

CS-315 OPERATING SYSTEMS LAB-5

PART-1

To display the time quanta spent by each process in the CPU, we add the following statement inside the 'sched_proc()' function in the system.c file present in '/usr/src/minix/kernel/' directory:

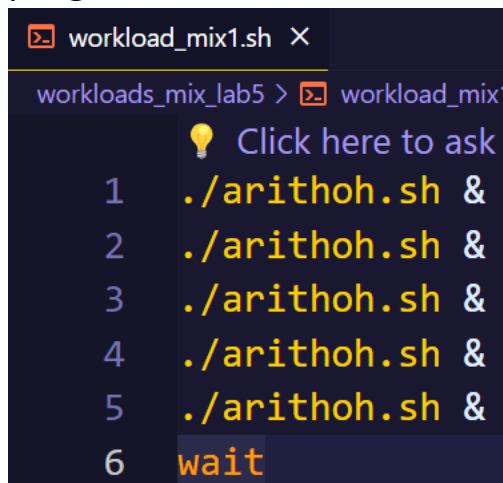
```
printf("MINIX 210010050: Time Quantum Executed: %d out of %d (Endpoint: %d)\n",
p->p_quantum_size_ms - cpu_time_2_ms(p->p_cpu_time_left),
p->p_quantum_size_ms, _ENDPOINT_P(p->p_endpoint));
```

Run run_part1.sh to build the changes made. The new workload mixes(1,2,3,4) are already copied to the '/byte-unixbench-mod/Unixbench/workload_mix' folder.

```
cp system.c /usr/src/minix/kernel/
cd /usr/src/
make build MKUPDATE=yes
```

1. Workload-mix1 (Completely CPU-intensive):

We design a workload mix consisting of 5 instances of arithoh.sh, which is CPU-intensive due to the computational nature of the program/code:



The screenshot shows a terminal window with a title bar 'workload_mix1.sh'. The prompt is 'workloads_mix_lab5 >'. The user has entered 'workload_mix1.sh'. The output shows a list of commands: 1 ./arithoh.sh &, 2 ./arithoh.sh &, 3 ./arithoh.sh &, 4 ./arithoh.sh &, 5 ./arithoh.sh &, and 6 wait. A lightbulb icon and the text 'Click here to ask' are visible above the list.

When we execute this workload mix, we observe, from the screenshots below, that the PIDs/ Endpoint IDs are repeating in the round-robin format. We also observe that the total of 200 time quantum is fully utilized in every burst, hence confirming the fact that arithoh.sh is CPU-intensive.

```

MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 188)
MINIX 210010050: PID 188 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 189)
MINIX 210010050: PID 189 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 190)
MINIX 210010050: PID 190 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 187)
MINIX 210010050: PID 187 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 189)
MINIX 210010050: PID 189 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 190)
MINIX 210010050: PID 190 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 187)
MINIX 210010050: PID 187 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 188)
MINIX 210010050: PID 188 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 189)
MINIX 210010050: PID 189 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 187)
MINIX 210010050: PID 187 swapped in

```

```

2:38.90 real      31.88 user      0.03 sys
Minix 210010050: PID 208 exited
arithoh completed
---
Minix 210010050: PID 203 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 190)
MINIX 210010050: PID 190 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
Minix 210010050: PID 215 exited
2:39.10 real      31.68 user      0.00 sys
Minix 210010050: PID 207 exited
arithoh completed
---
Minix 210010050: PID 202 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
Minix 210010050: PID 211 exited
2:39.51 real      32.18 user      0.00 sys
Minix 210010050: PID 206 exited
arithoh completed
---
Minix 210010050: PID 201 exited
Minix 210010050: PID 200 exited
#

```

2. Workload-mix2 (I/O intensive):

We design a workload mix consisting of 5 instances of fstime.sh, which is I/O-intensive due to the read & write nature of the program/code. When we execute this workload mix, we observe, from the screenshots below, that the five I/O-bound processes run in a round-robin format, as expected.

```
workload_mix2.sh X
workloads_mix_lab5 > workload_mix2.sh
Click here to ask B
1 ./fstime.sh &
2 ./fstime.sh &
3 ./fstime.sh &
4 ./fstime.sh &
5 ./fstime.sh &
6 wait
```

We also observe that they do not always use the entire allotted time quantum. We can see that fstime was sometimes allotted a time quantum of 500, which is more than the usual 200 but it may not always use the entire 500, as fstime being I/O-bound, it doesn't usually use up the entire time slice.

