CS-314 OPERATING SYSTEMS LAB-4

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1. Scheduling Schemes

We measure performance by measuring average response time, turnaround time, waiting time, penalty ratio, and system throughput. We maintain two queues – one for CPU-bound processes and another for I/O-bound processes. To run the program, first run:

```
$ g++ sjf.cpp -o sjf
```

```
$ g++ srtf.cpp -o srtf
```

Then run:

```
./sjf <path_to_data_file>
```

```
./srtf <path_to_data_file>
```

1.1 Shortest Job First (SJF)

The shortest job first algorithm initially sorts processes that have arrived in the CPU queue according to the burst time, i.e., when the arrival time is less than the time count or current time. It is non-preemptive. Once the CPU burst of a particular process is completed, it will be removed from the CPU Queue and the IO-bound process following it will be added to the IO Queue. Once the IO-bound process is completed, it will be removed from the IO Queue and the next CPU-bound process will be added to the CPU Queue. If an entire process is completed, that is when we reach -1 as given in the input file, the last CPU-bound process that was just completed will be removed from the CPU Queue and the CPU Queue will be sorted to run the process that has the least burst time among the arrived processes.

Advantages

- Used for long-term scheduling.
- Reduces average waiting time.

Disadvantages

- It is necessary to know the job completion time beforehand as it is hard to predict.
- Used for long-term scheduling in a batch system.
- Can't implement this algorithm for CPU scheduling for the short term as we can't predict the length of the upcoming CPU burst.

1.2 Shortest Remaining Time First (SRTF)

The shortest remaining time first algorithm initially sorts processes that have arrived in the CPU queue according to the burst time. It is preemptive. While a CPU-bound process is being executed, at each second (time count), we check whether a new CPU-bound process has arrived. If yes, we preempt the current process if the remaining burst time of the current process is greater than the burst time of the new incoming process. Once the CPU burst of a particular process is completed, it will be removed from the CPU Queue and the IO-bound process following it will be added to the IO Queue. Once the IO bound process is completed, it will be removed from the IO Queue and the next CPU bound process will be added to the CPU Queue and the cycle follows from Step 1. If an entire process is completed, that is we reach -1 as given in the input file, the last CPU-bound process that was just completed will be removed from the CPU Queue and the CPU Queue will be sorted to run the process which has the least burst time among the arrived processes.

Advantages

- The main advantage of the SRTF algorithm is that it makes the processing of the jobs faster than the SJF algorithm, mentioned it's overhead charges are not counted.

Disadvantages

- In SRTF, context switching is done a lot more times than in SJN due to more consumption of the CPU’s valuable time for processing. The consumed time of the CPU then adds up to its processing time and which then diminishes the advantage of fast processing of this algorithm.

2. Job characteristics of Scheduling schemes

2.1 Shortest Job First(SJF)

It is greedy and non-preemptive. It involves fewer context switches. Hence, response times tend to be high. Under SJF scheduling, jobs with shorter execution durations are done faster because the work with the shortest execution time is chosen first. SJF works on optimizing the turnaround time which leads to an increase in response time. In the SJF algorithm, the problem of starvation occurs.

2.2 Shortest Remaining Time First(SRTF)

It is greedy and preemptive. It involves more context switches. Response time is less if consecutive processes have decreasing burst times. Shorter processes are executed fast. It continuously selects the process with the shortest remaining time to execute next. This approach aims to minimize the waiting time and enhance system throughput by giving preference to processes with the least remaining computation. While STRF can provide optimal turnaround time, it may introduce additional overhead due to the need for frequent context switches. It does not optimize response time always.

