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## CS 314 – Operating Systems Lab

### Lab-5 Report

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### 1 Part 1

In this part, we have to make 4 workload mixes having different characteristics, ranging from all compute-intensive benchmarks to all I/O-intensive benchmarks using the various UnixBench benchmarks . These workloads have been prepared such that they spawn 5 processes atleast. In order to display the time quanta used and left by the processes, we made some changes to the `/minix/kernel/system.c` file. In the `system.c` file, we made the following changes under the `sched_proc` function :

```
printf("Allotted Quantum is %d, Used Quantum is %d, Quantum Left to run on
the CPU is %d\n", p->p_quantum_size_ms,
p->p_quantum_size_ms - cpu_time_2_ms(p->p_cpu_time_left),
cpu_time_2_ms(p->p_cpu_time_left));
```

We used the function `cpu_time_2_ms` to convert the cpu time to milliseconds since the quantum is in milliseconds. We also removed the "swapped in" print statement in order to know the actual PIDs of the spawned processes.

To execute the build on MINIX3, we ran the shell script `run1.sh`:

```
echo "copying files";
cp system.c /usr/src/minix/kernel/;
echo "going to src directory and building the updated code";
cd /usr/src/;
make build MKUPDATE=yes >log.txt 2>log.txt;
echo "build completed successfully";
exit 0;
```

```
# bash run.sh
```

Figure 1: Executing Shell Script

```

minix: PID 20728 exited
minix: PID 20729 created
minix: PID 20729 exited
minix: PID 20730 created
minix: PID 20730 exited
minix: PID 20731 created
minix: PID 20731 exited
minix: PID 20732 created
minix: PID 20732 exited
minix: PID 20733 created
minix: PID 20733 exited
minix: PID 20645 created
minix: PID 20645 exited
minix: PID 20568 created
minix: PID 20567 exited
minix: PID 20734 created
minix: PID 20734 exited
minix: PID 20735 created
minix: PID 20736 created
minix: PID 20736 exited
minix: PID 20735 exited
minix: PID 25983 created
build completed successfully
minix: PID 25981 exited

```

Figure 2: Successful Build

## 1.1 Workload\_mix1

In workload\_mix1.sh the following code is present

```

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

```

The processes here are all arithoh.sh and are CPU intensive processes. We noticed that the quantum is being fully used here. There is no waiting for the command prompt as seen for I/O processes since all the processes are CPU intensive here. The processes can exit in any order since they all have the same priority. The order of the exiting Process IDs that we saw is 413,411,412,414,410. The processes are alternatively scheduled since they all require the CPU. The scheduling is done in a Round Robin fashion because we can see that the print statements are showing "Allotted Quantum is 200" consecutively 5 times indicating that the processes are executing one after the other.

```

Minix: PID 430 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 431 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 432 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 433 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 434 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 435 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 436 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 437 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 438 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 439 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 440 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 441 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0

```

Figure 3: workloadmix1 Execution

```
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 424 exited
    1:16.51 real      15.28 user      0.00 sys
Minix: PID 419 exited
arith0n completed
---
Minix: PID 414 exited
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Minix: PID 420 exited
    1:16.66 real      15.40 user      0.00 sys
Minix: PID 415 exited
arith0n completed
---
Minix: PID 410 exited
Minix: PID 409 exited
#
```

Figure 4: workloadmix1 Completion

## 1.2 Workload\_mix2

In workload\_mix2.sh the following code is present

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

The processes here are all syscall.sh and are System CPU intensive processes. We observe that there is context switching occurring (as the process sits in a loop and keeps on calling getpid function), since the allotted quantum to the process is not being completely used and waiting for I/O is not there. At certain points, the quantum is being fully used while sometimes it is not. We can infer that the processes are CPU intensive but less CPU intensive when compared to arithoh.sh. The exiting order of the processes is the following: PID 427, PID 431, PID 429, PID 428, PID 430. The processes have same priority and are scheduled in a Round Robin fashion as well.

```
1 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
2 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
3 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
4 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
5 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
6 allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
7 allotted Quantum is 200, Used Quantum is 23, Quantum Left to run on the CPU is 17
8
9 allotted Quantum is 200, Used Quantum is 24, Quantum Left to run on the CPU is 17
10 allotted Quantum is 200, Used Quantum is 24, Quantum Left to run on the CPU is 17
11 allotted Quantum is 200, Used Quantum is 24, Quantum Left to run on the CPU is 17
12 allotted Quantum is 200, Used Quantum is 23, Quantum Left to run on the CPU is 17
13
```