Hence, confirming that fstime.sh is I/O-bound.

```
MINIX 210010050: Time Quantum Executed: 44 out of 200 (Endpoint: 204)
MINIX 210010050: PID 204 swapped in
MINIX 210010050: Time Quantum Executed: 44 out of 200 (Endpoint: 205)
MINIX 210010050: PID 205 swapped in
MINIX 210010050: Time Quantum Executed: 49 out of 200 (Endpoint: 206)
MINIX 210010050: PID 206 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Read done: 1000004 in 10.5333, score 23734
COUNT:23734:0:KBps
TIME:10.5
Read done: 1000004 in 10.6500, score 23474
COUNT:23474:0:KBps
TIME:10.6
Read done: 1000004 in 10.8000, score 23148
COUNT:23148:0:KBps
TIME:10.8
Read done: 1000004 in 10.8167, score 23112
COUNT:23112:0:KBps
TIME:10.8
Read done: 1000004 in 11.0333, score 22658
COUNT:22658:0:KBps
TIME:11.0
MINIX 210010050: Time Quantum Executed: 427 out of 500 (Endpoint: 24)
```

```
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 199)
MINIX 210010050: PID 199 swapped in
Minix 210010050: PID 225 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 200)
MINIX 210010050: PID 200 swapped in
Minix 210010050: PID 226 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 201)
MINIX 210010050: PID 201 swapped in
Minix 210010050: PID 227 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 202)
MINIX 210010050: PID 202 swapped in
Minix 210010050: PID 228 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 203)
MINIX 210010050: PID 203 swapped in
Minix 210010050: PID 229 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 204)
MINIX 210010050: PID 204 swapped in
Minix 210010050: PID 230 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 205)
MINIX 210010050: PID 205 swapped in
Minix 210010050: PID 231 created
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 206)
MINIX 210010050: PID 206 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
```

```

fstime completed
---
Minix 210010050: PID 220 exited
MINIX 210010050: Time Quantum Executed: 130 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Copy done: 1000004 in 23.1833, score 10783
COUNT:10783:0:KBps
TIME:23.2
Minix 210010050: PID 231 exited
57.11 real      0.78 user      6.83 sys
Minix 210010050: PID 226 exited
fstime completed
---
Minix 210010050: PID 221 exited
Copy done: 1000004 in 23.3000, score 10729
COUNT:10729:0:KBps
TIME:23.3
Minix 210010050: PID 228 exited
57.46 real      0.95 user      9.53 sys
Minix 210010050: PID 223 exited
fstime completed
---
Minix 210010050: PID 218 exited
Minix 210010050: PID 216 exited
#

```

3. Workload-mix3 (mix of CPU-intensive and I/O intensive):

We design a workload consisting of instances of both arithoh.sh and fstime.sh:

```

workload_mix3.sh X
workloads_mix_lab5 > workload_mix3.sh
Click here to ask Bl
1  ./arithoh.sh &
2  ./fstime.sh &
3  ./arithoh.sh &
4  ./fstime.sh &
5  ./arithoh.sh &
6  wait|

```

When we execute this workload mix, we observe, from the below screenshots, that the processes execute in a round-robin format, with fstime finishing first followed by arithoh. We can see that fstime was sometimes allotted a time quantum of 500, which is more than the usual 200 but it may not always use the entire 500, as fstime being I/O-bound, it doesn't usually use up the entire time slice. Once its done, the three arithoh processes execute and complete in round robin.

```

MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 16 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Write done: 1008000 in 4.4833, score 56208
Write done: 1008000 in 4.4833, score 56208
COUNT:56208:0:KBps
COUNT:56208:0:KBps
TIME:4.5
TIME:4.5

```

```

28.98 real 0.80 user 7.93 sys
Minix 210010050: PID 240 exited
fstime completed
---
Minix 210010050: PID 235 exited
Copy done: 1000004 in 8.7667, score 28517
COUNT:28517:0:KBps
TIME:8.8
Minix 210010050: PID 247 exited
29.28 real 0.76 user 8.43 sys
Minix 210010050: PID 242 exited
fstime completed
---
Minix 210010050: PID 237 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 131 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 83 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in

```

```

MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 221)
MINIX 210010050: PID 221 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in

```

```

Minix 210010050: PID 241 exited
arithoh completed
---
Minix 210010050: PID 236 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 223)
MINIX 210010050: PID 223 swapped in
Minix 210010050: PID 248 exited
1:52.28 real      31.83 user      0.03 sys
Minix 210010050: PID 243 exited
arithoh completed
---
Minix 210010050: PID 238 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 219)
MINIX 210010050: PID 219 swapped in

