

# Lab6 Report

210010054

Suyash Gaurav

## Part 1:

- **The task** is to create four workload mixes, each with different levels of computational and I/O intensity. These mixes range from entirely compute-focused to purely I/O-driven, with variations in between. Each workload will spawn approximately five background processes, utilizing benchmarks from UnixBench or custom-made ones.

### Some Commands:

- **'time' command:** The time command in Minix3 can be used to measure the execution time of a command or script. It has three different time measurements:
  - **Real-Time:** It provides the total time the process takes to complete, including time spent waiting for resources.
  - **User Time:** It represents the CPU time spent executing the process in user mode, indicating the actual computation performed by the application.
  - **System Time:** It represents the CPU time spent in the kernel or system mode, indicating the overhead related to system calls and kernel-level activities.

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- **'top' command:** It is used to monitor CPU usage in real-time.

## Running benchmarks:

- **Repeated arithoh (entirely compute-focused):**

Now I have run repeated arithoh which is a CPU bound process. Following are the observations:

```
1  #!/bin/sh
2  ./arithoh.sh &
3  ./arithoh.sh &
4  ./arithoh.sh &
5  ./arithoh.sh &
6  ./arithoh.sh &
7  wait
```

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
426	root	11	0	724K	RUN	0:01	20.69%	arithoh
423	root	11	0	724K	RUN	0:01	20.47%	arithoh
424	root	11	0	724K	RUN	0:01	20.43%	arithoh
425	root	11	0	724K	RUN	0:01	20.03%	arithoh
427	root	10	0	724K	RUN	0:01	17.07%	arithoh
-1	root	0		2802K		0:00	0.70%	kernel
9	root	1	0	180K		0:01	0.26%	tty
11	root	2	0	8496K		0:00	0.12%	vm
7	root	5	0	1216K		0:00	0.11%	vfs
40	root	7	0	1208K	RUN	0:00	0.03%	procfs
49	service	5	0	5672K		0:00	0.02%	mfs
401	root	7	0	652K		0:00	0.02%	top
107	root	7	0	188K		0:00	0.01%	devmand
79	root	7	0	200K		0:00	0.01%	devman
5	root	4	0	596K		0:00	0.01%	pm
176	root	7	0	312K		0:00	0.01%	syslogd
134	root	7	0	112K		0:00	0.01%	lance
73	service	5	0	64900K		0:00	0.00%	mfs
139	service	7	0	1152K		0:00	0.00%	inet
155	service	2	0	148K		0:00	0.00%	log
6	root	4	0	48K		0:00	0.00%	sched

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```
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
Minix 210010054: PID 200 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32972
Minix 210010054: PID 204 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
Minix 210010054: PID 205 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
Minix 210010054: PID 200 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32972
Minix 210010054: PID 204 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32969
Minix 210010054: PID 201 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
Minix 210010054: PID 205 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
Minix 210010054: PID 200 swapped in
```

## repeated arithoh swapping

I noticed that tasks, labeled with Endpoint 32968, 32972, 32973, 32970 and 32969 (corresponding PIDs 200, 204, 205, 202, 201), keep appearing over and over again (Round Robin fashion). Each time they show up, they use up all the time slice they're given to work on , which is about 200 ms. This makes us more certain that a script called 'arithoh.sh' is really focused on using the CPU a lot.

42.68 real arithoh completed	8.96 user	0.00 sys
44.85 real arithoh completed	8.90 user	0.00 sys
45.16 real arithoh completed	9.20 user	0.01 sys
45.40 real arithoh completed	9.20 user	0.00 sys
45.65 real arithoh completed	9.31 user	0.01 sys

## repeated arithoh completion (round-robin)

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- **Repeated fstime: (purely I/O driven)**

Now I have run repeated fstime which is a I/O bound process. Following are the observations:

```
1  #!/bin/sh
2  ./fstime.sh &
3  ./fstime.sh &
4  ./fstime.sh &
5  ./fstime.sh &
6  ./fstime.sh &
7  wait
```

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
7	root	5	0	1220K		0:03	37.90%	vfs
-1	root	0		2802K		0:00	35.25%	kernel
76	service	5	0	2700K		0:02	20.34%	mfs
386	root	7	0	752K	RUN	0:00	1.34%	fstime ←
384	root	7	0	752K	RUN	0:00	1.26%	fstime ←
385	root	7	0	752K	RUN	0:00	1.26%	fstime ←
383	root	7	0	752K	RUN	0:00	1.23%	fstime ←
382	root	7	0	752K	RUN	0:00	1.21%	fstime ←
11	root	2	0	6188K		0:00	0.11%	vm
40	root	7	0	1208K	RUN	0:00	0.03%	procfs
361	root	7	0	652K		0:00	0.02%	top
49	service	5	0	5664K		0:00	0.02%	mfs
79	root	7	0	200K		0:00	0.01%	devman
107	root	7	0	188K		0:00	0.01%	devmand
5	root	4	0	596K		0:00	0.01%	pm
134	root	7	0	112K		0:00	0.00%	lance
139	service	7	0	1152K		0:00	0.00%	inet
305	root	7	0	2440K		0:00	0.00%	sshd
143	service	7	0	204K		0:00	0.00%	pty
4	root	4	0	1196K		0:00	0.00%	rs
164	root	7	0	104K		0:00	0.00%	vbox

top command

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```
COUNT:27322:0:KBps
TIME:9.2
 29.85 real      0.35 user      3.31 sys
fstime completed
--
# Time Slice: 500, Time Slice Executed: 279 Endpoint: 65560
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
```

```
TIME:4.7
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 62 Endpoint: 65560
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 33000
Minix 210010054: PID 232 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 33007
Minix 210010054: PID 239 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 33002
Minix 210010054: PID 234 swapped in
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 39 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 1 Endpoint: 33000
Minix 210010054: PID 232 swapped in
Time Slice: 200, Time Slice Executed: 1 Endpoint: 33002
Minix 210010054: PID 234 swapped in
Time Slice: 200, Time Slice Executed: 1 Endpoint: 33007
Minix 210010054: PID 239 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 33004
Minix 210010054: PID 236 swapped in
```

The I/O-bound processes run in a round-robin fashion, just as we anticipated. Looking at the figures provided, we can see that they don't utilize the full allotted time slice. This leads us to a clear conclusion: fstime.sh is definitely I/O-bound.

```
Write done: 1008000 in 4.8333, score 52137
COUNT:52137:0:KBps
COUNT:52137:0:KBps
COUNT:52137:0:KBps
COUNT:52137:0:KBps
COUNT:52137:0:KBps
```

**repeated fstime completion  
(round-robin)**

```
COUNT:30864:0:KBps
TIME:8.1
TIME:8.1
TIME:8.1
TIME:8.1
 28.98 real      28.98 real      28.98 real      28.98 real      0.48 user
  0.16 user      0.26 user      0.41 user      3.43 sys
  3.43 sys
  3.48 sys
fstime completed
  2.90---
  sys
fstime completed
---
fstime completed
---
fstime completed
---
Copy done: 1000004 in 8.5833, score 29126
COUNT:29126:0:KBps
TIME:8.6
 29.43 real      0.51 user      3.26 sys
fstime completed
```

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- **repeated syscall:**

Now I have run repeated syscall. It will flood with many system calls, thus increase in sys-time. Following are the observations:

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

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
7	root	5	0	1212K		0:26	34.33%	vfs
-1	root	0		2802K		0:00	33.76%	kernel
5	root	4	0	596K		0:03	10.28%	pm
284	root	7	0	712K	RUN	0:01	4.35%	syscall ←
283	root	7	0	712K	RUN	0:00	4.30%	syscall ←
289	root	7	0	712K	RUN	0:01	4.22%	syscall ←
285	root	7	0	712K	RUN	0:01	4.21%	syscall ←
288	root	7	0	712K	RUN	0:00	4.12%	syscall ←
9	root	1	0	180K		0:00	0.22%	tty
11	root	2	0	5364K		0:00	0.11%	vm
40	root	7	0	1208K	RUN	0:00	0.03%	procfs
273	root	7	0	656K		0:00	0.02%	top
49	service	5	0	8204K		0:00	0.02%	mfs
79	root	7	0	200K		0:00	0.01%	devman
107	root	7	0	188K		0:00	0.01%	devmand
175	root	7	0	312K		0:00	0.01%	syslogd
134	root	7	0	112K		0:00	0.00%	lance
139	service	7	0	1152K		0:00	0.00%	inet
73	service	5	0	11112K		0:00	0.00%	mfs
155	service	2	0	148K		0:00	0.00%	log
269	root	7	0	2468K		0:00	0.00%	sshd