Figure 5: workloadmix2 Execution

```

Allotted Quantum is 200, Used Quantum is 41, Quantum Left to run on the CPU is 15
Allotted Quantum is 200, Used Quantum is 41, Quantum Left to run on the CPU is 15
minix: PID 438 exited
    3:39.95 real    13.40 user    29.68 sys
minix: PID 434 exited
syscall completed
...
minix: PID 429 exited
minix: PID 436 exited
    3:40.21 real    13.45 user    31.03 sys
minix: PID 433 exited
syscall completed
...
minix: PID 428 exited
minix: PID 440 exited
    3:40.26 real    13.40 user    31.18 sys
minix: PID 437 exited
syscall completed
...
minix: PID 430 exited
minix: PID 426 exited

```

Figure 6: workloadmix2 Completion

### 1.3 Workload\_mix3

In workload\_mix3.sh the following code is present

```

#!/bin/sh
./arithoh.sh &
./arithoh.sh &
./fstime.sh &
./fstime.sh &
./syscall.sh &
wait

```

The processes here are arithoh.sh, fstime.sh and syscall.sh. We observed that quantums of 500 are being allotted to the processes. Usually driver processes are allotted quantum of 500. We can infer that fstime.sh is an I/O bound process since it finishes earlier. arithoh.sh is a CPU intensive process which completely uses all of its allotted quantum and finishes and exits. Apart from the driver process, all the other processes are user processes which are allotted quantum of 200 by default. Also, the I/O process fstime.sh does not use all of its allotted quantum. The exiting order is shown through the process IDs: 445,446,447,444,443. We can see that fstime.sh exits first followed by syscall.sh and then finally arithoh.sh. In the end, the 2 arithoh.sh processes are scheduled on the CPU one after the other in a Round Robin sense which uses the whole quantum of 200.

```

Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 0, Quantum Left to run on the CPU is 200
Allotted Quantum is 200, Used Quantum is 0, Quantum Left to run on the CPU is 200
Allotted Quantum is 200, Used Quantum is 56, Quantum Left to run on the CPU is 15
...
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 0, Quantum Left to run on the CPU is 200
Allotted Quantum is 200, Used Quantum is 62, Quantum Left to run on the CPU is 13
...
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0

```

Figure 7: workloadmix3 Execution

```

Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 183, Quantum Left to run on the CPU is 1
7
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 450 exited
    2:02.49 real      15.55 user      0.00 sys
minix: PID 441 exited
arithoh completed
--_
minix: PID 443 exited
minix: PID 442 exited

```

Figure 8: workloadmix3 Completion

## 1.4 Workload\_mix4

In workload\_mix4.sh the following code is present

```

#!/bin/sh
./spawn.sh &
./spawn.sh &
./fstime.sh &
./fstime.sh &
./fstime.sh &
wait

```

The processes are spawn.sh and fstime.sh. The spawn.sh creates many child processes which could be seen when several "PID is created" print statements were being generated. These child processes arrive at the same time when current process are running and those child processes are prioritised first. Since new processes get more priority, fstime is scheduled later. We notice that the spawn.sh processes are exiting first followed by the fstime.sh. fstime.sh is an I/O bound process which is allotted quantum of 500. The exiting order of the processes is as follows: PID 460,PID 461,PID 463,PID 462,PID 464.

```

minix: PID 1197 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1198 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1197 exited
minix: PID 1198 exited
minix: PID 1199 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1200 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1199 exited
minix: PID 1200 exited
minix: PID 1201 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1202 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1203 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1204 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
minix: PID 1205 created

```

Figure 9: workloadmix4 Creating many processes

```

Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the CPU is 0
Allotted Quantum is 500, Used Quantum is 377, Quantum Left to run on the CPU is 1
23
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the CPU is 0
Allotted Quantum is 500, Used Quantum is 189, Quantum Left to run on the CPU is 3
11
Allotted Quantum is 200, Used Quantum is 20, Quantum Left to run on the CPU is 18
9
Allotted Quantum is 200, Used Quantum is 20, Quantum Left to run on the CPU is 18
9
Allotted Quantum is 200, Used Quantum is 22, Quantum Left to run on the CPU is 17
3
Write done: 1000000 in 48.5000, score 5195
COUNT1519510iKbps
TIME148.5
Write done: 1000000 in 48.6833, score 5176
COUNT1517610iKbps
TIME148.7
Write done: 1000000 in 48.8167, score 5162
COUNT1516210iKbps
TIME148.8

