OS LAB 5 REPORT

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PART 1:

In this part, first we have removed the process swapped in printf statement from the *schedule.c* program and rebuilt the machine. Then we have made some modifications to *system.c* which is located at /minix/kernel/. We have added the following lines in the *sched_proc* function to know the allotted time quantum and used time quantum for a process.

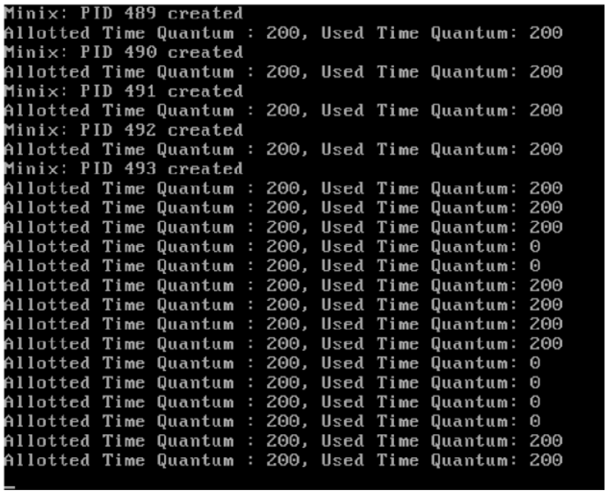
printf("Allotted Time Quantum : %d, Used Time Quantum: %d\n", p->p_quantum_size_ms, p->p_quantum_size_ms-cpu_time_2_ms(p->p_cpu_time_left));

Observations and Inferences:

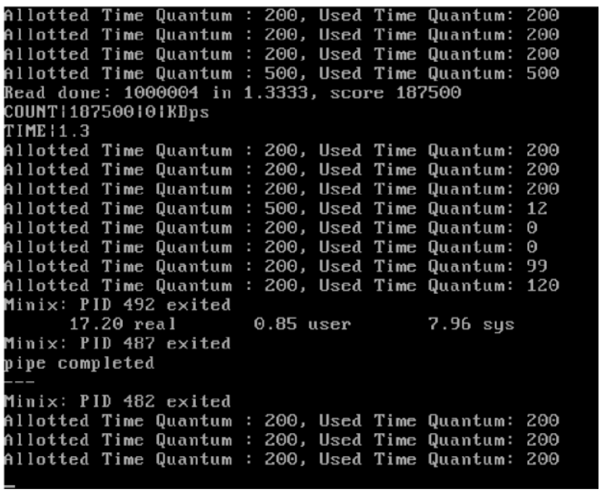
- Workload 1:

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

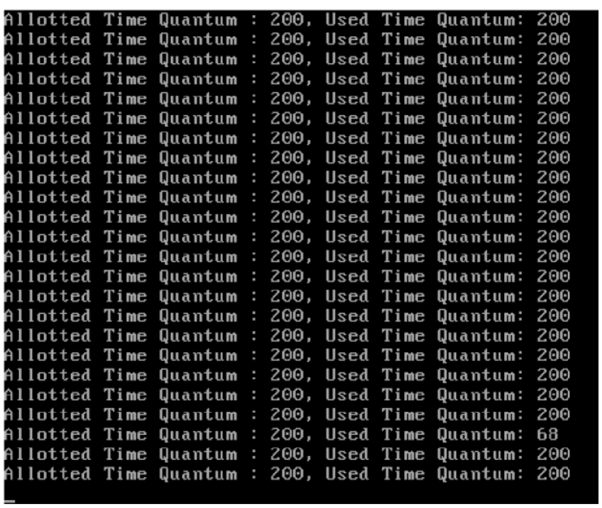
All the 5 processes are executed parallelly in the minix system. Here the time quanta allotted for *arithoh*, *pipe* and *syscall* (CPU intensive) processes is 200 and the time quantum allotted for the *fstime* (I/O bound) process is 500. During the execution, CPU intensive tasks completely used their allotted time quanta each time unless they are completely executed. But for I/O bound task, as it waits for the input, it is blocked, so it cannot completely utilize the time quanta allotted to it. We have observed that these processes are scheduled in Round Robin fashion until they are completely executed.



```
Minix: PID 489 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 490 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 491 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 492 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 493 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
```



```
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
Read done: 1000004 in 1.3333, score 187500
COUNT|187500|0|KBps
TIME|1.3
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 12
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 99
Allotted Time Quantum : 200, Used Time Quantum: 120
Minix: PID 492 exited
      17.20 real        0.85 user        7.96 sys
Minix: PID 487 exited
pipe completed
---
Minix: PID 482 exited
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
```



```
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 68
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
```