```

4. Workload-mix4 (Mix of different type of workloads)

We design a workload consisting of instances of arithoh.sh, fstime.sh and syscall.sh:

```

workload_mix4.sh X
workloads_mix_lab5 > workload_mix
Click here to ask
1 ./arithoh.sh &
2 ./fstime.sh &
3 ./arithoh.sh &
4 ./syscall.sh &
5 ./arithoh.sh &
6 wait|

```

When we execute this workload mix, we observe, from the below screenshots, that the processes execute in a round-robin format, with fstime finishing first followed by syscall and then arithoh. We can see that fstime was sometimes allotted a time quantum of 500, which is more than the usual 200 but it may not always use the entire 500, as fstime being I/O-bound, it doesn't usually use up the entire time slice. We observe, for syscall, that the time quanta is not always being fully used. From this, we conclude that syscall.sh is less CPU-intensive than arithoh.sh. Since CPU-intensive processes don't need to wait for I/O, they don't use the

CPU until the end of their time bursts. Once its done, the three arithoh processes execute and complete in round robin.

```
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 236)
MINIX 210010050: PID 236 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 22 out of 200 (Endpoint: 236)
MINIX 210010050: PID 236 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 15 out of 200 (Endpoint: 238)
MINIX 210010050: PID 238 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
Read done: 1000004 in 2.0333, score 122951
COUNT:122951:0:KBps
TIME:2.0
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 238)
MINIX 210010050: PID 238 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
```

```
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: Time Quantum Executed: 171 out of 500 (Endpoint: 24)
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 238)
MINIX 210010050: PID 238 swapped in
MINIX 210010050: Time Quantum Executed: 116 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 236)
MINIX 210010050: PID 236 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
Copy done: 1000004 in 4.5833, score 54545
COUNT:54545:0:KBps
TIME:4.6
Minix 210010050: PID 261 exited
20.51 real 0.75 user 8.08 sys
Minix 210010050: PID 256 exited
fstime completed
---
Minix 210010050: PID 251 exited
```

```

MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
Minix 210010050: PID 263 exited
31.18 real      3.85 user      8.51 sys
Minix 210010050: PID 258 exited
syscall completed
---
Minix 210010050: PID 253 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 16 out of 200 (Endpoint: 237)
MINIX 210010050: PID 237 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in

```

```

MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 239)
MINIX 210010050: PID 239 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
Minix 210010050: PID 264 exited
1:56.66 real    31.90 user      0.00 sys
Minix 210010050: PID 259 exited
arithoh completed
---
Minix 210010050: PID 254 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
MINIX 210010050: Time Quantum Executed: 166 out of 200 (Endpoint: 235)
MINIX 210010050: PID 235 swapped in
Minix 210010050: PID 260 exited
1:57.08 real    32.11 user      0.01 sys
Minix 210010050: PID 255 exited
arithoh completed
---
Minix 210010050: PID 250 exited
Minix 210010050: PID 249 exited
#

```

PART-2

To implement Pseudo-FIFO policy for the user-level scheduler, we must make the following changes in the MINIX source code:

In the file `schedule.c` in the directory `'/usr/src/minix/servers/sched/'`:

- Inside the function `'do_noquantum()'`: we modify the line: `rmpp->priority +=1` to `rmpp->priority -=1`. This increases the priority, thus allowing the FIFO policy and preventing the incoming process from pre-emptively getting time slices for execution.


```

if (rmp->priority < MIN_USER_Q) {
    //changing +=1 to -=1 to increase priority
    //rmp->priority += 1; /* lower priority */
    rmp->priority -=1;
}

```

- Inside the function 'balance_queues()', we comment the following line so that the priority of processes don't increase and the priority queue won't overflow:

```

static void balance_queues(minix_timer_t *tp)
{
    struct schedproc *rmp;
    int proc_nr;

    for (proc_nr=0, rmp=schedproc; proc_nr < NR_PROCS; proc_nr++, rmp++) {
        if (rmp->flags & IN_USE) {
            if (rmp->priority > rmp->max_priority) {
                // rmp->priority -= 1; /* increase priority */
                schedule_process_local(rmp);
            }
        }
    }
}

```

- Now run run_part2.sh to build the changes made:

```

run_part2.sh
  Click here to ask Blackbox to help you code faster
1  cp schedule.c /usr/src/minix/servers/sched/
2  cd /usr/src/
3  make build MKUPDATE=yes