```

Figure 10: workloadmix4 Execution

```

Minix: PID 470 exited
fstime completed
---
Minix: PID 463 exited
Copy done: 1000004 in 34.8000, score 7183
COUNT1718310iKbps
TIME134.8
Minix: PID 471 exited
1:51.43 real    2.81 user     19.30 sys
Minix: PID 467 exited
fstime completed
---
Minix: PID 462 exited
Copy done: 1000004 in 35.2500, score 7092
COUNT1709210iKbps
TIME135.2
Minix: PID 482 exited
1:52.23 real    2.55 user     20.78 sys
Minix: PID 472 exited
fstime completed
---
Minix: PID 464 exited
Minix: PID 459 exited
#

```

Figure 11: workloadmix4 Completion

## 1.5 Workload\_mix5

In workload\_mix5.sh the following code is present

```

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

```

The processes are all fstime.sh here. fstime.sh is an I/O bound process. We notice that in this workload all the processes execute sequentially in a Round Robin fashion. These I/O bound processes wait for I/O in order to continue executing. They do not utilize their allotted quantum entirely. We notice that their allotted quantum is 500 rather than the default 200. All the processes wait until they receive I/O and then they finish their execution in that sequence. The order of exiting of the processes is as follows: PID 20483, PID 20480, PID 20484, PID 20482, PID 20481.

```

minix: PID 20491 exited
fstime completed
minix: PID 20484 exited
Copy done: 1000004 in 59.4500, score 4205
COUNT14205101KBps
TIME159.5
minix: PID 20492 exited
2:08.35 real 2.76 user 20.40 sys
minix: PID 20489 exited
fstime completed
---
minix: PID 20482 exited
Copy done: 1000004 in 59.6833, score 4188
COUNT141980101KBps
TIME159.7
minix: PID 20490 exited
2:08.65 real 2.85 user 22.45 sys
minix: PID 20487 exited
fstime completed
---
minix: PID 20481 exited
minix: PID 20478 exited

```

Figure 12: workloadmix5 Execution

```

Allocated Quantum is 500, Used Quantum is 500, Quantum Left to run on the CPU is 0
Allocated Quantum is 500, Used Quantum is 210, Quantum Left to run on the CPU is 290
Allocated Quantum is 500, Used Quantum is 500, Quantum Left to run on the CPU is 0
Allocated Quantum is 500, Used Quantum is 201, Quantum Left to run on the CPU is 299
Allocated Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allocated Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allocated Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allocated Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
Allocated Quantum is 500, Used Quantum is 500, Quantum Left to run on the CPU is 0
Allocated Quantum is 500, Used Quantum is 282, Quantum Left to run on the CPU is 218
Allocated Quantum is 200, Used Quantum is 28, Quantum Left to run on the CPU is 172
Allocated Quantum is 200, Used Quantum is 25, Quantum Left to run on the CPU is 175
Allocated Quantum is 200, Used Quantum is 26, Quantum Left to run on the CPU is 174
Allocated Quantum is 200, Used Quantum is 25, Quantum Left to run on the CPU is 175
Allocated Quantum is 200, Used Quantum is 29, Quantum Left to run on the CPU is 171

```

Figure 13: workloadmix5 Completion

## 2 Part 2

In the `minix/servers/sched/schedule.c` file, we made the following changes under the `do_noquantum()` function :

```

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

```

We made these changes so that after a process finishes its quantum, it goes to the priority queue above it. But now we are increasing the priority so that the process goes into some higher priority queue and then continues running in that priority queue. This way we convert the scheduling of processes from round robin to pseudo FIFO. The process that arrives first keeps running till it exits.

In the `balance_queues()` function, we made the following changes:

```

if (rmp->priority > rmp->max_priority)
{
    // rmp->priority -= 1; /* increase priority */
    schedule_process_local(rmp);
}

```

We made these changes to prevent overflowing in the priority queue. When we decrement the priority, there is a possibility for the priority queue to face overflow. So that line is commented out.