*top command*

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```
Time Slice: 200, Time Slice Executed: 154 Endpoint: 65605
Minix 210010054: PID 69 swapped in
Time Slice: 200, Time Slice Executed: 154 Endpoint: 65606
Minix 210010054: PID 70 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65603
Minix 210010054: PID 67 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65601
Minix 210010054: PID 65 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65599
Minix 210010054: PID 63 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65606
Minix 210010054: PID 70 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65605
Minix 210010054: PID 69 swapped in
Time Slice: 200, Time Slice Executed: 6 Endpoint: 65599
Minix 210010054: PID 63 swapped in
Time Slice: 200, Time Slice Executed: 6 Endpoint: 65601
Minix 210010054: PID 65 swapped in
Time Slice: 200, Time Slice Executed: 6 Endpoint: 65603
Minix 210010054: PID 67 swapped in
Time Slice: 200, Time Slice Executed: 6 Endpoint: 65605
Minix 210010054: PID 69 swapped in
Time Slice: 200, Time Slice Executed: 6 Endpoint: 65606
Minix 210010054: PID 70 swapped in
```

## repeated syscall swapping

Thus we observe Round Robin scheduling here also. Again the time slice is not totally used thus, we can conclude that it is less cpu-intensive than *arithoh.sh*.

22.86 real syscall completed	1.71 user	2.85 sys
---		
22.96 real syscall completed	1.35 user	3.33 sys
---		
23.00 real syscall completed	1.33 user	3.25 sys
---		
23.03 real syscall completed	1.75 user	3.18 sys
---		
23.06 real syscall completed	1.40 user	2.88 sys
---		

## repeated syscall completion (round-robin)

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- **arithoh and fstime:**

*arithoh* being CPU-bound and *fstime* being a I/O bound process. We observe that arithoh swaps occur when fstime waits for I/O.

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

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
341	root	15	0	712K	RUN	0:03	32.85%	arithoh
334	root	15	0	712K	RUN	0:03	26.09%	arithoh
338	root	15	0	712K	RUN	0:03	14.59%	arithoh
-1	root	0		2802K		0:00	9.77%	kernel
7	root	5	0	1212K		0:53	9.61%	vfs
76	service	5	0	4736K		0:15	5.11%	mfs
336	root	7	0	744K	RUN	0:00	1.21%	fstime
340	root	7	0	744K	RUN	0:00	0.36%	fstime
9	root	1	0	180K		0:01	0.17%	tty
11	root	2	0	5372K		0:00	0.10%	vm
49	service	5	0	8204K		0:00	0.03%	mfs
40	root	7	0	1208K	RUN	0:00	0.02%	procfs
273	root	7	0	656K		0:00	0.02%	top
73	service	5	0	11136K		0:00	0.01%	mfs
79	root	7	0	200K		0:00	0.01%	devman
107	root	7	0	188K		0:00	0.01%	devmand
5	root	4	0	596K		0:12	0.01%	pm
32	service	7	0	188K		0:01	0.01%	at_wini
175	root	7	0	312K		0:00	0.01%	syslogd
134	root	7	0	112K		0:00	0.00%	lance
139	service	7	0	1152K		0:00	0.00%	inet

top command

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```
Minix 210010054: PID 100 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65640
Minix 210010054: PID 104 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65643
Minix 210010054: PID 107 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65640
Minix 210010054: PID 104 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65643
Minix 210010054: PID 107 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65636
Minix 210010054: PID 100 swapped in
Time Slice: 500, Time Slice Executed: 192 Endpoint: 65560
Time Slice: 200, Time Slice Executed: 0 Endpoint: 65636
Minix 210010054: PID 100 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65640
Minix 210010054: PID 104 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65643
Minix 210010054: PID 107 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65643
Minix 210010054: PID 107 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65636
Minix 210010054: PID 100 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65640
Minix 210010054: PID 104 swapped in
```

## arithoh and fstime swapping

This benchmark comprised of *arithoh* and *fstime*. We observe Round Robin scheduling here also. *fstime* being a I/O process completed first followed by *arithoh* being a CPU bound process. It is also observed that when *fstime* goes for I/O, swaps for *arithoh* occurs.

```
      17.03 real      0.38 user      2.93 sys
fstime completed
---
Copy done: 1000004 in 2.7333, score 91463
COUNT:91463:0:KBps
TIME:2.7
      17.06 real      0.38 user      2.83 sys
fstime completed
---
      32.86 real      9.30 user      0.08 sys
arithoh completed
---
      33.63 real      9.41 user      0.00 sys
arithoh completed
---
      34.35 real      9.23 user      0.00 sys
arithoh completed
---
```

## arithoh & fstime completion (round-robin)

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- **fstime & syscall & ftime:**

Now I have run ftime (I/O process), syscall and arithoh (CPU process) to observe the swaps. In this case, the kernel activities parts of the syscall code swap in when ftime waits for I/O.