Fig. 1 Output of Workload 1

- Workload 2:

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

In this workload, all the 5 processes are *arithoh* and they are executed in Round Robin fashion by the minix3 scheduler. *arithoh* is a CPU intensive process, so the allotted time quantum is 200 by default in minix3. CPU intensive processes fully utilize the allotted time quantum every time they are scheduled as they don't need to wait for I/O. Here all the 5 processes are the same, so they took almost the same time to execute. In this case, the first scheduled process will be the first completed process.

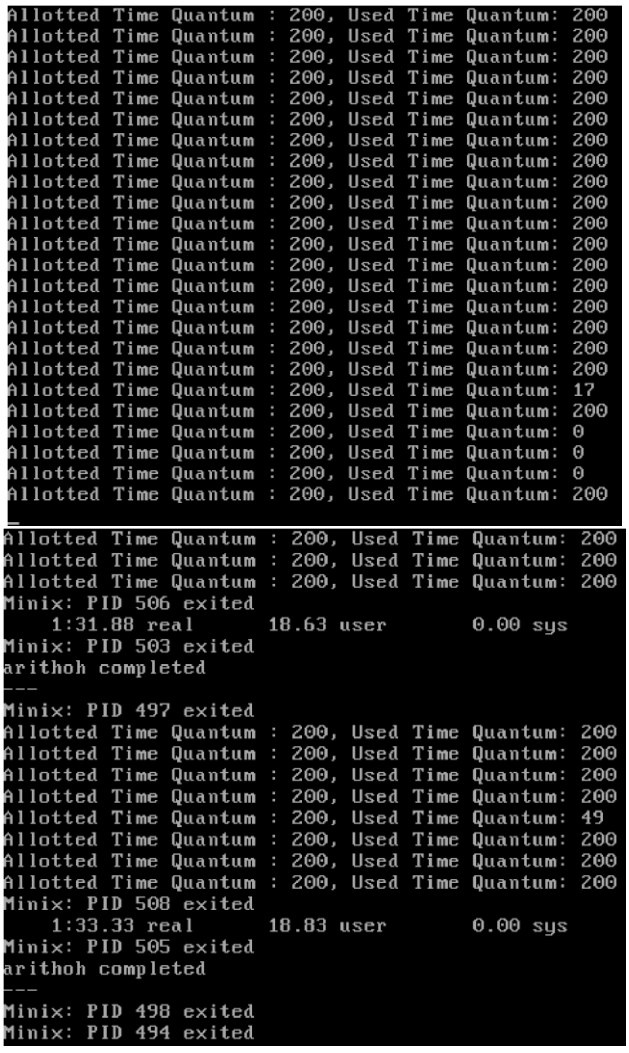
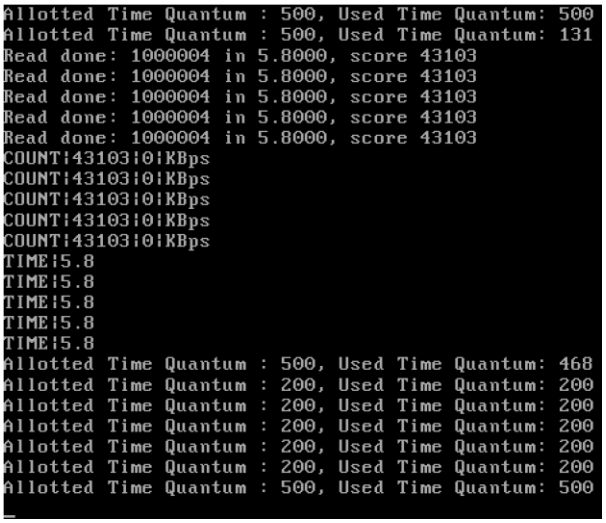


Fig. 2 Output of Workload 2

❖ Workload 3:

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

In this workload, all the 5 processes are *fstime*. They are executed in Round Robin fashion by the minix3 scheduler. *fstime* is an I/O bound process, so the allotted time quantum is 500 by default in minix3. I/O bound processes do not fully utilize the allotted time quantum every time they are scheduled as they have to wait for I/O. Here all the 5 processes are I/O bound, so they wait for I/O and then utilize the CPU. Here all the processes wait for I/O and whichever process receives I/O will be resumed to utilize the remaining time quantum.