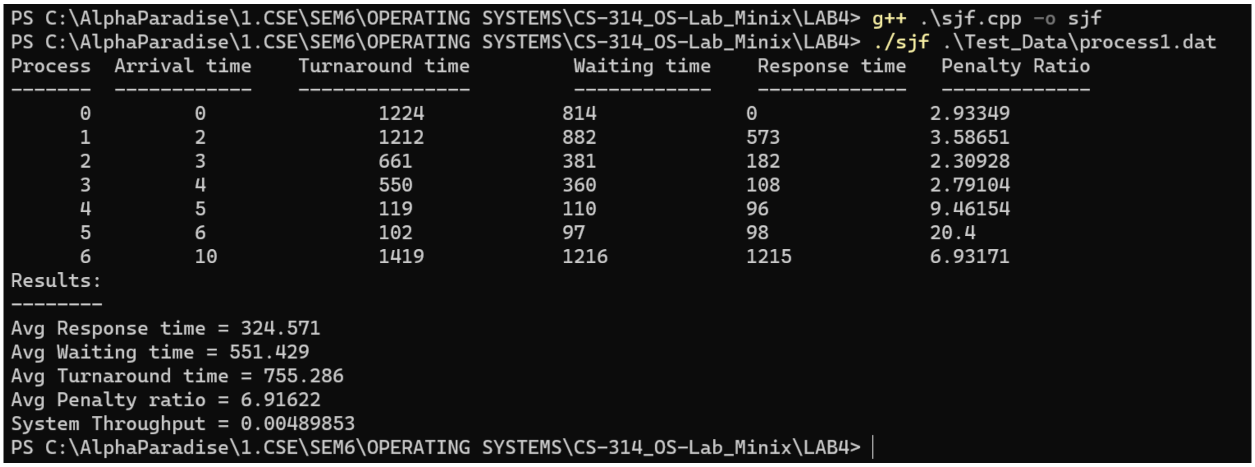
2.3 Comparison

SRTF always performs better than SJF as SJF is non-preemptive. Thus, it runs a long job which arrives first, to completion even though shorter jobs arrive later and can be completed fast. SRTF also has a disadvantage because even though a long job came first, it will be preempted if shorter jobs keep coming, which leads to a high value of completion and turnaround time. Finally, if all jobs are arriving at the same time, SJF is optimal whereas if all jobs are arriving at different times, SRTF is optimal.

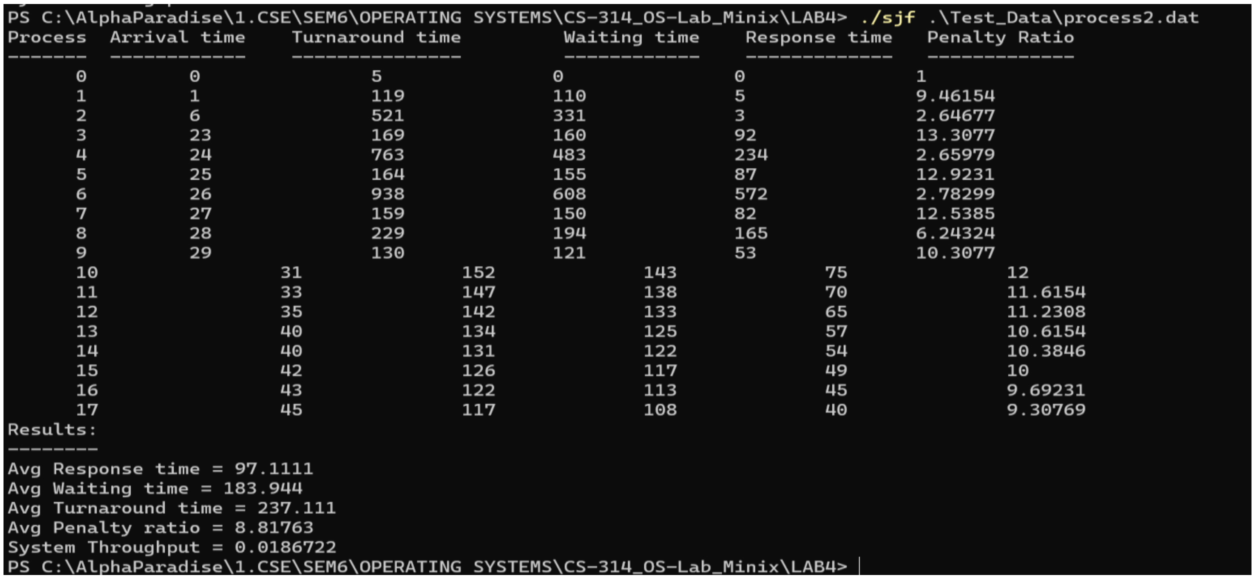
3. Performance Analysis

After running the executables with the different data files provided, we got the following results:

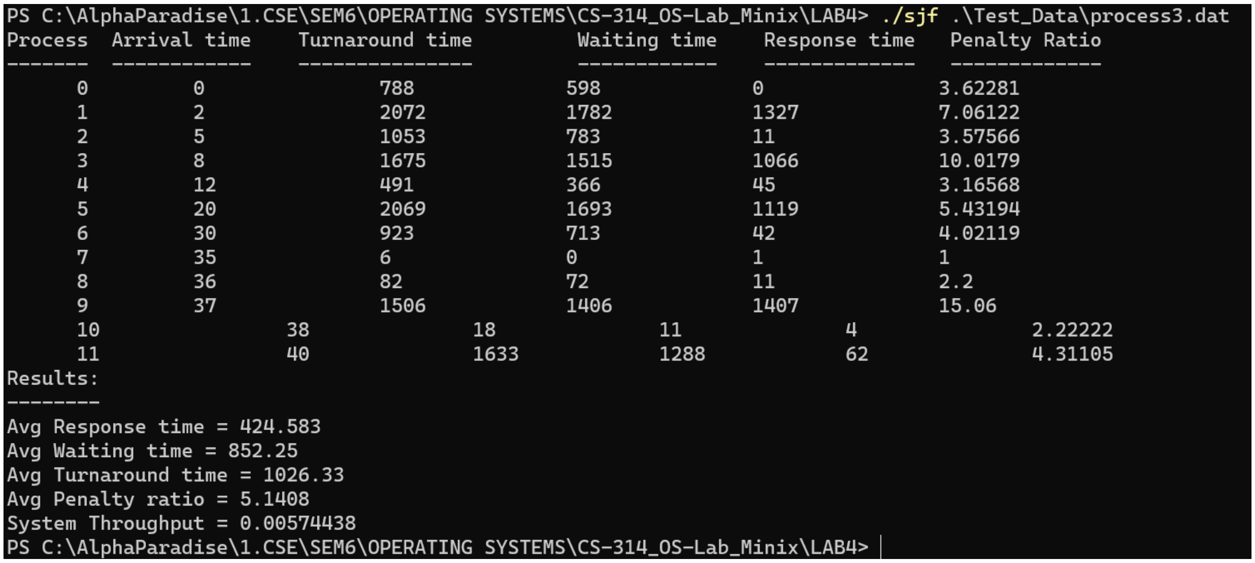
SJF:



```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> g++ .\sjf.cpp -o sjf
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./sjf .\Test_Data\process1.dat
Process  Arrival time    Turnaround time         Waiting time    Response time   Penalty Ratio
-------  ------------    ---------------         ------------    -------------   -------------
      0        0               1224            814             0               2.93349
      1        2               1212            882             573             3.58651
      2        3               661             381             182             2.30928
      3        4               550             360             108             2.79104
      4        5               119             110             96              9.46154
      5        6               102             97              98              20.4
      6        10              1419            1216            1215            6.93171
Results:
--------
Avg Response time = 324.571
Avg Waiting time = 551.429
Avg Turnaround time = 755.286
Avg Penalty ratio = 6.91622
System Throughput = 0.00489853
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> |
```

