

OPERATING SYSTEMS LAB

Laboratory 5

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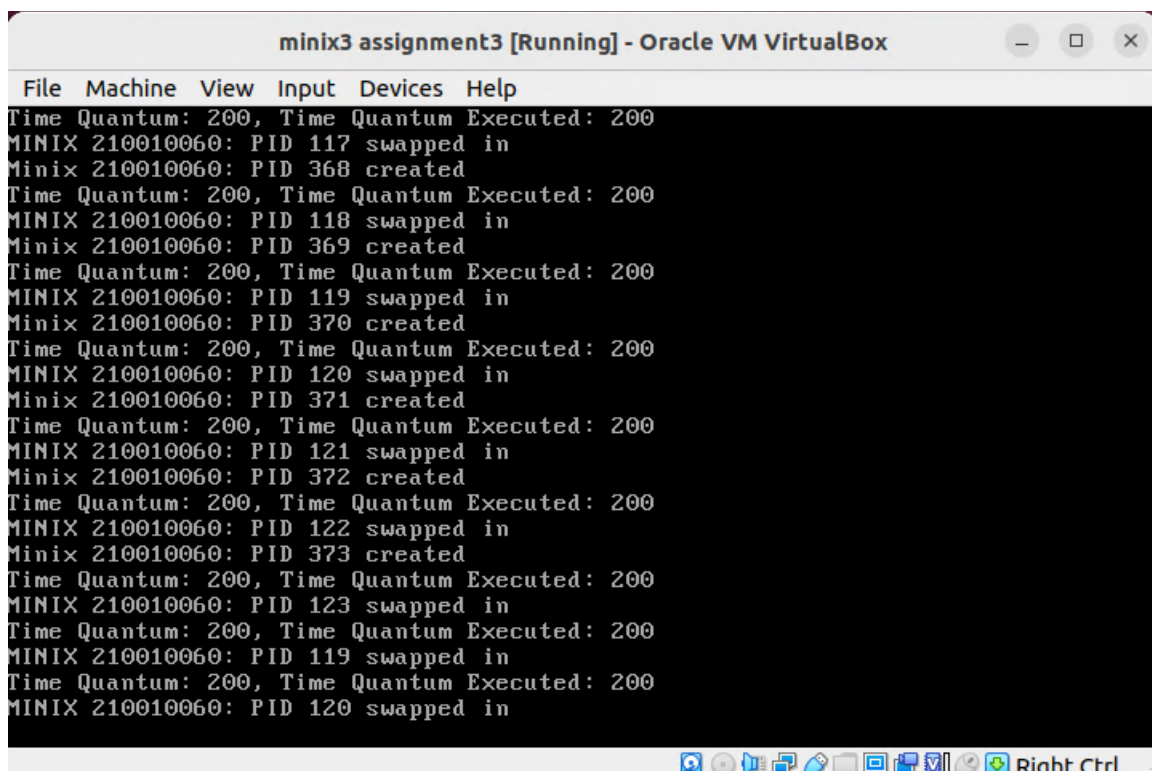
Part 1