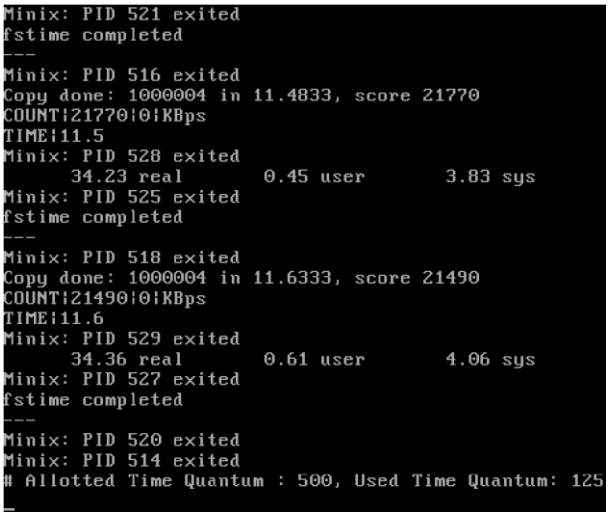


Fig. 3 Output of Workload 3

❖ Workload 4:

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

In this workload, all the 5 processes are *syscall* and they are executed in Round Robin fashion by the minix3 scheduler. *syscall* is a CPU intensive process, so the allotted time quantum is 200 by default in minix3. Here *syscall* is not as CPU intensive as *arithoh*, so the CPU is not fully utilized in the allotted time quantum. Here all the 5 processes are the same, so they took almost the same time to execute.

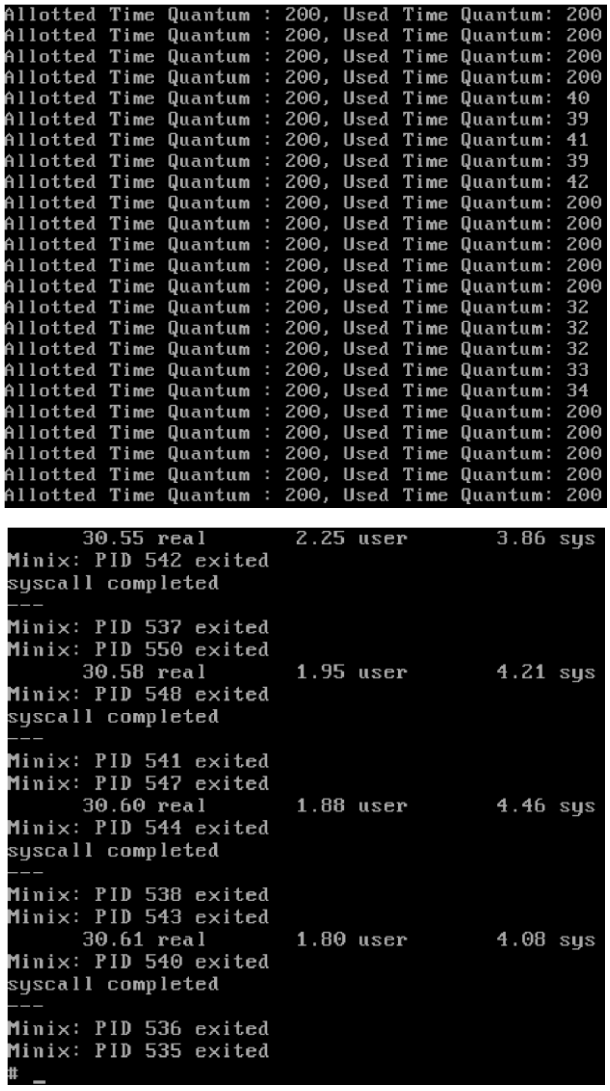


Fig. 4 Output of Workload 4

PART 2:

In this second part, we have modified the user-level scheduler in Minix3 to follow Pseudo-FIFO policy which is among the user-level processes that are ready to execute, the one that entered the earliest must be scheduled.