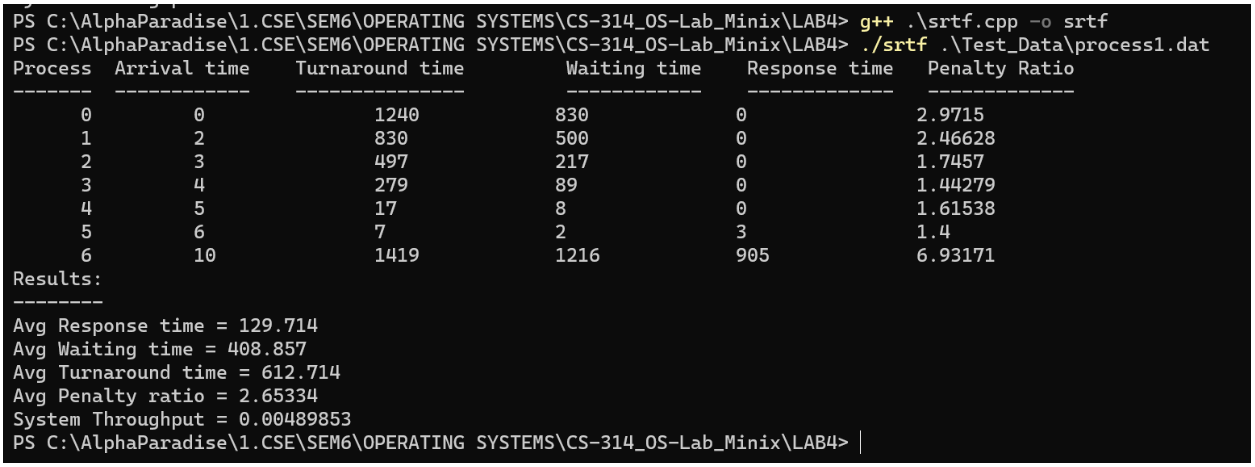


```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./sjf .\Test_Data\process2.dat
Process  Arrival time    Turnaround time         Waiting time    Response time   Penalty Ratio
-------  ------------    ---------------         ------------    -------------   -------------
      0        0               5               0               0               1
      1        1               119             110             5               9.46154
      2        6               521             331             3               2.64677
      3        23              169             160             92              13.3077
      4        24              763             483             234             2.65979
      5        25              164             155             87              12.9231
      6        26              938             608             572             2.78299
      7        27              159             150             82              12.5385
      8        28              229             194             165             6.24324
      9        29              130             121             53              10.3077
      10               31              152             143             75              12
      11               33              147             138             70              11.6154
      12               35              142             133             65              11.2308
      13               40              134             125             57              10.6154
      14               40              131             122             54              10.3846
      15               42              126             117             49              10
      16               43              122             113             45              9.69231
      17               45              117             108             40              9.30769
Results:
--------
Avg Response time = 97.1111
Avg Waiting time = 183.944
Avg Turnaround time = 237.111
Avg Penalty ratio = 8.81763
System Throughput = 0.0186722
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> |
```

