OS Scheduler Phase1

Team 1

Name	Section	Bench Number
Ahmed Nasser	1	8
Ahmed Hesham Eid	1	9
Abdelrahman Farid	1	34
Youssef Walid	2	34

Data Structures

- **Priority queue**:
  - HPF algorithm
  - SRTN algorithm
- **Circular queue**:
  - RR algorithm

Algorithm Explanation

- Process generator parses test case and gets Algorithm to be used in scheduling from the user.
- Process generator forks clock and scheduler processes and passes processes to scheduler when their arrival time comes.
- When scheduler is initialized, it loads the required algorithm interface and creates the PCB.
- Each iteration in scheduler:
  1. Checks if a new process arrived
     - Forks and add it to the PCB.
     - Insert it in the running algorithm's data structure according to it's criteria.
  2. Updates PCB if a clock cycle passed.
  3. Checks if a preemption is needed according to the running algorithm.
     - Scheduler preempts the running process.
     - Gets next process according to the running algorithm's data structure

    - Updates PCB
4. Whenever a process finishes or is launched, the algorithm tries to schedule it if it is fit, this is used instead of polling each time inside the while loop and slowing the scheduler down.

Results

Test Case

```
#id arrival runtime priority
1   9   13  7
2   16  10  2
3   18  8   5
4   28  20  5
5   38  24  10
6   43  11  7
7   45  27  3
8   47  27  3
```

HPF Results

1. scheduler.log

```
#At time x process y state arr w total z remain y wait k
At time 9 process 1 started arr 9 total 13 remain 13 wait 0
At time 22 process 1 finished arr 9 total 13 remain 0 wait 0 TA 13 WTA 1.00
At time 22 process 2 started arr 16 total 10 remain 10 wait 6
At time 32 process 2 finished arr 16 total 10 remain 0 wait 6 TA 16 WTA 1.60
At time 32 process 4 started arr 28 total 20 remain 20 wait 4
At time 52 process 4 finished arr 28 total 20 remain 0 wait 4 TA 24 WTA 1.20
At time 52 process 7 started arr 45 total 27 remain 27 wait 7
At time 79 process 7 finished arr 45 total 27 remain 0 wait 7 TA 34 WTA 1.26
At time 79 process 8 started arr 47 total 27 remain 27 wait 33
At time 106 process 8 finished arr 47 total 27 remain 0 wait 33 TA 59 WTA 2.19
At time 106 process 3 started arr 18 total 8 remain 8 wait 88
At time 114 process 3 finished arr 18 total 8 remain 0 wait 88 TA 96 WTA 12.00
At time 114 process 6 started arr 43 total 11 remain 11 wait 71
At time 125 process 6 finished arr 43 total 11 remain 0 wait 71 TA 82 WTA 7.45
At time 125 process 5 started arr 38 total 24 remain 24 wait 87
At time 149 process 5 finished arr 38 total 24 remain 0 wait 87 TA 111 WTA 4.62
```

2. scheduler.perf

```
CPU utilization = 94.63%
Avg WTA = 3.92
Avg Waiting = 37.00
Std WTA = 3.70
```

- **SRTN Results**

1. scheduler.log

```
#At time x process y state arr w total z remain y wait k
At time 9 process 1 started arr 9 total 13 remain 13 wait 0
At time 22 process 1 finished arr 9 total 13 remain 0 wait 0 TA 13 WTA 1.00
At time 22 process 3 started arr 18 total 8 remain 8 wait 4
At time 30 process 3 finished arr 18 total 8 remain 0 wait 4 TA 12 WTA 1.50
At time 30 process 2 started arr 16 total 10 remain 10 wait 14
At time 40 process 2 finished arr 16 total 10 remain 0 wait 14 TA 24 WTA 2.40
At time 40 process 4 started arr 28 total 20 remain 20 wait 12
At time 43 process 4 stopped arr 28 total 20 remain 17 wait 12
At time 43 process 6 started arr 43 total 11 remain 11 wait 0
At time 54 process 6 finished arr 43 total 11 remain 0 wait 0 TA 11 WTA 1.00
At time 54 process 4 resumed arr 28 total 20 remain 17 wait 23
At time 71 process 4 finished arr 28 total 20 remain 0 wait 23 TA 43 WTA 2.15
At time 71 process 5 started arr 38 total 24 remain 24 wait 33
At time 95 process 5 finished arr 38 total 24 remain 0 wait 33 TA 57 WTA 2.38
At time 95 process 8 started arr 47 total 27 remain 27 wait 48
At time 122 process 8 finished arr 47 total 27 remain 0 wait 48 TA 75 WTA 2.78
At time 122 process 7 started arr 45 total 27 remain 27 wait 77
At time 149 process 7 finished arr 45 total 27 remain 0 wait 77 TA 104 WTA 3.85
```