Minix Scheduling

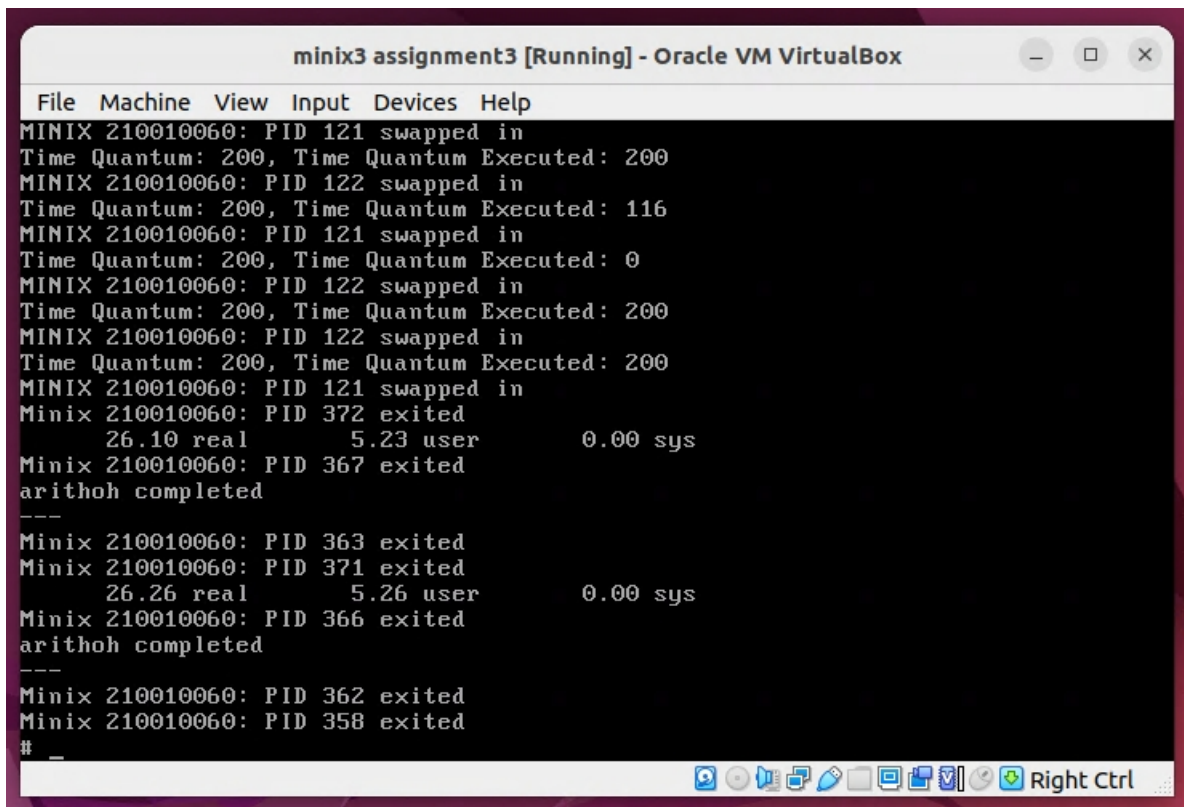
1) Workload Mix 1: Completely CPU intensive

```
#!/bin/bash
./arithoh.sh &
./arithoh.sh &
./arithoh.sh &
./arithoh.sh &
./arithoh.sh &
wait
```

This workload contains five instances of arithoh.sh making it completely CPU intensive. We can observe the Round Robin nature of scheduling as processes are being swapped in a repeated manner. The time quantum of 200 is fully utilized in each burst thus proving it is CPU intensive.



The screenshot shows a terminal window titled "minix3 assignment3 [Running] - Oracle VM VirtualBox". The terminal output displays a sequence of events where processes are created and then swapped in, demonstrating the Round Robin scheduling algorithm. The logs show a repeating pattern of "Time Quantum: 200, Time Quantum Executed: 200" followed by "MINIX 210010060: PID [number] swapped in" and "Minix 210010060: PID [number] created". The PIDs shown are 117, 368, 118, 369, 119, 370, 120, 371, 121, 372, 122, 373, 123, 119, and 120. The window has a standard menu bar with File, Machine, View, Input, Devices, and Help. The bottom of the window shows a taskbar with various icons and a "Right Ctrl" button.



```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
MINIX 210010060: PID 121 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 122 swapped in
Time Quantum: 200, Time Quantum Executed: 116
MINIX 210010060: PID 121 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 122 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 122 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 121 swapped in
Minix 210010060: PID 372 exited
26.10 real 5.23 user 0.00 sys
Minix 210010060: PID 367 exited
arithoh completed
---
Minix 210010060: PID 363 exited
Minix 210010060: PID 371 exited
26.26 real 5.26 user 0.00 sys
Minix 210010060: PID 366 exited
arithoh completed
---
Minix 210010060: PID 362 exited
Minix 210010060: PID 358 exited
# _
```

2) Workload Mix 2: Completely IO intensive



```
#!/bin/bash
./fstime.sh &
./fstime.sh &
./fstime.sh &
./fstime.sh &
./fstime.sh &
wait
```

This workload contains five instances of `fstime.sh` making it completely IO intensive. These five processes also run in Round Robin manner. Also we can see that the burst is not fully utilized proving it is IO intensive.

