = 300
FCFS Algorithm

   Average waiting time: 105976.284375

N = 8 Bcount = 40 minB = 250 avgB = 300 minA = 600 avgA = 300
FCFS Algorithm

   Average waiting time: 69427.112500

N = 8 Bcount = 40 minB = 150 avgB = 300 minA = 600 avgA = 300
FCFS Algorithm

   Average waiting time: 54544.550000

N = 8 Bcount = 40 minB = 500 avgB = 300 minA = 600 avgA = 300
SJF Algorithm

   Average waiting time: 86749.593750

N = 8 Bcount = 40 minB = 250 avgB = 300 minA = 600 avgA = 300
SJF Algorithm

   Average waiting time: 47018.243750

N = 8 Bcount = 40 minB = 150 avgB = 300 minA = 600 avgA = 300
SJF Algorithm

   Average waiting time: 33193.196875

The change in minB considerably decreases the average waiting time of the bursts as the exponentially distributed random values can be generated faster.

Effect of minA

N = 8 Bcount = 20 minB = 400 avgB = 300 minA = 900 avgA = 300
SJF Algorithm

    Average waiting time: 33232.143750

N = 8 Bcount = 20 minB = 400 avgB = 300 minA = 500 avgA = 300
SJF Algorithm

    Average waiting time: 35840.162500

N = 8 Bcount = 20 minB = 400 avgB = 300 minA = 300 avgA = 300
SJF Algorithm

    Average waiting time: 38921.862500

N = 8 Bcount = 20 minB = 400 avgB = 300 minA = 150 avgA = 300
SJF Algorithm

    Average waiting time: 39479.706250

As the minA decreases, the average waiting time increases. However, as can bee seen, although minA decreases exponentially, the change in average waiting time is neglectable.