2. scheduler.perf

```
CPU utilization = 94.63%
Avg WTA = 2.13
Avg Waiting = 24.88
Std WTA = 0.90
```

- **RR with Q=2 Results**

1. scheduler.log

```
#At time x process y state arr w total z remain y wait k
At time 9 process 1 started arr 9 total 13 remain 13 wait 0
At time 17 process 1 stopped arr 9 total 13 remain 5 wait 0
At time 17 process 2 started arr 16 total 10 remain 10 wait 1
At time 19 process 2 stopped arr 16 total 10 remain 8 wait 1
At time 19 process 1 resumed arr 9 total 13 remain 5 wait 2
At time 21 process 1 stopped arr 9 total 13 remain 3 wait 2
At time 21 process 3 started arr 18 total 8 remain 8 wait 3
At time 23 process 3 stopped arr 18 total 8 remain 6 wait 3
At time 23 process 2 resumed arr 16 total 10 remain 8 wait 5
At time 25 process 2 stopped arr 16 total 10 remain 6 wait 5
At time 25 process 1 resumed arr 9 total 13 remain 3 wait 6
At time 27 process 1 stopped arr 9 total 13 remain 1 wait 6
At time 27 process 3 resumed arr 18 total 8 remain 6 wait 7
At time 29 process 3 stopped arr 18 total 8 remain 4 wait 7
At time 29 process 2 resumed arr 16 total 10 remain 6 wait 9
At time 31 process 2 stopped arr 16 total 10 remain 4 wait 9
At time 31 process 1 resumed arr 9 total 13 remain 1 wait 10
At time 32 process 1 finished arr 9 total 13 remain 0 wait 10 TA 23 WTA 1.77
At time 32 process 4 started arr 28 total 20 remain 20 wait 5
At time 34 process 4 stopped arr 28 total 20 remain 18 wait 5
At time 34 process 3 resumed arr 18 total 8 remain 4 wait 12
At time 36 process 3 stopped arr 18 total 8 remain 2 wait 12
At time 36 process 2 resumed arr 16 total 10 remain 4 wait 14
At time 38 process 2 stopped arr 16 total 10 remain 2 wait 14
At time 38 process 4 resumed arr 28 total 20 remain 18 wait 9
At time 40 process 4 stopped arr 28 total 20 remain 16 wait 9
At time 40 process 3 resumed arr 18 total 8 remain 2 wait 16
At time 42 process 3 finished arr 18 total 8 remain 0 wait 16 TA 24 WTA 3.00
At time 42 process 2 resumed arr 16 total 10 remain 2 wait 18
At time 44 process 2 finished arr 16 total 10 remain 0 wait 18 TA 28 WTA 2.80
At time 44 process 5 started arr 38 total 24 remain 24 wait 6
At time 46 process 5 stopped arr 38 total 24 remain 22 wait 6
At time 46 process 4 resumed arr 28 total 20 remain 16 wait 15
At time 48 process 4 stopped arr 28 total 20 remain 14 wait 15
At time 48 process 6 started arr 43 total 11 remain 11 wait 5
At time 50 process 6 stopped arr 43 total 11 remain 9 wait 5
At time 50 process 7 started arr 45 total 27 remain 27 wait 5
At time 52 process 7 stopped arr 45 total 27 remain 25 wait 5
At time 52 process 5 resumed arr 38 total 24 remain 22 wait 12
At time 54 process 5 stopped arr 38 total 24 remain 20 wait 12
At time 54 process 8 started arr 47 total 27 remain 27 wait 7
At time 56 process 8 stopped arr 47 total 27 remain 25 wait 7
At time 56 process 4 resumed arr 28 total 20 remain 14 wait 23
At time 58 process 4 stopped arr 28 total 20 remain 12 wait 23
At time 58 process 6 resumed arr 43 total 11 remain 9 wait 13
At time 60 process 6 stopped arr 43 total 11 remain 7 wait 13
At time 60 process 7 resumed arr 45 total 27 remain 25 wait 13
At time 62 process 7 stopped arr 45 total 27 remain 23 wait 13
At time 62 process 5 resumed arr 38 total 24 remain 20 wait 20
At time 64 process 5 stopped arr 38 total 24 remain 18 wait 20
At time 64 process 8 resumed arr 47 total 27 remain 25 wait 15
At time 66 process 8 stopped arr 47 total 27 remain 23 wait 15
At time 66 process 4 resumed arr 28 total 20 remain 12 wait 31
At time 68 process 4 stopped arr 28 total 20 remain 10 wait 31
At time 68 process 6 resumed arr 43 total 11 remain 7 wait 21
At time 70 process 6 stopped arr 43 total 11 remain 5 wait 21
At time 70 process 7 resumed arr 45 total 27 remain 23 wait 21
At time 72 process 7 stopped arr 45 total 27 remain 21 wait 21
At time 72 process 5 resumed arr 38 total 24 remain 18 wait 28
At time 74 process 5 stopped arr 38 total 24 remain 16 wait 28
At time 74 process 8 resumed arr 47 total 27 remain 23 wait 23
At time 76 process 8 stopped arr 47 total 27 remain 21 wait 23
At time 76 process 4 resumed arr 28 total 20 remain 10 wait 39
At time 78 process 4 stopped arr 28 total 20 remain 8 wait 39
At time 78 process 6 resumed arr 43 total 11 remain 5 wait 29
At time 80 process 6 stopped arr 43 total 11 remain 3 wait 29
At time 80 process 7 resumed arr 45 total 27 remain 21 wait 29
At time 82 process 7 stopped arr 45 total 27 remain 19 wait 29