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

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
7	root	5	0	1212K		1:04	33.47%	vfs
-1	root	0	0	2802K		0:00	32.35%	kernel
76	service	6	0	4736K		0:19	11.30%	mfs
374	root	9	0	712K	RUN	0:00	7.00%	arithoh ←
5	root	4	0	596K		0:13	4.23%	pm
370	root	8	0	712K	RUN	0:01	4.19%	syscall ←
377	root	8	0	712K	RUN	0:01	4.17%	syscall ←
376	root	7	0	744K		0:00	1.60%	ftime ←
372	root	7	0	744K		0:00	1.43%	ftime ←
11	root	2	0	5380K		0:00	0.10%	vm
9	root	1	0	180K		0:01	0.05%	tty
40	root	7	0	1208K	RUN	0:00	0.02%	procfs
49	service	5	0	8204K		0:00	0.02%	mfs
273	root	7	0	656K		0:00	0.02%	top
107	root	7	0	188K		0:00	0.01%	devmand
79	root	7	0	200K		0:00	0.01%	devman
73	service	5	0	11184K		0:00	0.01%	mfs
32	service	7	0	188K		0:01	0.01%	at_wini
134	root	7	0	112K		0:00	0.00%	lance
139	service	7	0	1152K		0:00	0.00%	inet
175	root	7	0	312K		0:00	0.00%	syslogd

top command

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```
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65681
Minix 210010054: PID 145 swapped in
Time Slice: 200, Time Slice Executed: 0 Endpoint: 65676
Minix 210010054: PID 140 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65676
Minix 210010054: PID 140 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65681
Minix 210010054: PID 145 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65672
Minix 210010054: PID 136 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65676
Minix 210010054: PID 140 swapped in
Time Slice: 200, Time Slice Executed: 150 Endpoint: 65672
Minix 210010054: PID 136 swapped in
Time Slice: 200, Time Slice Executed: 0 Endpoint: 65676
Minix 210010054: PID 140 swapped in
Time Slice: 200, Time Slice Executed: 150 Endpoint: 65681
Minix 210010054: PID 145 swapped in
Write done: 1008000 in 2.1667, score 116307
Write done: 1008000 in 2.1667, score 116307
COUNT:116307|0|KBps
COUNT:116307|0|KBps
TIME:2.2
TIME:2.2
```

## *arithoh and fstime & syscall swapping*

This benchmark comprised of *arithoh* and *fstime* and *syscall*. We observe Round Robin scheduling here also. *syscall* being a kernel process completes first followed by *fstime* being a I/O process completed second followed by *arithoh* being a CPU bound process. It is also observed that when *fstime* goes for I/O, swaps for *arithoh* occurs.

```
14.06 real      1.63 user      3.00 sys
syscall completed
---
13.85 real      1.61 user      3.28 sys
syscall completed
---
Copy done: 1000004 in 2.9833, score 83799
Copy done: 1000004 in 2.9833, score 83799
COUNT:83799|0|KBps
COUNT:83799|0|KBps
TIME:3.0
TIME:3.0
17.88 real      17.88 real      0.36 user      0.35 user      3.31 sys
2.55 sys
fstime completed
---
fstime completed
---
25.18 real      9.01 user      0.00 sys
arithoh completed
---
```

## *arithoh & fstime & syscall completion (round-robin)*

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## Part 2:

- **Task**: Modify the user-level scheduler in Minix3 to the following “Pseudo-FIFO” policy: among the user-level processes that are ready to execute, the one that entered the earliest must be scheduled.
- In *minix/servers/sched/schedule.c*, in function *int do\_noquantum(message \*m\_ptr)* is changed **as**:
  - *rmp->priority -= 1;*
- **This** ensures that for a new coming process, priority of process will get decrease, thus prevent preemption and the process executing will be processed until it goes to block state.

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## Running Workloads:

- Repeated arithoh  
(entirely compute-focused):