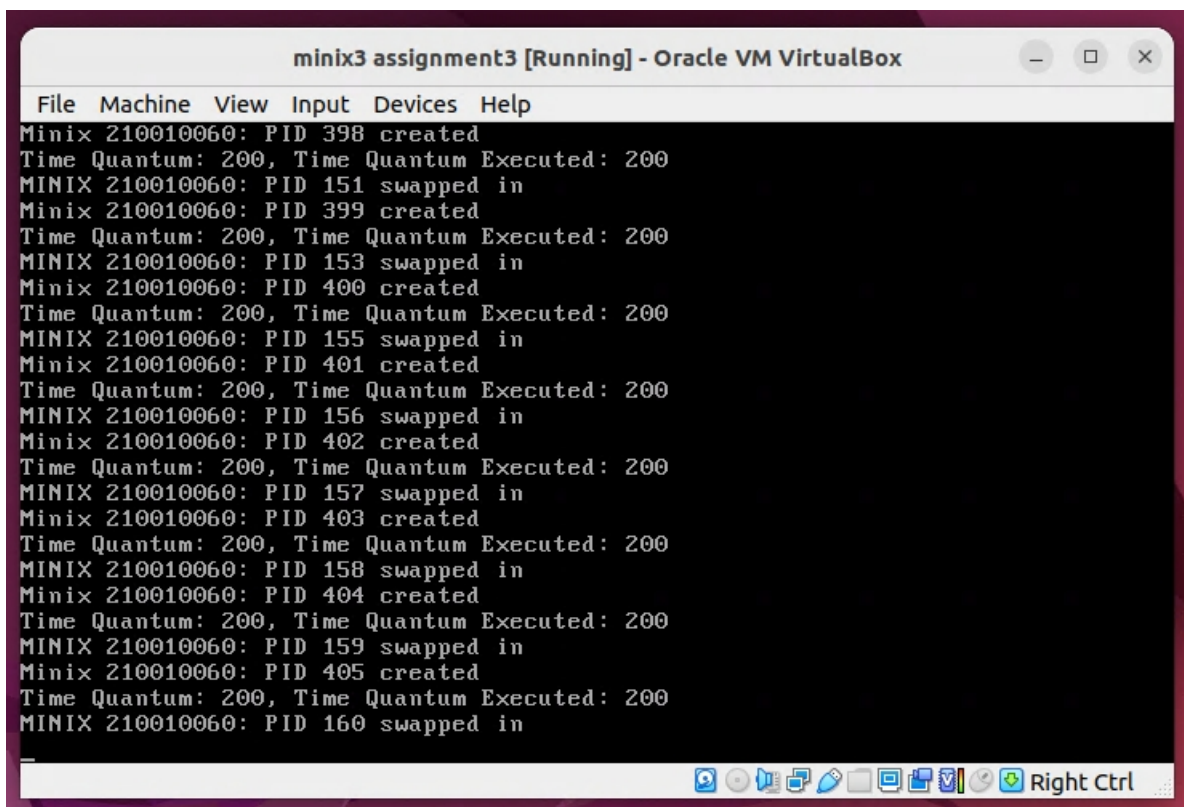
```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Minix 210010060: PID 382 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 132 swapped in
Minix 210010060: PID 383 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 133 swapped in
Minix 210010060: PID 384 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 134 swapped in
Minix 210010060: PID 385 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 135 swapped in
Minix 210010060: PID 386 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 136 swapped in
Minix 210010060: PID 387 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 137 swapped in
Minix 210010060: PID 388 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 138 swapped in
Minix 210010060: PID 389 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 139 swapped in
```