At time 82 process 5 resumed arr 38 total 24 remain 16 wait 36
At time 84 process 5 stopped arr 38 total 24 remain 14 wait 36
```

```
At time 84 process 8 resumed arr 47 total 27 remain 21 wait 31
At time 86 process 8 stopped arr 47 total 27 remain 19 wait 31
At time 86 process 4 resumed arr 28 total 20 remain 8 wait 47
At time 88 process 4 stopped arr 28 total 20 remain 6 wait 47
At time 88 process 6 resumed arr 43 total 11 remain 3 wait 37
At time 90 process 6 stopped arr 43 total 11 remain 1 wait 37
At time 90 process 7 resumed arr 45 total 27 remain 19 wait 37
At time 92 process 7 stopped arr 45 total 27 remain 17 wait 37
At time 92 process 5 resumed arr 38 total 24 remain 14 wait 44
At time 94 process 5 stopped arr 38 total 24 remain 12 wait 44
At time 94 process 8 resumed arr 47 total 27 remain 19 wait 39
At time 96 process 8 stopped arr 47 total 27 remain 17 wait 39
At time 96 process 4 resumed arr 28 total 20 remain 6 wait 55
At time 98 process 4 stopped arr 28 total 20 remain 4 wait 55
At time 98 process 6 resumed arr 43 total 11 remain 1 wait 45
At time 99 process 6 finished arr 43 total 11 remain 0 wait 45 TA 56 WTA 5.09
At time 99 process 7 resumed arr 45 total 27 remain 17 wait 44
At time 101 process 7 stopped arr 45 total 27 remain 15 wait 44
At time 101 process 5 resumed arr 38 total 24 remain 12 wait 51
At time 103 process 5 stopped arr 38 total 24 remain 10 wait 51
At time 103 process 8 resumed arr 47 total 27 remain 17 wait 46
At time 105 process 8 stopped arr 47 total 27 remain 15 wait 46
At time 105 process 4 resumed arr 28 total 20 remain 4 wait 62
At time 107 process 4 stopped arr 28 total 20 remain 2 wait 62
At time 107 process 7 resumed arr 45 total 27 remain 15 wait 50
At time 109 process 7 stopped arr 45 total 27 remain 13 wait 50
At time 109 process 5 resumed arr 38 total 24 remain 10 wait 57
At time 111 process 5 stopped arr 38 total 24 remain 8 wait 57
At time 111 process 8 resumed arr 47 total 27 remain 15 wait 52
At time 113 process 8 stopped arr 47 total 27 remain 13 wait 52
At time 113 process 4 resumed arr 28 total 20 remain 2 wait 68
At time 115 process 4 finished arr 28 total 20 remain 0 wait 68 TA 87 WTA 4.35
At time 115 process 7 resumed arr 45 total 27 remain 13 wait 56
At time 117 process 7 stopped arr 45 total 27 remain 11 wait 56
At time 117 process 5 resumed arr 38 total 24 remain 8 wait 63
At time 119 process 5 stopped arr 38 total 24 remain 6 wait 63
At time 119 process 8 resumed arr 47 total 27 remain 13 wait 58
At time 121 process 8 stopped arr 47 total 27 remain 11 wait 58
At time 121 process 7 resumed arr 45 total 27 remain 11 wait 60
At time 123 process 7 stopped arr 45 total 27 remain 9 wait 60
At time 123 process 5 resumed arr 38 total 24 remain 6 wait 67
At time 125 process 5 stopped arr 38 total 24 remain 4 wait 67
At time 125 process 8 resumed arr 47 total 27 remain 11 wait 62
At time 127 process 8 stopped arr 47 total 27 remain 9 wait 62
At time 127 process 7 resumed arr 45 total 27 remain 9 wait 64
At time 129 process 7 stopped arr 45 total 27 remain 7 wait 64
At time 129 process 5 resumed arr 38 total 24 remain 4 wait 71
At time 131 process 5 stopped arr 38 total 24 remain 2 wait 71
At time 131 process 8 resumed arr 47 total 27 remain 9 wait 66
At time 133 process 8 stopped arr 47 total 27 remain 7 wait 66
At time 133 process 7 resumed arr 45 total 27 remain 7 wait 68
At time 135 process 7 stopped arr 45 total 27 remain 5 wait 68
At time 135 process 5 resumed arr 38 total 24 remain 2 wait 75
At time 137 process 5 finished arr 38 total 24 remain 0 wait 75 TA 99 WTA 4.12
At time 137 process 8 resumed arr 47 total 27 remain 7 wait 70
At time 139 process 8 stopped arr 47 total 27 remain 5 wait 70
At time 139 process 7 resumed arr 45 total 27 remain 5 wait 72
At time 141 process 7 stopped arr 45 total 27 remain 3 wait 72
At time 141 process 8 resumed arr 47 total 27 remain 5 wait 72
At time 143 process 8 stopped arr 47 total 27 remain 3 wait 72
At time 143 process 7 resumed arr 45 total 27 remain 3 wait 74
At time 145 process 7 stopped arr 45 total 27 remain 1 wait 74
At time 145 process 8 resumed arr 47 total 27 remain 3 wait 74
At time 147 process 8 stopped arr 47 total 27 remain 1 wait 74
At time 147 process 7 resumed arr 45 total 27 remain 1 wait 76
At time 148 process 7 finished arr 45 total 27 remain 0 wait 76 TA 103 WTA 3.81
At time 148 process 8 resumed arr 47 total 27 remain 1 wait 75
At time 149 process 8 finished arr 47 total 27 remain 0 wait 75 TA 102 WTA 3.78
```