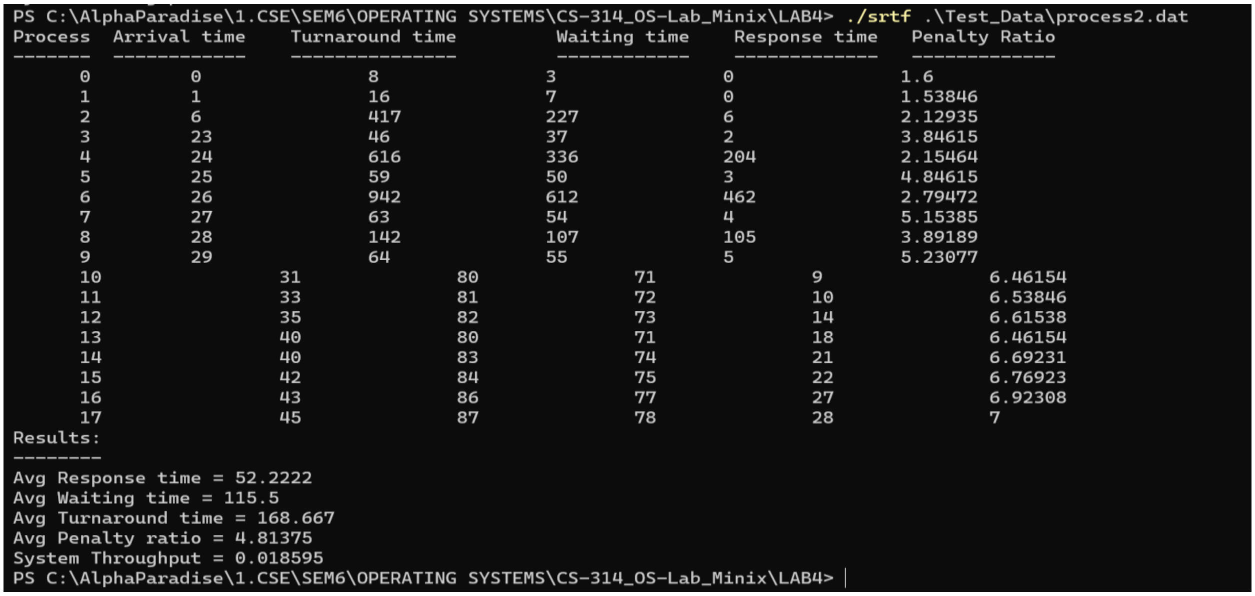


```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./sjf .\Test_Data\process3.dat
Process  Arrival time    Turnaround time         Waiting time     Response time    Penalty Ratio
-------  ------------    ---------------         ------------     -------------    -------------
      0         0              788             598              0                3.62281
      1         2              2072            1782             1327             7.06122
      2         5              1053            783              11               3.57566
      3         8              1675            1515             1066             10.0179
      4         12             491             366              45               3.16568
      5         20             2069            1693             1119             5.43194
      6         30             923             713              42               4.02119
      7         35             6               0                1                1
      8         36             82              72               11               2.2
      9         37             1506            1406             1407             15.06
      10                38              18              11               4                2.22222
      11                40              1633            1288             62               4.31105
Results:
--------
Avg Response time = 424.583
Avg Waiting time = 852.25
Avg Turnaround time = 1026.33
Avg Penalty ratio = 5.1408
System Throughput = 0.00574438
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4>
```