```
1  #!/bin/sh
2  ./arithoh.sh &
3  ./arithoh.sh &
4  ./arithoh.sh &
5  ./arithoh.sh &
6  ./arithoh.sh &
7  wait
```

```
11.25 real      11.25 user      20.68      0.00 real sys
arithoh completed
9.41---
user      18.58      0.00 real sys
arithoh completed
---
9.15 user      0.00 sys
18.11 real arithoh completed
---
8.96 user      17.91 real      0.00 sys
arithoh completed
---
8.93 user      0.00 sys
arithoh completed
---
```

## repeated arithoh completion (Pseudo FIFO)

- I have run 5 arithoh (cpu bound) processes, and swapping between process is happening sequentially, i.e. 98339 -> 98341, 98341 -> 65575, 65575 -> 65577, 65577 -> 65578 as shown in following screenshots. Hence, showing pseudo FIFO behaviour.

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```
File Machine View Input Devices Help
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 73 Endpoint: 98339
Minix 210010054: PID 35 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98339
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 40 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
```

**98339 -> 98341 (FIFO)**

```
File Machine View Input Devices Help
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 98341
Minix 210010054: PID 37 swapped in
Time Slice: 200, Time Slice Executed: 68 Endpoint: 98341
Minix 210010054: PID 41 swapped in
10.55 real      10.55 userTime Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
```

**98341 -> 65575 (FIFO)**

# Lab3 Report

210010054

Suyash Gaurav

```
MINIX3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 151 Endpoint: 65575
Minix 210010054: PID 39 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Minix 210010054: PID 42 swapped in
  19.90 real      0.00 sys
  9.33arithoh completed
user---
  18.68 realTime Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
_
```

65575 -> 65577 (FIFO)

```
MINIX3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Minix 210010054: PID 41 swapped in
Time Slice: 200, Time Slice Executed: 0 Endpoint: 65577
Minix 210010054: PID 41 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Minix 210010054: PID 41 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Minix 210010054: PID 41 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65577
Minix 210010054: PID 41 swapped in
Time Slice: 200, Time Slice Executed: 15 Endpoint: 65577
Minix 210010054: PID 41 swapped in
  0.00 sys
arithoh completed
---
  9.30 userTime Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65578
Minix 210010054: PID 42 swapped in
_
```

65577 -> 65578(FIFO)

# Lab3 Report

210010054

Suyash Gaurav

- Repeated fstime: (purely I/O driven)

```
COUNT:4799910:KBps
COUNT:4799910:KBps
COUNT:4799910:KBps
COUNT:4799910:KBps
TIME:5.2
TIME:5.2
TIME:5.2
TIME:5.2
TIME:5.2
Read done: 1000004 in 5.0000, score 50000
COUNT:5000010:KBps
COUNT:5000010:KBps
COUNT:5000010:KBps
COUNT:5000010:KBps
COUNT:5000010:KBps
TIME:5.0
TIME:5.0
TIME:5.0
TIME:5.0
TIME:5.0
```

```
1  #!/bin/sh
2  ./fstime.sh &
3  ./fstime.sh &
4  ./fstime.sh &
5  ./fstime.sh &
6  ./fstime.sh &
7  wait
```

```
29.23 real      0.43 user      3.98 sys
fstime completed
---
Copy done: 1000004 in 8.5500, score 29239
COUNT:2923910:KBps
TIME:8.5
29.90 real      0.41 user      3.53 sys
fstime completed
---
Copy done: 1000004 in 9.1667, score 27272
COUNT:2727210:KBps
TIME:9.2
30.50 real      0.38 user      3.80 sys
fstime completed
---
Copy done: 1000004 in 9.6500, score 25906
COUNT:2590610:KBps
TIME:9.7
30.98 real      0.31 user      3.41 sys
fstime completed
---
```

*repeated fstime completion (Pseudo FIFO)*

# Lab3 Report

210010054

Suyash Gaurav

```
TIME:4.9
TIME:4.9
TIME:4.9
TIME:4.9
TIME:4.9
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65594
Time Slice: 500, Time Slice Executed: 167 Endpoint: 65560
Minix 210010054: PID 24 swapped in

fstime completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65587
Copy done: 1000004 in 9.0000, score 27777
COUNT:27777@1KBps
TIME:9.0
    29.90 real      0.28 user      3.68 sys
fstime completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65593
Copy done: 1000004 in 9.4167, score 26548
COUNT:26548@1KBps
TIME:9.4
    30.33 real      0.36 user      3.53 sys
fstime completed
---
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
```

## Repeating fstime swapping (Pseudo FIFO)

- Thus, we observe that repeated fstime workload is not following FIFO as if one process goes for I/O it will get blocked and another process will take CPU & when the first one comes from I/O, it will get pushed into the ready queue, and it has to wait until the current process completes its execution.