2. scheduler.perf

```
CPU utilization = 94.63%
Avg WTA = 3.59
Avg Waiting = 47.88
Std WTA = 0.97
```

Assumptions

- RR
  - If a process arrives at the time the RR quanta ends, the preemption happens before that process enters, i.e. if there is one process only and the quanta ends when another one arrives, we continue running the one process only.
- HPF
  - If many processes have same priority, they are scheduled according to the ordering of the min-heap, that is, the one inserted first in the min-heap will be scheduled first, but after that, we start from the last process that arrived. This behaviour can be called 'random' but it is predictible in some way.
- SRTN
  - If a process arrives that has the same remaining time as the currently running one, no preemption happens.
  - If more than one process have the same remaining time, when one is scheduled, we pick them in a min-heap fashion. i.e. the processes are scheduled last arrived to first arrived.

Workload Distribution

Name	SEC: BN:	Load
Ahmed Nasser	SEC: 1 BN: 8	PCB Table Scheduler
Ahmed Hesham Eid	SEC: 1 BN: 9	Process generator Scheduler
Abdelrahman Farid	SEC: 1 BN: 34	Circular Queue Scheduler RR and SRTN
Youssef Walid	SEC: 2 BN: 34	Priority Queue Scheduler HPF

Time Taken For Tasks

Task	Hrs
Algorithms	4 Hrs
Data Structures	3 Hrs
Scheduler	3 Hrs
Process Generator	1 Hrs
Debugging	10 Hrs

Memory Management

Algorithm Explanation

- When a process arrives, we insert it in a 'waiting' queue.
- According to the scheduling algorithm, we check that waiting queue for candidate processes to enter our scheduling algorithm's datastructure, i.e:
  - In SRTN: if any process in the waiting queue has less remaining time than the currently running process, it enters the SRTN's circular queue, however the older process remains allocated inthe memory.
  - In RR: if there is a free space, the first process in the waiting queue is moved to the RR's circular queue instantly, as we will schedule it sooner or later in that same order.
  - In HPF: after the currently running process ends, we check the waiting queue for the best fit for the HPF (the one with the highest priority), this allows us to not allocate memory for unfit processes too early.