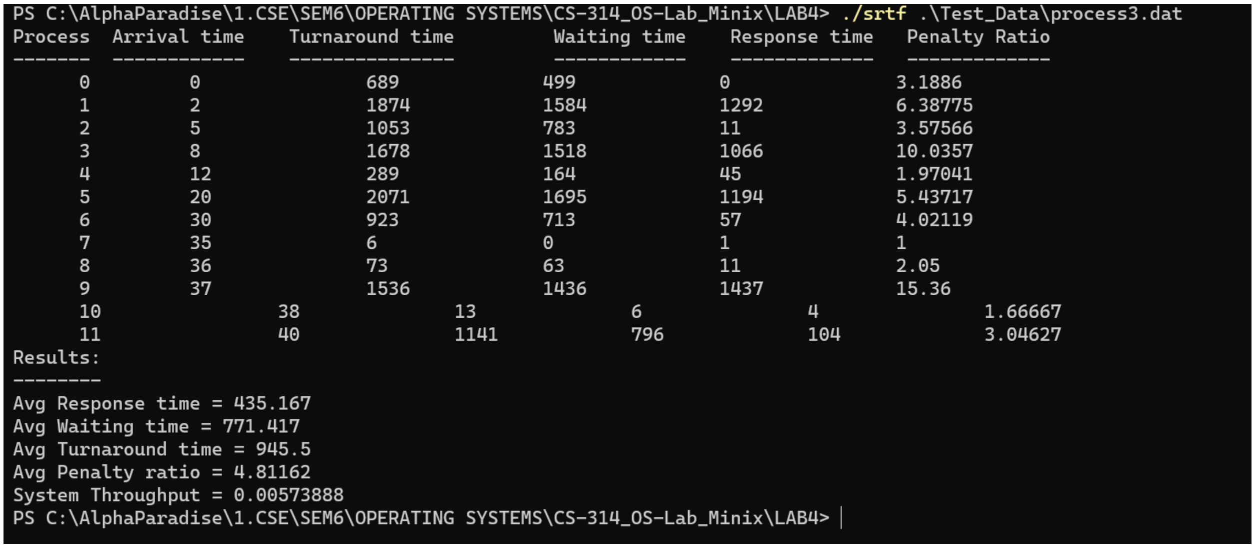
SRTF:



```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> g++ .\srtf.cpp -o srtf
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./srtf .\Test_Data\process1.dat
Process  Arrival time    Turnaround time         Waiting time     Response time    Penalty Ratio
-------  ------------    ---------------         ------------     -------------    -------------
      0         0              1240            830              0                2.9715
      1         2              830             500              0                2.46628
      2         3              497             217              0                1.7457
      3         4              279             89               0                1.44279
      4         5              17              8                0                1.61538
      5         6              7               2                3                1.4
      6         10             1419            1216             905              6.93171
Results:
--------
Avg Response time = 129.714
Avg Waiting time = 408.857
Avg Turnaround time = 612.714
Avg Penalty ratio = 2.65334
System Throughput = 0.00489853
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4>
```



```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./srtf .\Test_Data\process2.dat
Process  Arrival time    Turnaround time         Waiting time     Response time    Penalty Ratio
-------  ------------    ---------------         ------------     -------------    -------------
      0         0              8               3                0                1.6
      1         1              16              7                0                1.53846
      2         6              417             227              6                2.12935
      3         23             46              37               2                3.84615
      4         24             616             336              204              2.15464
      5         25             59              50               3                4.84615
      6         26             942             612              462              2.79472
      7         27             63              54               4                5.15385
      8         28             142             107              105              3.89189
      9         29             64              55               5                5.23077
      10                31              80              71               9                6.46154
      11                33              81              72               10               6.53846
      12                35              82              73               14               6.61538
      13                40              80              71               18               6.46154
      14                40              83              74               21               6.69231
      15                42              84              75               22               6.76923
      16                43              86              77               27               6.92308
      17                45              87              78               28               7
Results:
--------
Avg Response time = 52.2222
Avg Waiting time = 115.5
Avg Turnaround time = 168.667
Avg Penalty ratio = 4.81375
System Throughput = 0.018595
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4>
```



```
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> ./srtf .\Test_Data\process3.dat
Process  Arrival time    Turnaround time         Waiting time    Response time   Penalty Ratio
-------  ------------    ---------------         ------------    -------------   -------------
      0         0               689             499             0               3.1886
      1         2               1874            1584            1292            6.38775
      2         5               1053            783             11              3.57566
      3         8               1678            1518            1066            10.0357
      4         12              289             164             45              1.97041
      5         20              2071            1695            1194            5.43717
      6         30              923             713             57              4.02119
      7         35              6               0               1               1
      8         36              73              63              11              2.05
      9         37              1536            1436            1437            15.36
      10                38              13              6               4               1.66667
      11                40              1141            796             104             3.04627
Results:
--------
Avg Response time = 435.167
Avg Waiting time = 771.417
Avg Turnaround time = 945.5
Avg Penalty ratio = 4.81162
System Throughput = 0.00573888
PS C:\AlphaParadise\1.CSE\SEM6\OPERATING SYSTEMS\CS-314_OS-Lab_Minix\LAB4> |
```

We observed high values for all metrics in the case of SJF as compared to SRTF except system throughput, which is approximately the same for SJF and SRTF as shown below.

Data File/Process	SJF Throughput	SRTF Throughput
process1	0.00489853	0.00489853
process2	0.0186722	0.018595
process3	0.00574438	0.00573888

Suitability of SJF:

If jobs all arriving at the same time, it is proven that SJF is indeed an optimal scheduling algorithm.

Test case:
<html>
<body>
<pre>
0 100 2 90 2 80 3 70 2 60 2 10 -1
0 80 2 80 2 50 3 70 2 40 2 10 -1
0 70 2 70 2 40 3 70 2 20 2 10 -1
0 10 2 60 2 30 3 70 2 10 2 10 -1
0 3 2 3 2 3 -1
0 5 -1

```
0 200 2 3 -1
</pre></body></html>
```

Shortcoming of SJF:

If jobs all arriving at the different times, it is proven that SJF is indeed not a optimal scheduling algorithm

Test case:

```
<html>
<body>
<pre>
0 100 2 90 2 80 3 70 2 60 2 10 -1
2 80 2 80 2 50 3 70 2 40 2 10 -1
3 70 2 70 2 40 3 70 2 20 2 10 -1
4 10 2 60 2 30 3 70 2 10 2 10 -1
5 3 2 3 2 3 -1
6 5 -1
10 200 2 3 -1
</pre></body></html>
```

We observe that the turnaround time for the suitability test case is lower compared to the one of the shortcoming test case.

Suitability of SRTF:

If jobs all arriving at the different times, it is proven that SRTF is indeed an optimal scheduling algorithm.