```

1. Workload-mix1 (CPU-intensive):

When we execute the workload_mix1.sh(same as the one discussed in Part-1), we observe, from the screenshots below,

that the arithoh processes execute sequentially, i.e, one after the other, in contrast to the round-robin format, thus displaying a FIFO format. Since there is no I/O wait involved, we have obtained a Pseudo-FIFO scheduling policy. We can see below the order of execution of processes(PIDs): 208, 209, 210, 211, 212.

```
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
```

```
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
MINIX 210010050: Time Quantum Executed: 93 out of 200 (Endpoint: 208)
MINIX 210010050: PID 208 swapped in
Minix 210010050: PID 234 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: PID 209 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: PID 209 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: PID 209 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 209)
MINIX 210010050: PID 209 swapped in
```



```

0.00 sys
0.00Minix 210010050: PID 230 exited
sys
Minix 210010050: PID 231 exited
0.00arithoh completed
sys
---
Minix 210010050: PID 232 exited
arithoh completed
Minix 210010050: PID 224 exited
32.00---
arithoh completed
user---
Minix 210010050: PID 225 exited
Minix 210010050: PID 226 exited
arithoh completed
---
Minix 210010050: PID 227 exited
0.00 sys
Minix 210010050: PID 233 exited
arithoh completed
---
Minix 210010050: PID 228 exited
Minix 210010050: PID 223 exited
# _

```

2. Workload-mix2 (I/O intensive):

When we execute this workload_mix2, we observe that the Pseudo-FIFO policy is not followed because fstime is an I/O bound process, so when it requests for an I/O, it goes into sleeping/waiting state. After the I/O request is done, it goes back to the ready queue and continues execution when it gets the CPU. Thus, this is effectively like a round-robin. Hence, this case puts the 'Pseudo' into 'Pseudo-FIFO'. Thus, CPU-intensive jobs in the current policy will execute in a mostly FIFO policy, while the I/O-bound jobs frequently resort to round robin, by exiting and re-entering the ready state, when they wait for then receive I/O.

```

TIME:11.8
TIME:11.8
TIME:11.8
TIME:11.8
TIME:11.8
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 217 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 228)
Read done: 1000004 in 5.1167, score 48860
COUNT:48860:0:KBps
TIME:15.1
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 225)
Read done: 1000004 in 7.1500, score 34965
COUNT:34965:0:KBps
TIME:17.2
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 224)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 10 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in

```



```

MINIX 210010050: Time Quantum Executed: 10 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Read done: 1000004 in 9.4333, score 26501
COUNT:26501:0:KBps
TIME:9.4
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 228)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 36)
MINIX 210010050: PID 36 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 133 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Copy done: 1000004 in 5.6500, score 44247
COUNT:44247:0:KBps
TIME:5.7
Minix 210010050: PID 254 exited
33.65 real 0.90 user 8.71 sys
Minix 210010050: PID 249 exited
fstime completed
---
Minix 210010050: PID 244 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 226)
#

```

```

TIME:4.9
Minix 210010050: PID 252 exited
52.33 real 0.78 user 8.91 sys
Minix 210010050: PID 247 exited
fstime completed
---
Minix 210010050: PID 242 exited
MINIX 210010050: Time Quantum Executed: 93 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 227)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 489 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Copy done: 1000004 in 4.8500, score 51546
COUNT:51546:0:KBps
TIME:4.9
Minix 210010050: PID 253 exited
50.18 real 0.80 user 8.88 sys
Minix 210010050: PID 248 exited
fstime completed
---
Minix 210010050: PID 243 exited
Minix 210010050: PID 239 exited
#

```

3. Workload-mix3 (Mix of CPU intensive and I/O intensive)

When we execute this workload `_mix3`, we observe from the screenshots below, that a Pseudo-FIFO policy is being followed since the processes are being executed in such an order that the CPU takes up the CPU-intensive processes at first, which is a set of `arithoh.sh` processes running at the same time since the I/O-intensive processes get blocked after requesting for I/O. At this time, if the CPU-intensive process is entered, its execution is completed. Later, the execution of `fstime` is completed.