For this we have modified the 'schedule.c' file in 'minix/servers/sched' .

In this file I have modified the 'do_noquantum()', I have replaced the line

rmp->priority += 1; /* lower priority */

with rmp->priority -= 1; /* lower priority */

In the 'balance_queues()' function I have removed the line rmp->priority -= 1;.

After these modifications I made the build and rebooted the system and it started to use the Pseudo-FIFO policy.

Observations and Inferences:

- Workload 1:

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

In this workload, we have five processes in which the first two are *arithoh*, third is *fstime*, fourth is *pipe* and fifth is *syscall*. The scheduler implements the Pseudo FIFO, so whichever process comes first into the ready queue executes first. So we expect that the processes will be completed in the order *arithoh, arithoh, fstime, pipe, syscall*. But the order we observed is *arithoh, arithoh, syscall, pipe, fstime*. This is because as though we use Pseudo FIFO policy, I/O bound processes have to wait in the wait queue for I/O, after receiving the I/O, they will be placed back in the ready queue.

```
       0.00 sys
Minix: PID 371 exited
arithoh completed
---
Minix: PID 363 exited
arithoh completed
---
Minix: PID 362 exited
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
```

```
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 372 exited
      54.21 real       2.26 user       5.50 sys
Minix: PID 367 exited
syscall completed
---
Minix: PID 366 exited
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
Allotted Time Quantum : 500, Used Time Quantum: 500
Minix: PID 376 exited
    1:05.71 real       0.96 user      12.76 sys
Minix: PID 368 exited
pipe completed
---
Minix: PID 365 exited
Write done: 1008000 in 12.4333, score 20268
COUNT¦20268¦0¦KBps
TIME¦12.4
_
```