Test case:

```
<html>
<body>
<pre>
0 100 -1
10 10 -1
10 10 -1
</pre></body></html>
```

Shortcoming Of SRTF:

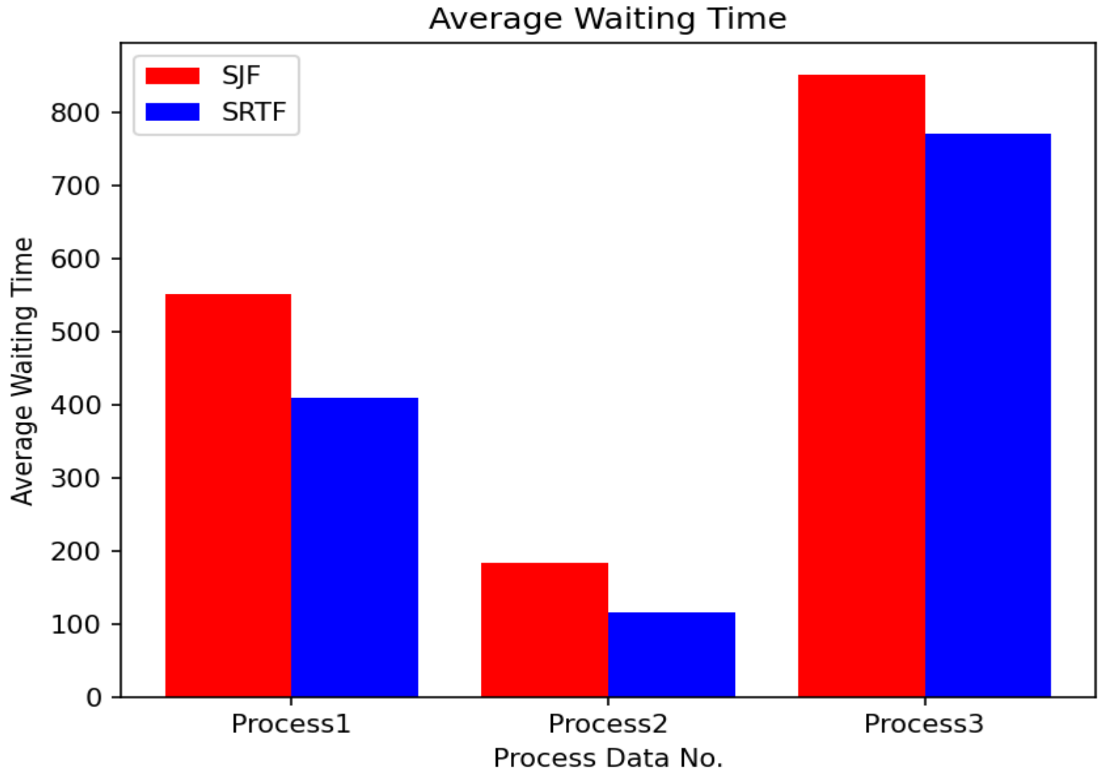
If three jobs arrive at the same time, for example, the third job has to wait for the previous two jobs to run in their entirety before being scheduled just once. While great for turnaround time, this approach is quite bad for response time and interactivity.

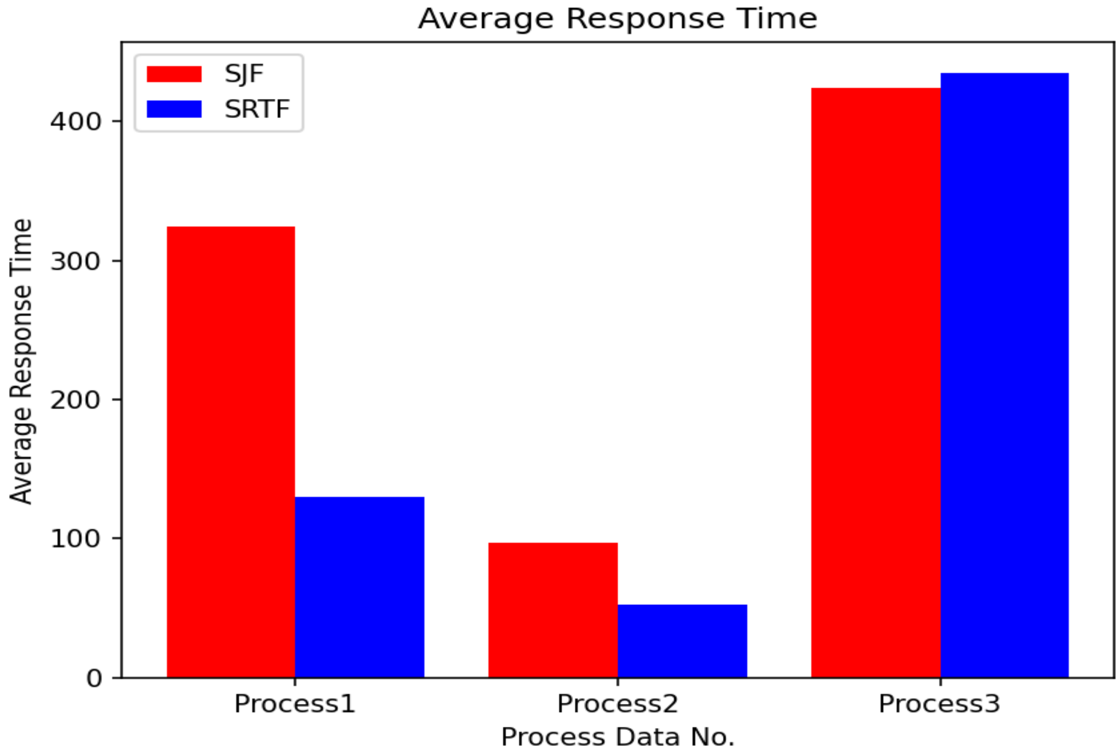
Test case:

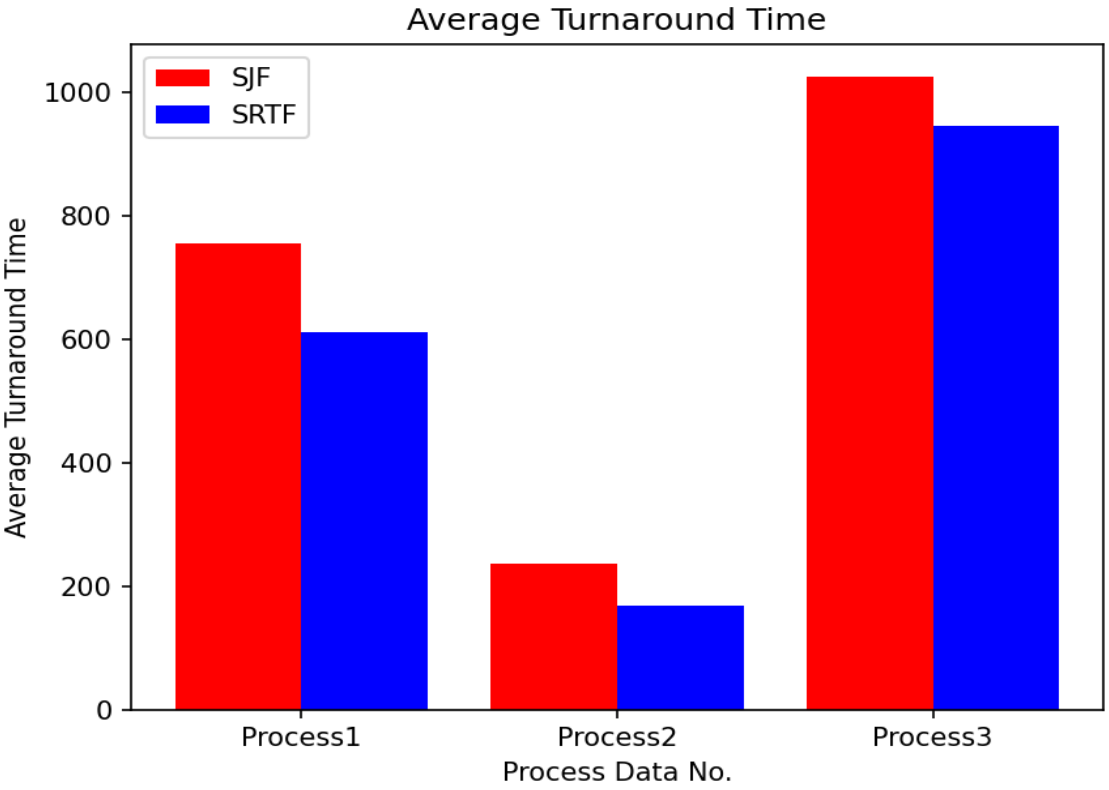
```
<html>
<body>
<pre>
0 10 -1
0 10 -1
0 10 -1
</pre></body></html>
```