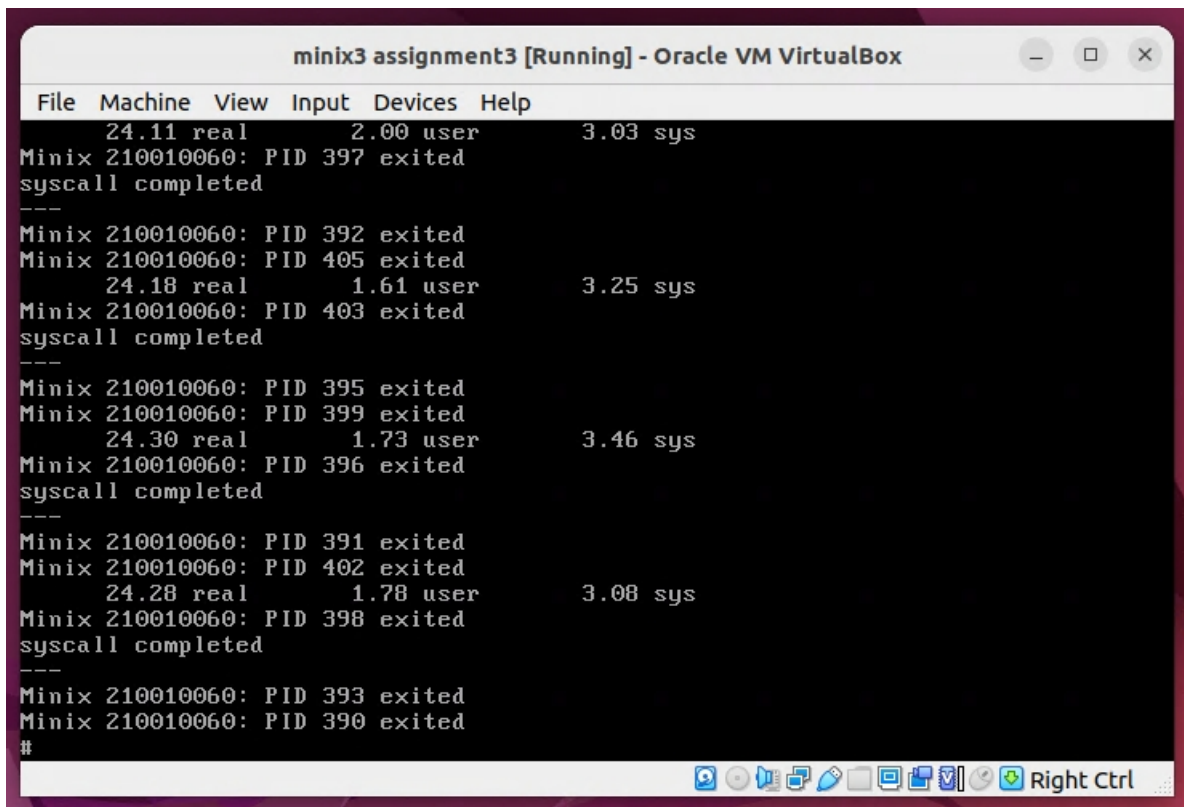
```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Copy done: 1000004 in 8.6333, score 28957
COUNT:28957:0:KBps
TIME:8.6
Minix 210010060: PID 389 exited
28.18 real 0.51 user 2.90 sys
Minix 210010060: PID 387 exited
fstime completed
---
Minix 210010060: PID 379 exited
Copy done: 1000004 in 9.2167, score 27124
COUNT:27124:0:KBps
TIME:9.2
Minix 210010060: PID 383 exited
28.76 real 0.46 user 4.33 sys
Minix 210010060: PID 380 exited
fstime completed
---
Minix 210010060: PID 375 exited
Minix 210010060: PID 374 exited
# Time Quantum: 500, Time Quantum Executed: 414
MINIX 210010060: PID 24 swapped in
Time Quantum: 500, Time Quantum Executed: 0
Time Quantum: 500, Time Quantum Executed: 0
#
```

3) Workload Mix 3: Completely System Call intensive

```
#!/bin/bash
./syscall.sh &
./syscall.sh &
./syscall.sh &
./syscall.sh &
./syscall.sh &
wait
```

This workload contains five instances of syscall.sh making it a fully system call intensive workload. These five processes also run in Round Robin manner. Here, the time quanta is not always fully utilized.