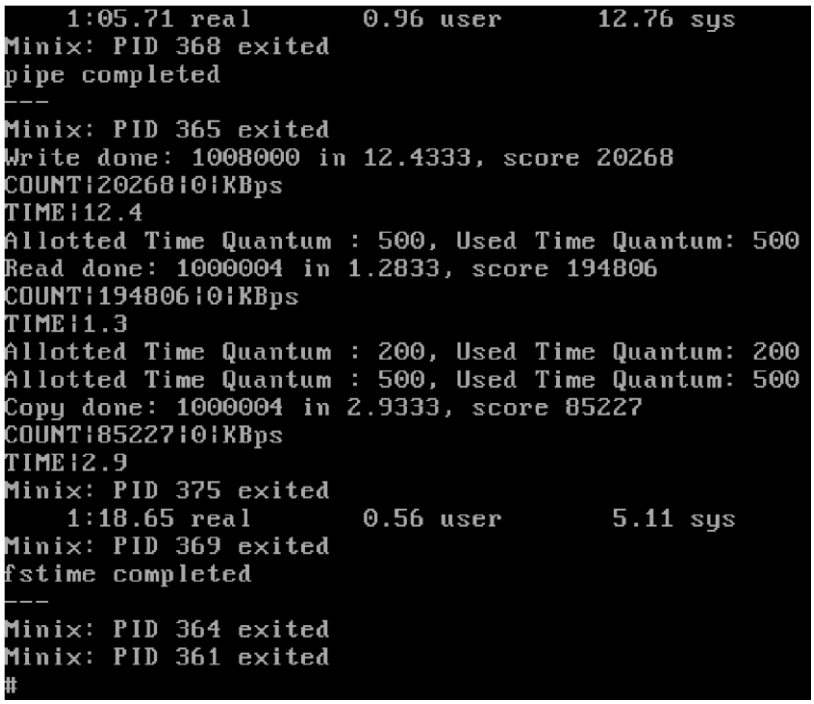


Fig. 5 Output of Workload 1 - Pseudo-FIFO

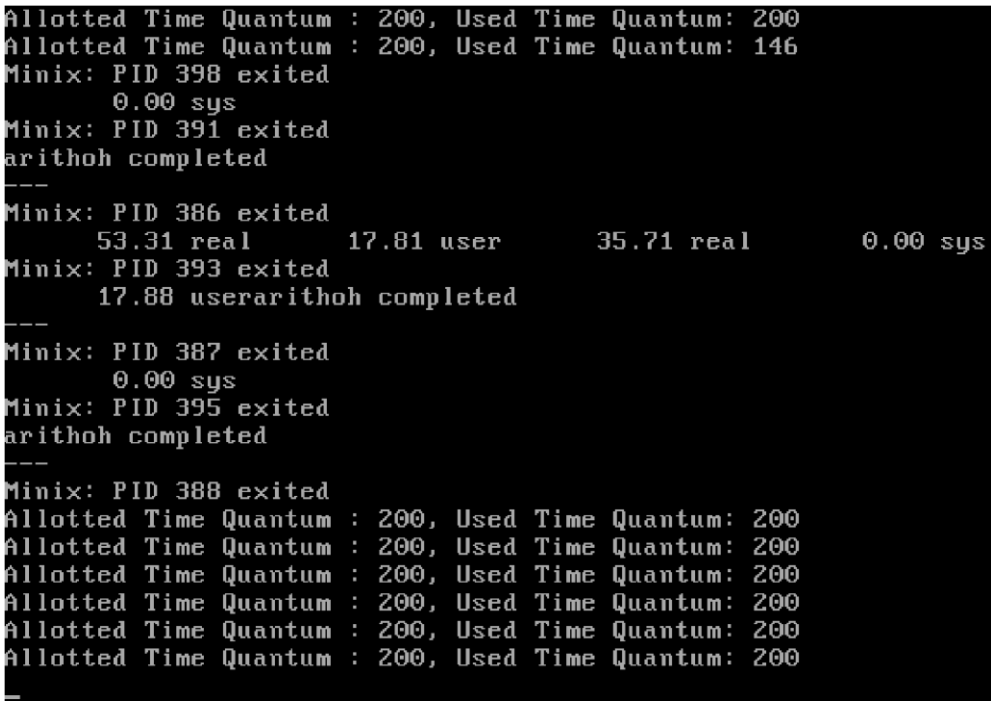
❖ Workload 2:

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

In this workload, all the processes are CPU intensive processes. They will be completely executed one after the other in First Come First Served fashion. They fully utilize the CPU in their allotted 200 time quanta as they are CPU intensive. Another process is scheduled only if the current executing process is completely executed.

```
Minix: PID 395 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
_
```

```
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 84
Minix: PID 396 exited
Minix: PID 389 exited
      17.78 userarithoh completed
---
Minix: PID 385 exited
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
_
```