# Lab3 Report

210010054

Suyash Gaurav

- **repeated syscall:**

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

8.56 real syscall completed	1.58 user	3.20 sys
---		
11.96 real syscall completed	1.35 user	2.90 sys
---		
15.36 real syscall completed	1.48 user	2.78 sys
---		
18.75 real syscall completed	1.21 user	3.10 sys
---		
22.13 real syscall completed	1.65 user	2.73 sys
---		

*repeated syscall completion (Pseudo FIFO)*

- The output is quite similar to arithoh process, as syscall is also a CPU bound process as well as kernel process. Thus swapping between multiple syscall is happening sequentially, thus following Pseudo FIFO behaviour.

# Lab3 Report

210010054

Suyash Gaurav

```
Minix 210010054: PID 74 swapped in
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65604
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65604
Time Slice: 500, Time Slice Executed: 0 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65604
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65604
    8.48 real      1.78 user      3.16 sys
syscall completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65607
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65607
Time Slice: 500, Time Slice Executed: 500 Endpoint: 98343
Minix 210010054: PID 39 swapped in
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65607
```

```
syscall completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65609
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65609
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65609
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65609
    15.51 real      1.65 user      2.75 sys
syscall completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65610
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65610
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65610
```

*Repeating syscall swapping (Pseudo FIFO)*

# Lab3 Report

210010054

Suyash Gaurav

- **arithoh and fstime:**

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

```
10.33 real      10.33 user      0.00 sys
arithoh completed
---
8.91 real      8.86 user      0.01 sys
arithoh completed
---
8.70 real      8.65 user      0.00 sys
arithoh completed
---
Write done: 1008000 in 1.6500, score 152727
COUNT:152727|0|KBps
TIME:1.7
Write done: 1008000 in 1.6833, score 149702
COUNT:149702|0|KBps
TIME:1.7
```

```
33.86 real      0.45 user      3.38 sys
fstime completed
---
Copy done: 1000004 in 3.8167, score 65502
COUNT:65502|0|KBps
TIME:3.8
44.51 real      0.36 user      3.43 sys
fstime completed
---
```

## *arithoh & fstime completion (Pseudo FIFO)*

- First 3 arithoh processes are completed, then the remaining fstime processes are completed. Although fstime process went before 2 arithoh process, it executed last, because when fstime went for I/O, arithoh will take cpu and execute completely.

# Lab3 Report

210010054

Suyash Gaurav

```
MINIX3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65619
Minix 210010054: PID 83 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65619
Minix 210010054: PID 83 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65619
Minix 210010054: PID 83 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65619
Minix 210010054: PID 83 swapped in
Time Slice: 200, Time Slice Executed: 111 Endpoint: 65619
Minix 210010054: PID 83 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Minix 210010054: PID 87 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65624
Minix 210010054: PID 88 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65625
Minix 210010054: PID 89 swapped in
    10.80 realTime Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65623
```

```
MINIX3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Minix 210010054: PID 87 swapped in
Time Slice: 200, Time Slice Executed: 144 Endpoint: 65623
Minix 210010054: PID 87 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
    10.78 user      0.00 sys
arithoh completed
-- 
    19.90 real      9.28 userTime Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
```

**arithoh & fstime swapping (Pseudo FIFO)**

# Lab3 Report

210010054

Suyash Gaurav

```
MINIX3 [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65626
Minix 210010054: PID 90 swapped in
Time Slice: 200, Time Slice Executed: 74 Endpoint: 65626
Minix 210010054: PID 90 swapped in
    0.01 sys
arithoh completed
---
      9.21 real      9.18 user      0.01 sys
arithoh completed
---
Time Slice: 500, Time Slice Executed: 1 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Write done: 1008000 in 1.6167, score 155876
COUNT:155876:0:KBps
TIME:1.6
Write done: 1008000 in 1.6667, score 151199
COUNT:151199:0:KBps
TIME:1.7
Time Slice: 500, Time Slice Executed: 353 Endpoint: 65560
Minix 210010054: PID 24 swapped in
```