Here, we are simulating a FIFO queue instead of really maintaining a real queue. This is called psuedo FIFO. To execute the build on MINIX3, we ran the shell script `run2.sh`:

```
echo "copying files";
cp schedule.c /usr/src/minix/servers/sched/;
echo "going to src directory and building the updated code";
cd /usr/src/;
make build MKUPDATE=yes >log.txt 2>log.txt;
echo "build completed successfully";
exit 0;
```

```
# bash run.sh
copying files
going to src directory and building the updated code
build completed successfully
#_
```

Figure 14: Executing Shell Script

```
Install -N /usr/src/etc -c -p -r ./sbin/init/init >boot/minix/.temp/modll_init
rm ./dev/c0d0p0s0:/boot/minix/3.3.0r12
Done.
Build started at: Sat Feb 4 06:10:09 IST 2023
Build finished at: Sat Feb 4 06:17:24 IST 2023
minix: PID 25081 exited
```

Figure 15: Successful Build

## 2.1 Workload\_mix1

In `workload_mix1.sh` the following code is present

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

The processes here are all `arithoh.sh` and are CPU intensive processes. We noticed that the quantum of 200 is being entirely used here. There is no waiting for the command prompt as seen for I/O processes since all the processes are CPU intensive here. The order of the exiting Process IDs that we saw is 366,363,365,364,367. The processes run one after the other sequentially in a pseudo FIFO order.

```
Alloted Quantum is 200, Used Quantum is 200
```

Figure 16: workloadmix1 Execution

```
          0.00      0.00 sys
sys
      0.00Minix: PID 368 exited
Minix: PID 370 exited
sys
arithoh completed
Minix: PID 369 exited
---
      0.00Minix: PID 366 exited
sys
Minix: PID 372 exited
arithoh completed
arithoh completed
---
---
arithoh completed
---
Minix: PID 363 exited
Minix: PID 365 exited
Minix: PID 364 exited
arithoh completed
---
Minix: PID 367 exited
Minix: PID 362 exited
#
```

Figure 17: workloadmix1 Completion

## 2.2 Workload\_mix2

In workload\_mix2.sh the following code is present

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

The processes here are all syscall.sh and are System CPU intensive processes. The exiting order of the processes is the following: PID 387, PID 386, PID 385, PID 383, PID 384. Here, as all the programs executing are same their priority will be same but they are less CPU intensive as compared to arithoh.sh. Only when one process's execution is stopped, the subsequent process is scheduled since they are being scheduled in a Pseudo FIFO manner. As syscall.sh is a demanding process for the CPU, it utilizes the majority of the time quantum allocated to it by the scheduler.

```
Alloted Quantum is 200, Used Quantum is 200
```

Figure 18: workloadmix2 Execution

```
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 170, Quantum Left to run on the
0
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 171, Quantum Left to run on the
9
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 170, Quantum Left to run on the
0
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 180, Quantum Left to run on the
0
Minix: PID 392 exited
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
    3:28.66 real      19.55 user      22.03 sys
Minix: PID 389 exited
syscall completed
---
Minix: PID 384 exited
Minix: PID 382 exited
#
```

Figure 19: workloadmix2 Completion

## 2.3 Workload\_mix3

In workload\_mix3.sh the following code is present

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

Here arithoh.sh, syscall.sh are CPU intense programs and they are completed earlier in comparison with fstime.sh as I/O process is added to the end of the queue after execution of I/O and get delayed to complete the execution. One can notice that the scheduling is Pseudo FIFO but CPU intense processes exit first as they will use the quantum allotted to them fully and they don't go into blocked state like I/O processes which will be sent to waiting queue when they request for I/O and after completion of I/O they are added to the end of the queue. So the completion order of processes is: 408, 409, 412, 410, 411. SO, both the arithoh.sh exited one after other, later syscall.sh exited and then the fstime.sh exited one after the other which is not as expected which is due to the reason that fstime.sh is added to the end of the queue after the execution of I/O.

```
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Allotted Quantum is 200, Used Quantum is 164, Quantum Left to run on the
6
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Allotted Quantum is 200, Used Quantum is 171, Quantum Left to run on the
9
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 422 exited
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
    41.68 real      19.93 user      21.73 sys
Minix: PID 420 exited
syscall completed
---
Minix: PID 412 exited
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
```