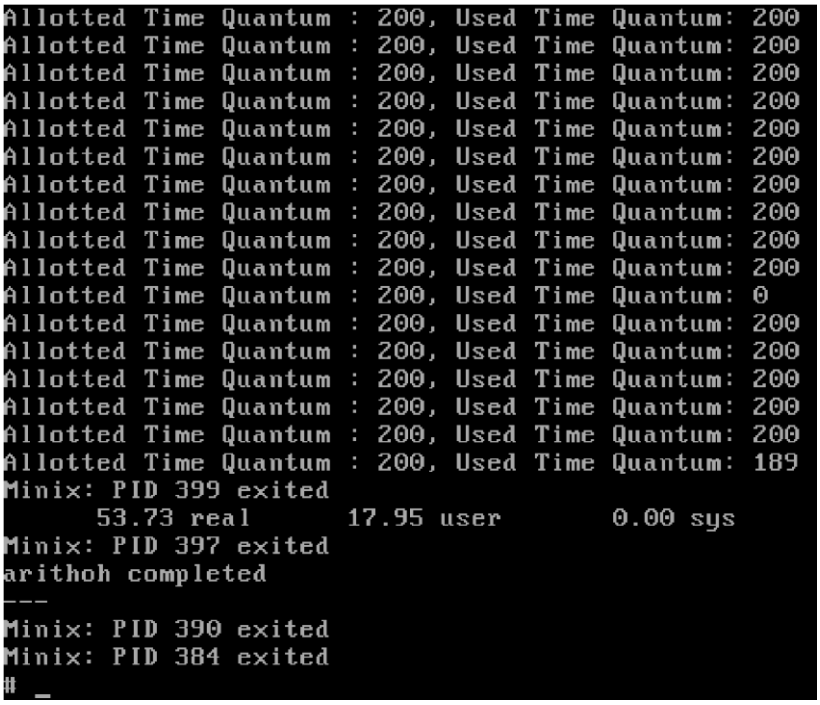


Fig. 6 Output of Workload 2 - Pseudo-FIFO

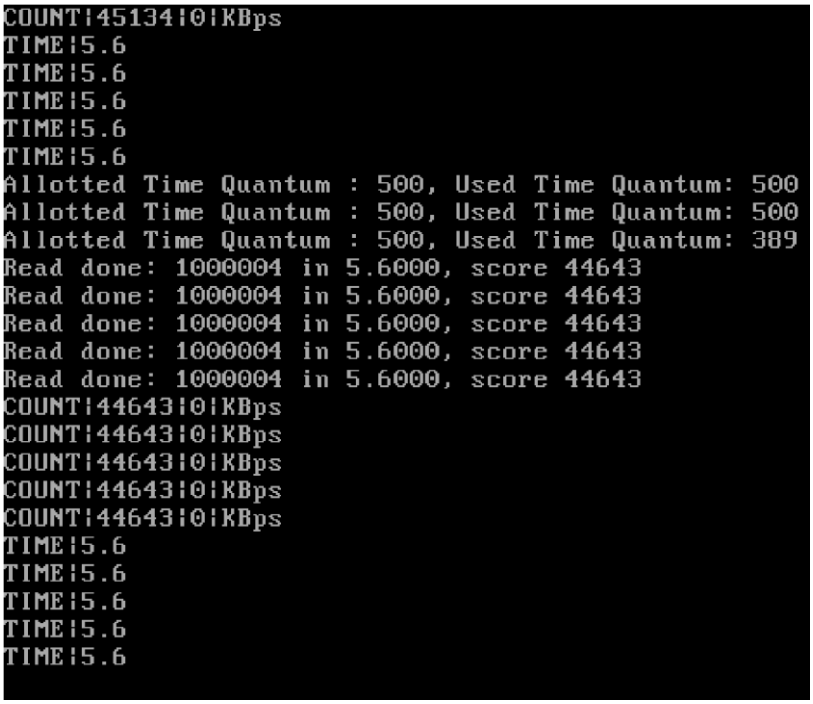
❖ Workload 3:

#!/bin/sh

./fstime.sh &
./fstime.sh &
./fstime.sh &
./fstime.sh &
./fstime.sh &
wait

In this workload, all the five processes are I/O bound processes (*fstime*). Here from the output we can observe that the FIFO policy is not followed properly. This is because I/O bound processes are sent to the waiting queue after requesting for I/O and when the I/O is received, they are placed back in the ready queue and scheduled to utilize the CPU.

```
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 414 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 415 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 416 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 500
Allotted Time Quantum : 500, Used Time Quantum: 500
Write done: 1008000 in 5.5833, score 45134
Write done: 1008000 in 5.5833, score 45134
Write done: 1008000 in 5.5833, score 45134
Write done: 1008000 in 5.5833, score 45134
Write done: 1008000 in 5.5833, score 45134
COUNT|45134|0|KBps
COUNT|45134|0|KBps
COUNT|45134|0|KBps
COUNT|45134|0|KBps
COUNT|45134|0|KBps
TIME|5.6
TIME|5.6
TIME|5.6
TIME|5.6
TIME|5.6
_
```