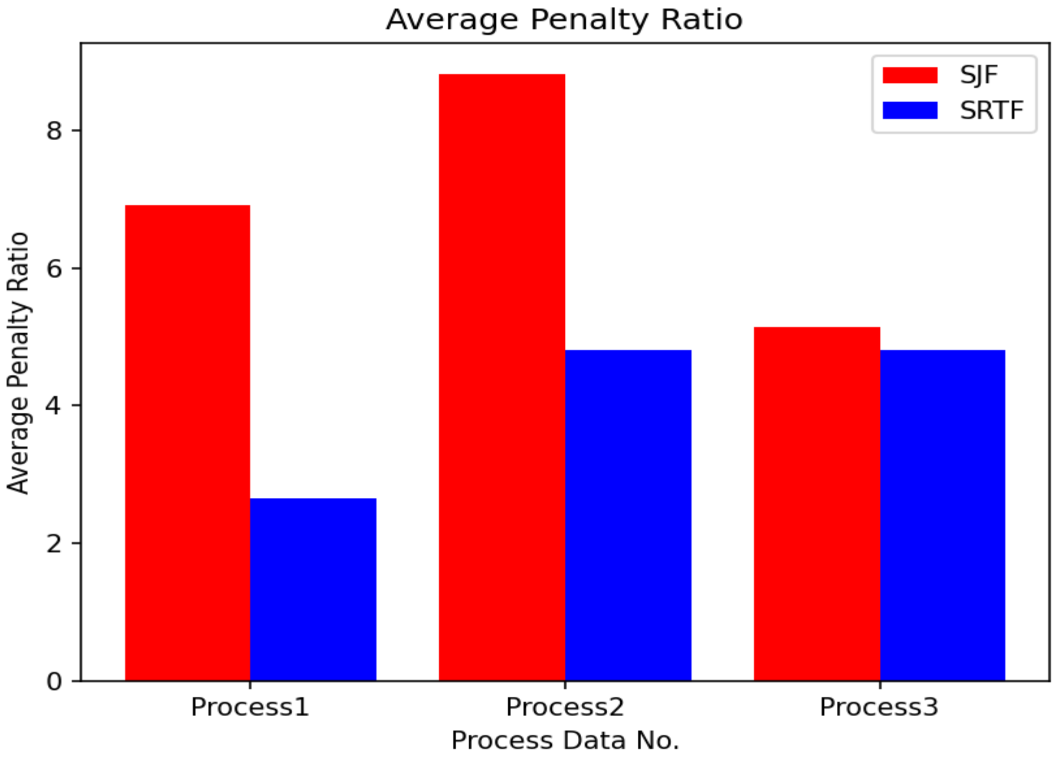
4. Plots

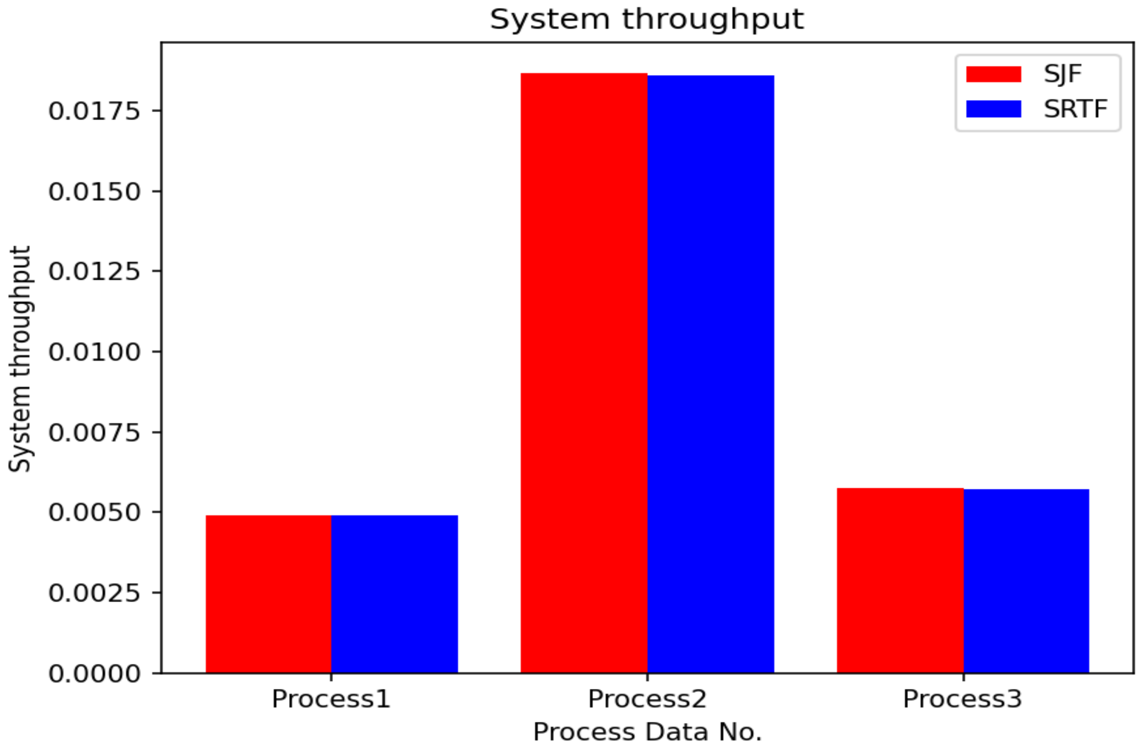
The following plots show the variation of the two algorithms in terms of waiting time, turnaround time, penalty ratio and system throughput. As we can see SRTF has less values for all these metrics(except throughput) compared to SJF. Thus, our above analysis can be verified by these plots.


Average Waiting Time
SJF
SRTF
Average Waiting Time
0
100
200
300
400
500
600
700
800
Process1
Process2
Process3
Process Data No.


Average Response Time
SJF
SRTF
Average Response Time
0
100
200
300
400
Process1
Process2
Process3
Process Data No.


Average Turnaround Time
SJF
SRTF
1000
800
600
400
200
0
Average Turnaround Time
Process1
Process2
Process3
Process Data No.


Average Penalty Ratio
SJF
SRTF
8
6
4
2
0
Average Penalty Ratio
Process1
Process2
Process3
Process Data No.


System throughput
SJF
SRTF
System throughput
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
Process1
Process2
Process3
Process Data No.