4) Workload Mix 4: Mixed workload

```
#!/bin/bash
./arithoh.sh &
./fstime.sh &
./arithoh.sh &
./syscall.sh &
./arithoh.sh &
```

This workload contains three instances of arithoh.sh, one fstime.sh and one syscall.sh. We can observe that syscall completes execution first, followed by fstime and finally the three arithoh. Also we can see that fstime is sometimes allotted a longer burst and is not fully utilized as it is IO intensive. Once fstime and syscall are done, the three arithoh run in Round Robin manner.

```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
MINIX 210010060: PID 161 swapped in
Time Quantum: 500, Time Quantum Executed: 7
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 161 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 169 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 173 swapped in
Time Quantum: 200, Time Quantum Executed: 199
MINIX 210010060: PID 175 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 176 swapped in
Minix 210010060: PID 420 exited
20.66 real 1.75 user 3.46 sys
Minix 210010060: PID 417 exited
syscall completed
---
Minix 210010060: PID 410 exited
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 169 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 176 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 173 swapped in
```

```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
MINIX 210010060: PID 169 swapped in
Time Quantum: 200, Time Quantum Executed: 38
MINIX 210010060: PID 171 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 173 swapped in
Time Quantum: 200, Time Quantum Executed: 39
MINIX 210010060: PID 175 swapped in
Time Quantum: 200, Time Quantum Executed: 0
MINIX 210010060: PID 176 swapped in
Copy done: 1000004 in 3.0000, score 83333
COUNT:83333:0KBps
TIME:3.0
Minix 210010060: PID 416 exited
16.10 real 0.23 user 3.13 sys
Minix 210010060: PID 413 exited
fstime completed
---
Minix 210010060: PID 408 exited
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 161 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 175 swapped in
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 169 swapped in
```

Part 2

Pseudo FIFO implementation

To modify the user-level scheduler in Minix3 to the “Pseudo-FIFO” policy: among the user-level processes that are ready to execute, the one that entered the earliest must be scheduled. The following changes are made in `minix/servers/sched/schedule.c` in `do_quantum()`

`rpm → priority += 1` was changed to `rpm → priority -= 1`

This allows FIFO to occur by lowering the priority value, preventing the incoming processes to preemptively get time slices for execution.

In this same file line:

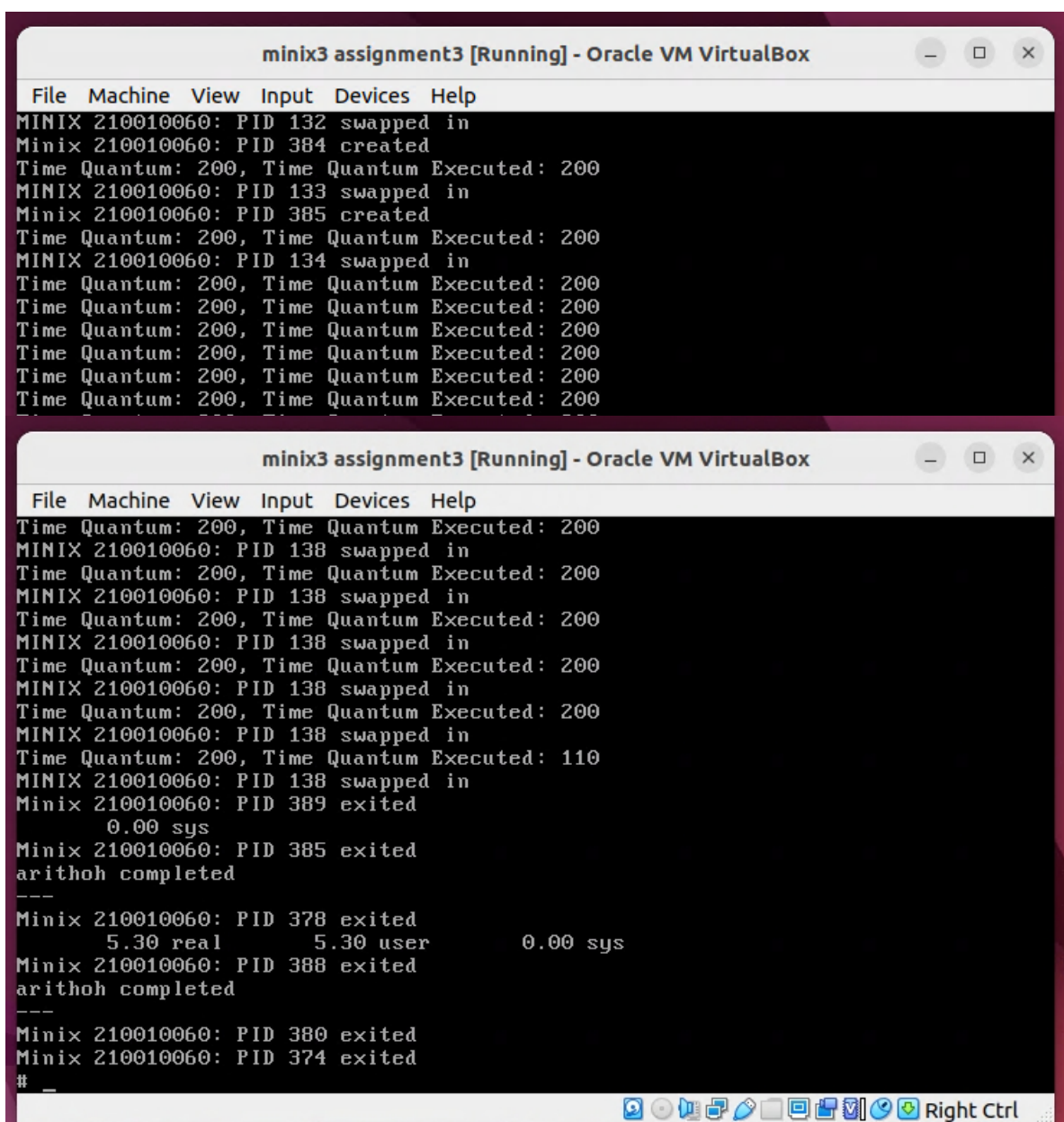
$$rmp \rightarrow priority \text{ -= } 1$$

was removed in the function `balance_queues()` to