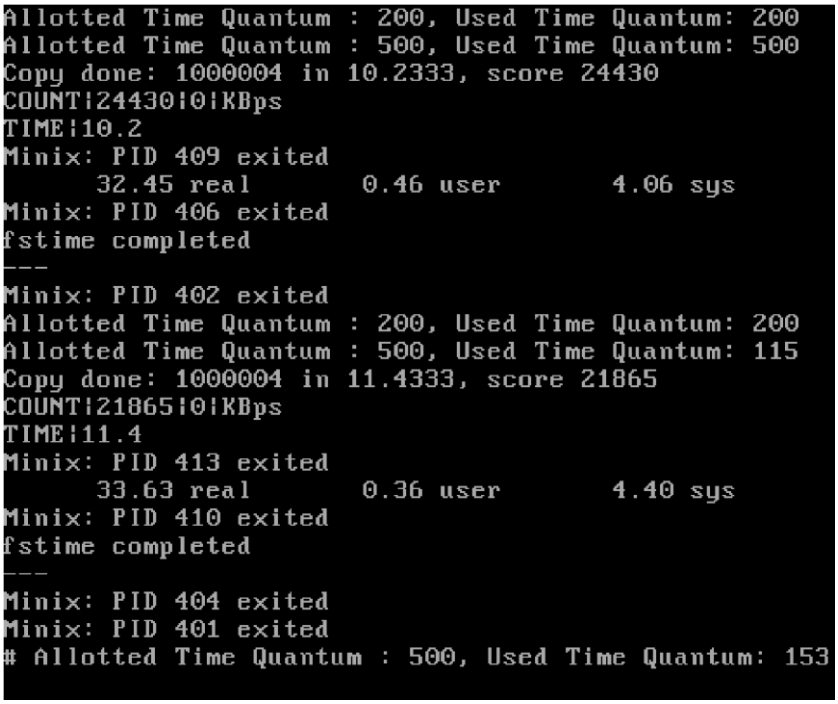


Fig. 7 Output of Workload 3 - Pseudo-FIFO

❖ Workload 4:

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

./syscall.sh &
./syscall.sh &
wait

In this workload, all the processes are CPU intensive processes (*syscall*) but not as CPU intensive as *arithoh*. They will be completely executed one after the other in First Come First Served fashion. They fully utilize the CPU in their allotted 200 time quanta as they are CPU intensive. Another process is scheduled only if the current executing process is completely executed.

```
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 442 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 443 created
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 1
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 0
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Minix: PID 443 exited
       9.05 real       1.93 user       3.91 sys
Minix: PID 441 exited
syscall completed
---
Minix: PID 434 exited
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 500, Used Time Quantum: 1
Allotted Time Quantum : 200, Used Time Quantum: 200
Allotted Time Quantum : 200, Used Time Quantum: 200
```

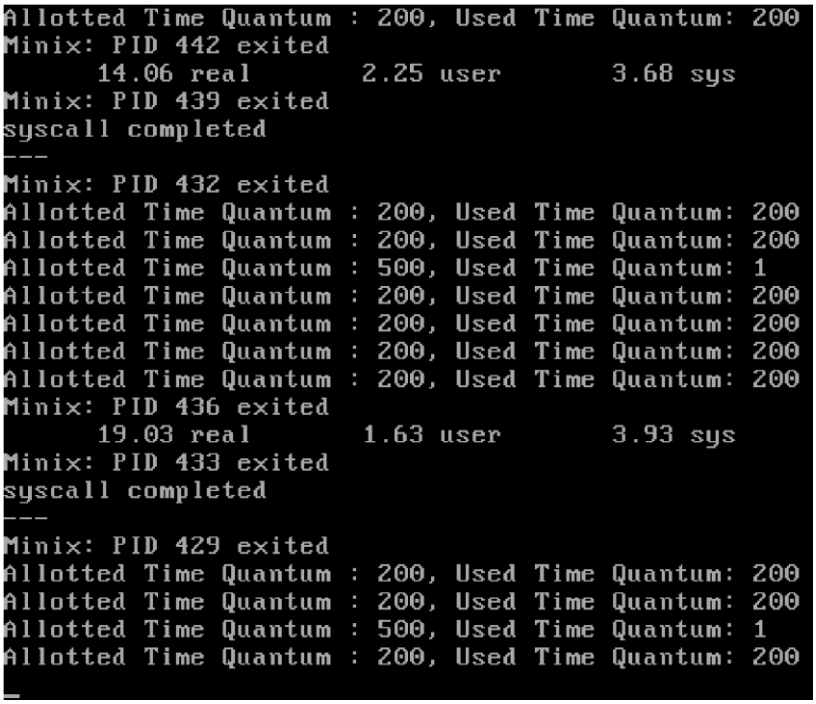


Fig. 8 Output of Workload 4 - Pseudo-FIFO

We can observe from workload 1 and workload 3 that FIFO policy is not properly followed, only CPU intensive processes are able to follow the FIFO policy whereas I/O bound processes can't. So we call it Pseudo FIFO policy.