*arithoh completed (Pseudo FIFO)*

```
      34.65 real      0.45 user      3.83 sys
fstime completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 65621
Time Slice: 500, Time Slice Executed: 354 Endpoint: 65560
Minix 210010054: PID 24 swapped in
Copy done: 1000004 in 4.2667, score 58593
COUNT:58593:0:KBps
TIME:4.3
      46.38 real      0.33 user      3.45 sys
fstime completed
---
```

*fstime completed (Pseudo FIFO)*

# Lab3 Report

210010054

Suyash Gaurav

- **fstime & syscall & ftime:**

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

```
10.08 real      10.03 user      0.01 sys
arithoh completed
---
15.13 real      1.30 user      2.78 sys
syscall completed
---
8.16 real      1.41 user      2.60 sys
syscall completed
---
Write done: 1008000 in 1.6833, score 149702
Write done: 1008000 in 1.6833, score 149702
COUNT:149702|0|KBps
COUNT:149702|0|KBps
TIME:1.7
TIME:1.7
```

```
Copy done: 1000004 in 3.6833, score 67873
COUNT:67873|0|KBps
TIME:3.7
32.26 real      0.33 user      3.50 sys
fstime completed
---
Copy done: 1000004 in 4.2000, score 59524
COUNT:59524|0|KBps
TIME:4.2
32.80 real      0.48 user      3.18 sys
fstime completed
---
```

*arithoh & fsime & syscall completion (Pseudo FIFO)*

# Lab3 Report

210010054

Suyash Gaurav

```
File Machine View Input Devices Help
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32971
Minix 210010054: PID 203 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32972
Minix 210010054: PID 204 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
Minix 210010054: PID 205 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32970
Minix 210010054: PID 202 swapped in
```

arithoh starts when all other process gets to blocked state

```
Minix 210010054: PID 202 swapped in
    11.00 real      10.96 user      0.00 sys
arithoh completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
```

arithoh completed

```
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32968
    16.31 real      1.38 user      2.70 sys
syscall completed
---
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32973
    19.48 real      1.15 user      3.01 sys
syscall completed
---
```

Then syscall completed

# Lab3 Report

210010054

Suyash Gaurav

```
COUNT:55384:0:KBps
TIME:4.6
TIME:4.6
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Read done: 1000004 in 1.8500, score 135135
Read done: 1000004 in 1.8500, score 135135
COUNT:135135:0:KBps
COUNT:135135:0:KBps
TIME:1.9
TIME:1.9
Time Slice: 500, Time Slice Executed: 500 Endpoint: 65560
Time Slice: 200, Time Slice Executed: 200 Endpoint: 32972
Copy done: 1000004 in 3.9167, score 63830
COUNT:63830:0:KBps
TIME:3.9
      33.75 real          0.33 user          3.48 sys
fstime completed
---
Copy done: 1000004 in 4.2500, score 58823
COUNT:58823:0:KBps
TIME:4.2
      34.06 real          0.26 user          3.61 sys
fstime completed
---
```

Finally fstime exucuted at last after coming from I/O-> readyQueue

- Here, I have taken 1 arithoh, 2 syscall and 2 fstime. First execution starts with syscall and fstime, but once they go to blocked state, arithoh which is cpu bound process will take cpu and run on a continuous stretch without preemption. Once arithoh is completed, other process systime and fstime completes its execution.

# Lab3 Report

210010054

Suyash Gaurav

## Conclusion:

- **Original Minix3 Scheduler**
  - **Round Robin Scheduling:** The scheduler appears to ensure fairness by allowing each process to get its fair share of CPU time, as observed with the CPU-bound processes.
  - The scheduler handles I/O-bound processes adequately, allowing them to execute efficiently with very less delay.
- **Modified Minix3 Scheduler:**
  - **Pseudo-FIFO Behavior:** Processes are swapped sequentially, with the process that entered the system earliest being scheduled first.
  - I/O-bound processes might experience delays in execution if they are pre-empted by CPU-bound processes. This delay occurs because the CPU-bound processes are given priority based on entry time, potentially leading to I/O-bound processes waiting longer in the ready queue.