prevent overflow of priority queues.

Workload mixes

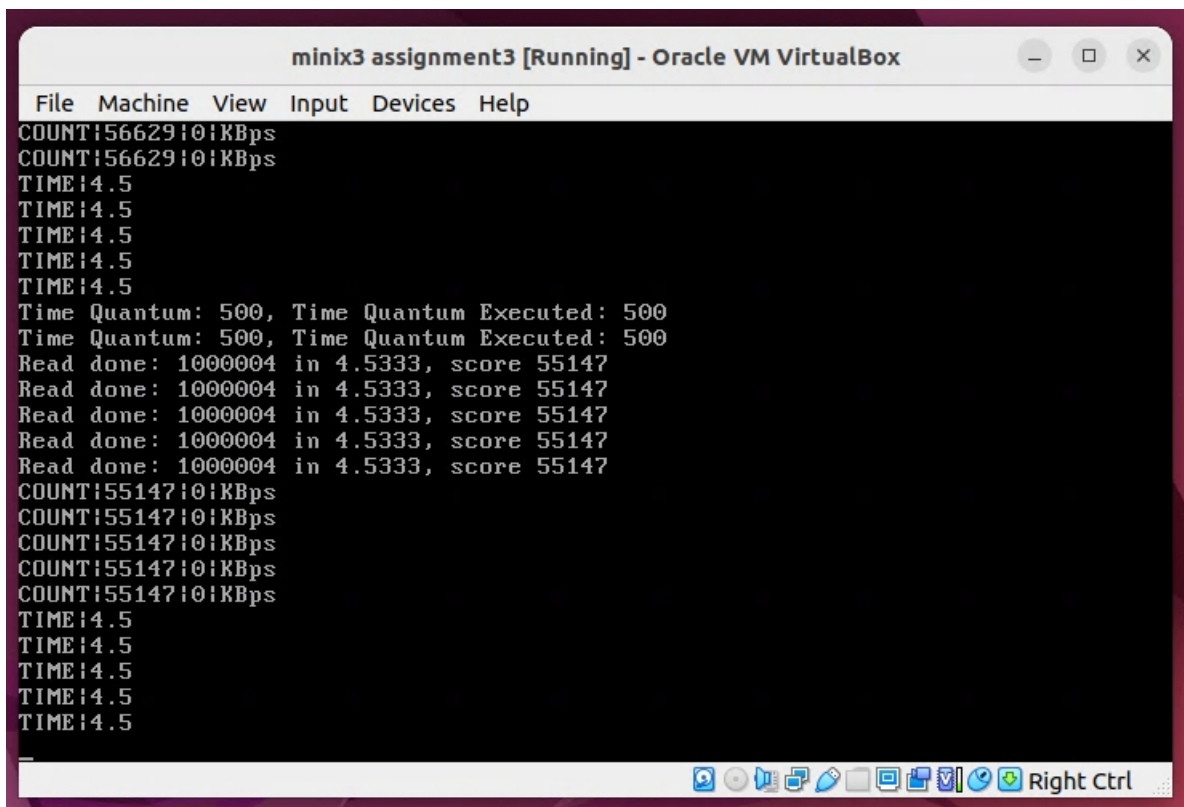
1) Workload Mix 1: Completely CPU intensive