Results

- Test case
  - ```
    #id arrival runtime priority memsize
    1 1 11  5 256
    2 2 9 5 256
    3 3 7 5 256
    4 4 5 5 256
    5 5 3 5 256
    6 6 1 1 182
    ```
- HPF
  - ```
    At time 1 allocated 256 bytes for process 1 from 0 to 256
    At time 12 freed 256 bytes from process 1 from 0 to 256
    At time 12 allocated 256 bytes for process 6 from 0 to 256
    At time 13 freed 256 bytes from process 6 from 0 to 256
    At time 13 allocated 256 bytes for process 2 from 0 to 256
    At time 22 freed 256 bytes from process 2 from 0 to 256
    At time 22 allocated 256 bytes for process 3 from 0 to 256
    At time 29 freed 256 bytes from process 3 from 0 to 256
    At time 29 allocated 256 bytes for process 4 from 0 to 256
    At time 34 freed 256 bytes from process 4 from 0 to 256
    At time 34 allocated 256 bytes for process 5 from 0 to 256
    At time 37 freed 256 bytes from process 5 from 0 to 256
    ```
- SRTN
  - ```
    At time 1 allocated 256 bytes for process 1 from 0 to 256
    At time 2 allocated 256 bytes for process 2 from 256 to 512
    At time 3 allocated 256 bytes for process 3 from 512 to 768
    At time 4 allocated 256 bytes for process 4 from 768 to 1024
    At time 9 freed 256 bytes from process 4 from 768 to 1024
    At time 9 allocated 256 bytes for process 6 from 768 to 1024
    At time 10 freed 256 bytes from process 6 from 768 to 1024
    At time 10 allocated 256 bytes for process 0 from 768 to 1024
    At time 11 freed 256 bytes from process 0 from 768 to 1024
    At time 11 allocated 256 bytes for process 0 from 768 to 1024
    At time 12 freed 256 bytes from process 0 from 768 to 1024
    At time 12 allocated 256 bytes for process 0 from 768 to 1024
    At time 13 freed 256 bytes from process 0 from 768 to 1024
    At time 13 allocated 256 bytes for process 5 from 768 to 1024
    At time 16 freed 256 bytes from process 5 from 768 to 1024
    At time 22 freed 256 bytes from process 3 from 512 to 768
    At time 30 freed 256 bytes from process 2 from 256 to 512
    At time 40 freed 256 bytes from process 1 from 0 to 256
    ```
    ```

- RR
  - ```
    At time 1 allocated 256 bytes for process 1 from 0 to 256
    At time 2 allocated 256 bytes for process 2 from 256 to 512
    At time 3 allocated 256 bytes for process 3 from 512 to 768
    At time 4 allocated 256 bytes for process 4 from 768 to 1024
    At time 26 freed 256 bytes from process 4 from 768 to 1024
    At time 26 allocated 256 bytes for process 5 from 768 to 1024
    At time 31 freed 256 bytes from process 3 from 512 to 768
    At time 31 allocated 256 bytes for process 6 from 512 to 768
    At time 34 freed 256 bytes from process 2 from 256 to 512
    At time 34 allocated 256 bytes for process 0 from 256 to 512
    At time 35 freed 256 bytes from process 1 from 0 to 256
    At time 35 allocated 256 bytes for process 0 from 0 to 256
    At time 36 freed 256 bytes from process 6 from 512 to 768
    At time 36 allocated 256 bytes for process 0 from 512 to 768
    At time 37 freed 256 bytes from process 5 from 768 to 1024
    At time 38 freed 256 bytes from process 0 from 256 to 512
    At time 39 freed 256 bytes from process 0 from 0 to 256
    At time 40 freed 256 bytes from process 0 from 512 to 768
    ```
    ```

Workload Distribution

Name	SEC: BN:	Load
Ahmed Nasser	SEC: 1 BN: 8	PCB Table Scheduler Memory Management Design Phase 3
Ahmed Hesham Eid	SEC: 1 BN: 9	Process generator Scheduler Memory Management Design Phase 3
Abdelrahman Farid	SEC: 1 BN: 34	Circular Queue Scheduler RR and SRTN Buddy System v1 Memory Management Design
Youssef Walid	SEC: 2 BN: 34	Priority Queue Scheduler HPF Buddy System v2 Waiting queue implementation Memory Management Design