We can observe the Pseudo-FIFO policy from the below screenshots as the process with PIDs are getting executed in the FIFO order: 185, 186, 189

```

MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 185)
MINIX 210010050: PID 185 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 185)
MINIX 210010050: PID 185 swapped in
MINIX 210010050: Time Quantum Executed: 80 out of 200 (Endpoint: 185)
MINIX 210010050: PID 185 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 200 (Endpoint: 185)
MINIX 210010050: PID 185 swapped in
Minix 210010050: PID 210 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 186)
MINIX 210010050: PID 186 swapped in

```

[illegible]


```

MINIX 210010050: PID 189 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 189)
MINIX 210010050: PID 189 swapped in
MINIX 210010050: Time Quantum Executed: 118 out of 200 (Endpoint: 189)
MINIX 210010050: PID 189 swapped in
Minix 210010050: PID 214 exited
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 35)
MINIX 210010050: PID 35 swapped in
    1:36.18 real    1:36.18 real    1:36.18 real    32.15 user    32.05 user
    31.96 user      0.00 sys
    0.00Minix 210010050: PID 205 exited
sys
Minix 210010050: PID 209 exited
    0.00arithoh completed
sys
---
Minix 210010050: PID 207 exited
arithoh completed
---
Minix 210010050: PID 200 exited
Minix 210010050: PID 204 exited
arithoh completed
---
Minix 210010050: PID 202 exited

```

```

arithoh completed
---
Minix 210010050: PID 200 exited
Minix 210010050: PID 204 exited
arithoh completed
---
Minix 210010050: PID 202 exited
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
Write done: 1008000 in 4.6667, score 54000
Write done: 1008000 in 4.6667, score 54000
COUNT:54000:0:KBps
COUNT:54000:0:KBps
TIME:4.7
TIME:4.7
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 188)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
Read done: 1000004 in 3.0333, score 82417
COUNT:82417:0:KBps
TIME:3.0
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 187)
Read done: 1000004 in 4.5000, score 55555
COUNT:55555:0:KBps
TIME:4.5

```

```

1:59.85 real      1.06 user      8.61 sys
Minix 210010050: PID 206 exited
fstime completed
---
Minix 210010050: PID 201 exited
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 187)
MINIX 210010050: Time Quantum Executed: 401 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Copy done: 1000004 in 4.9333, score 50675
COUNT:50675:10:KBps
TIME:4.9
Minix 210010050: PID 212 exited
2:05.80 real      0.65 user      8.70 sys
Minix 210010050: PID 208 exited
fstime completed
---
Minix 210010050: PID 203 exited
Minix 210010050: PID 199 exited
# MINIX 210010050: Time Quantum Executed: 342 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in

```

4. Workload-mix4 (Mix of different types of workloads):

We can observe from the below screenshots that even though we do have a pseudo-FIFO policy, the processes are being executed in such an order that the CPU takes up the CPU-bound processes at first, which is a set of arithoh.sh processes running at the same time as the I/O-intensive processes get blocked after requesting for I/O. The syscall is also a CPU-intensive process but not as intensive as arithoh. This is why syscall is executed after the complete execution of arithoh. After these both, fstime completes its execution. We observe that arithoh processes are executed in the order(identified by PIDs): 226, 228, 230. Next syscall executes, since it is also CPU-intensive. At last, fstime completes execution


```

MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 230)
MINIX 210010050: PID 230 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 230)
MINIX 210010050: PID 230 swapped in
MINIX 210010050: Time Quantum Executed: 144 out of 200 (Endpoint: 230)
MINIX 210010050: PID 230 swapped in
Minix 210010050: PID 256 exited
32.18 real 1:04.23 32.16 real user 1:36.21 real 32.05 user
0.00 sys
Minix 210010050: PID 247 exited
32.00 userarithoh completed
---
0.00 sys
Minix 210010050: PID 242 exited
Minix 210010050: PID 249 exited
0.00arithoh completed
sys
---
Minix 210010050: PID 251 exited
Minix 210010050: PID 244 exited
arithoh completed
---
Minix 210010050: PID 246 exited
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)

```

```

MINIX 210010050: Time Quantum Executed: 0 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
MINIX 210010050: Time Quantum Executed: 0 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 9 out of 200 (Endpoint: 229)
MINIX 210010050: PID 229 swapped in
Minix 210010050: PID 255 exited
1:48.93 real 4.73 user 7.91 sys
Minix 210010050: PID 250 exited
syscall completed
---
Minix 210010050: PID 245 exited

```

```

TIME:2.3
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 37)
MINIX 210010050: PID 37 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 38)
MINIX 210010050: PID 38 swapped in
MINIX 210010050: Time Quantum Executed: 401 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 200 out of 200 (Endpoint: 227)
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
MINIX 210010050: Time Quantum Executed: 500 out of 500 (Endpoint: 24)
MINIX 210010050: PID 24 swapped in
Copy done: 1000004 in 4.8667, score 51370
COUNT:51370:0:KBps
TIME:4.9
Minix 210010050: PID 253 exited
2:07.66 real 1.06 user 8.63 sys
Minix 210010050: PID 248 exited
fstime completed
---
Minix 210010050: PID 243 exited
Minix 210010050: PID 241 exited

```