Here we observe that arithoh processes run sequentially, ie they exit in the order they arrive. This is in contrast to the earlier scheduler.

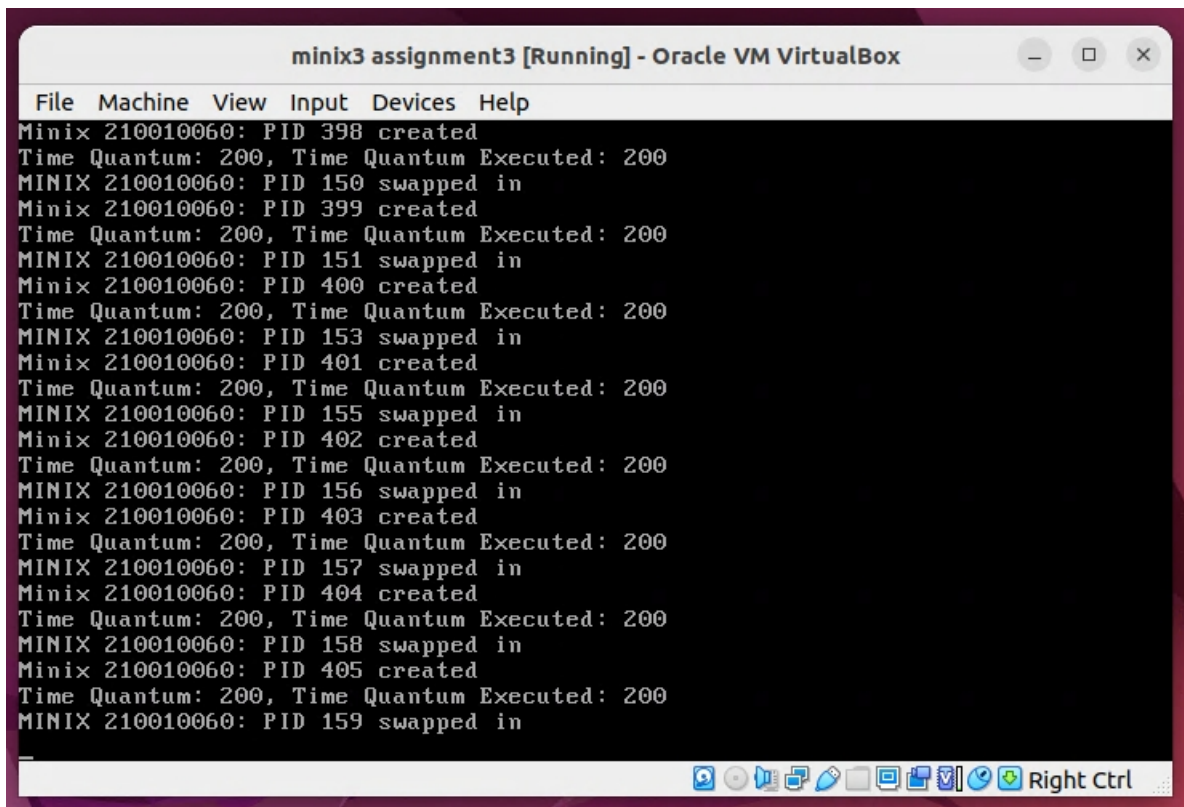


2) Workload Mix 2: Completely IO intensive

In this workload mix we took 5 fstime.sh continuously, according to First In First Out scheduling algorithm the 5 processes should be exited in order of their arrival but from the output we can see that FIFO is not happening properly, making this scheduling process Pseudo FIFO. This is because fstime.sh is I/O bound process which goes to blocked state waiting for response, in the meanwhile the next process is scheduled and this whole results in round robin scheduling. So, there is no difference in output for original minix scheduler and Pseudo FIFO for this workload mix.



```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
COUNT!56629!0!KBps
COUNT!56629!0!KBps
TIME!4.5
TIME!4.5
TIME!4.5
TIME!4.5
TIME!4.5
Time Quantum: 500, Time Quantum Executed: 500
Time Quantum: 500, Time Quantum Executed: 500
Read done: 1000004 in 4.5333, score 55147
Read done: 1000004 in 4.5333, score 55147
Read done: 1000004 in 4.5333, score 55147
Read done: 1000004 in 4.5333, score 55147
Read done: 1000004 in 4.5333, score 55147
COUNT!55147!0!KBps
COUNT!55147!0!KBps
COUNT!55147!0!KBps
COUNT!55147!0!KBps
COUNT!55147!0!KBps
TIME!4.5
TIME!4.5
TIME!4.5
TIME!4.5
TIME!4.5
Right Ctrl
```

```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Minix 210010060: PID 398 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 150 swapped in
Minix 210010060: PID 399 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 151 swapped in
Minix 210010060: PID 400 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 153 swapped in
Minix 210010060: PID 401 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 155 swapped in
Minix 210010060: PID 402 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 156 swapped in
Minix 210010060: PID 403 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 157 swapped in
Minix 210010060: PID 404 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 158 swapped in
Minix 210010060: PID 405 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 159 swapped in
```

3) Workload Mix 3: Completely System call intensive

The execution of this workload script is quite similar to that of the arithoh-based CPU-intensive script. This is because syscall is effectively a CPU-intensive process, though not as intensive as arithoh. Note that syscall process uses the full CPU burst a lot of the time, and doesn't end up in the round-robin that I/O processes end up doing. Hence, Pseudo-FIFO behaviour has been observed in the scheduling policy after we made modifications to the source code of Minix3, as mentioned at the beginning of the section.

```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Time Quantum: 200, Time Quantum Executed: 200
You have the Auto capture keyboard option turned on. This will cause the Virtual Machine to automatically
Minix 210010060: PID 371 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 121 swapped in
Minix 210010060: PID 372 created
Time Quantum: 200, Time Quantum Executed: 200
MINIX 210010060: PID 122 swapped in
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 500, Time Quantum Executed: 500
MINIX 210010060: PID 35 swapped in
Minix 210010060: PID 372 exited
7.90 real 1.63 user 3.11 sys
Minix 210010060: PID 368 exited
syscall completed
---
Minix 210010060: PID 362 exited
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
```

```
minix3 assignment3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Time Quantum: 200, Time Quantum Executed: 200
You have the Auto capture keyboard option turned on. This will cause the Virtual Machine to automatically
3.16 sys
Minix 210010060: PID 363 exited
syscall completed
---
Minix 210010060: PID 358 exited
19.98 real 1.56 user 3.11 sys
Minix 210010060: PID 365 exited
syscall completed
---
Minix 210010060: PID 360 exited
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Time Quantum: 200, Time Quantum Executed: 200
Minix 210010060: PID 369 exited
23.98 real 1.65 user 3.08 sys
Minix 210010060: PID 364 exited
syscall completed
---
Minix 210010060: PID 359 exited
Minix 210010060: PID 357 exited
# _
```

4) Workload Mix 4: Mixed workload