Figure 20: workloadmix3 Execution

```

Alloted Quantum is 500, Used Quantum is 179, Quantum Left to run on the
21
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 169, Quantum Left to run on the
31
Alloted Quantum is 500, Used Quantum is 409, Quantum Left to run on the
1
Copy done: 10000004 in 25.8500, score 9671
COUNT:9671;0;KBps
TIME:25.8
Minix: PID 421 exited
    1:54.55 real    1:54.55 real      3.08 user      3.71 user      2
Minix: PID 416 exited
    22.48 sys
Minix: PID 418 exited
fstime completed
---
Minix: PID 410 exited
fstime completed
---
Minix: PID 411 exited
Minix: PID 407 exited
# _
```

Figure 21: workloadmix3 Completion

## 2.4 Workload\_mix4

In workload\_mix4.sh the following code is present:

```

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

Here, the processes are spawn.sh and fstime.sh. The exiting order of the process IDs is the following: 432,433,434,436,435. We observe that the spawn.sh processes are exiting before the fstime.sh processes. This is because after the fstime.sh processes request for I/O, they go into the waiting queue and after the execution of I/O, they are added to the end of the queue. During that time, the spawn.sh processes run on the CPU and finish their execution. Spawn.sh is CPU bound and so it won't be going to waiting queue. spawn.sh creates many new processes which are added to the queue and execute when their turn comes.

```
Minix: PID 3972 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3971 exited
Minix: PID 3973 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3972 exited
Minix: PID 3974 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3973 exited
Minix: PID 3975 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3974 exited
Minix: PID 3976 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3975 exited
Minix: PID 3977 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3976 exited
Minix: PID 3978 created
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Minix: PID 3977 exited
Minix: PID 3979 created
```

Figure 22: workloadmix4 Execution

```
fstime completed
---
Minix: PID 436 exited
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 21, Quantum Left to run on the
9
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Alloted Quantum is 500, Used Quantum is 171, Quantum Left to run on the
29
Alloted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Copy done: 1000004 in 12.1000, score 20661
COUNT:20661:0:KBps
TIME:12.1
Minix: PID 448 exited
    1:59.26 real      3.88 user      20.18 sys
Minix: PID 442 exited
fstime completed
---
Minix: PID 435 exited
Minix: PID 431 exited
#
```

Figure 23: workloadmix4 Completion

## 2.5 Workload\_mix5

In workload\_mix5.sh the following code is present

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

Here, fstime.sh is an I/O bound process. We can see that the Pseudo FIFO order is not followed necessarily in I/O bound processes from the way the processes are exiting. They are exiting in the order: PID 365, PID 366, PID 367, PID 363, PID 364. This is the reason why this implementation is called pseudo FIFO. Such cases tend to be exceptions. We notice that the I/O bound processes go to the waiting queue after requesting for I/O and are then put back at the end of the ready queue. I/O bound tasks don't always completely use the quantum of 500 allotted to them. Due to this, they end up executing in a Round Robin manner. This is the no change observed when Pseudo FIFO is the scheduling policy. So, finally we could see that after our necessary changes in the code, the CPU intensive were able to be scheduled in a FIFO manner whereas I/O bound processes weren't.

```
Allotted Quantum is 500, Used Quantum is 179, Quantum Left to run on the
21
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Allotted Quantum is 500, Used Quantum is 172, Quantum Left to run on the
28
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Read done: 1000004 in 9.4833, score 26362
COUNT:26362:0:KBps
TIME:9.5
Allotted Quantum is 500, Used Quantum is 500, Quantum Left to run on the
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the
Allotted Quantum is 500, Used Quantum is 161, Quantum Left to run on the
39
```

Figure 24: workloadmix5 Execution

```
24.60 sys
Minix: PID 369 exited
fstime completed
---
Minix: PID 363 exited
fstime completed
-
Minix: PID 364 exited
Minix: PID 362 exited
# ls
Minix: PID 388 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
arithoh.sh      spawn.sh      workload_mix2.sh    workload_mix5.sh
fstime.sh       syscall.sh     workload_mix3.sh
pipe.sh        workload_mix1.sh  workload_mix4.sh
Minix: PID 388 exited
# ls
Minix: PID 389 created
Allotted Quantum is 200, Used Quantum is 200, Quantum Left to run on the CPU is 0
arithoh.sh      spawn.sh      workload_mix2.sh    workload_mix5.sh
fstime.sh       syscall.sh     workload_mix3.sh
pipe.sh        workload_mix1.sh  workload_mix4.sh
Minix: PID 389 exited
#
```

Figure 25: workloadmix5 Completion