

Assignment-2

CS-314:Operating Systems Laboratory

Shahil Patel-200010039
Pranav Talegaonkar-200010041

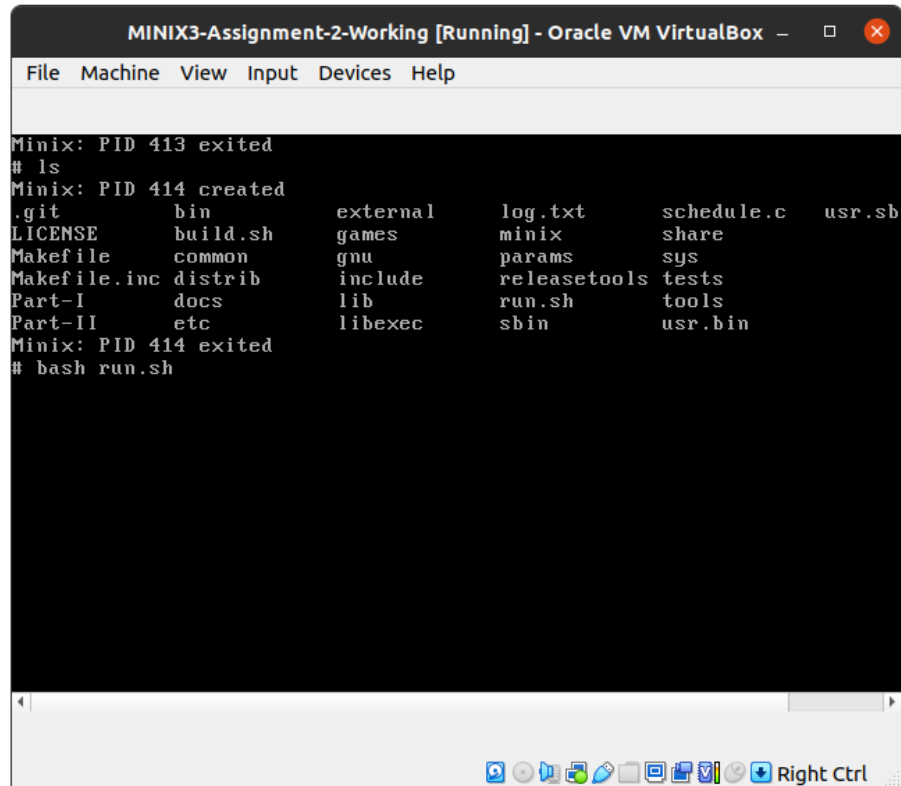
Part-1

In part 1, we have updated the *Minix-3* source code so that anytime a user-level process is brought in by the scheduler, the string “*PID <pid> swapped in*” is printed.

To accomplish this, we added the following lines of C code to the *schedule.c* file, which can be found in the */minix/minix/servers/sched* directory.

```
if(rmp->priority >= USER_Q){  
    printf("(200010039, 200010041)Minix: PID %d swapped in\n",  
_ENDPOINT_P(rmp->endpoint));  
}
```

Also to make the appropriate changes to the Minix machine we have made ***run.sh*** which will copy the modified code to appropriate location in the Minix machine and rebuild the Minix OS. The changes are reflected after a successful build and reboot.



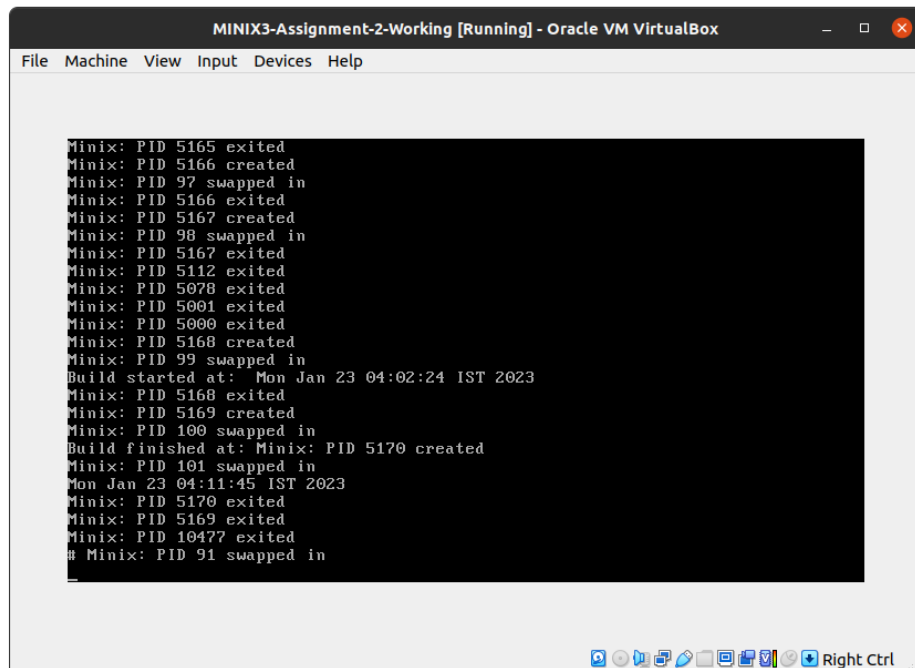
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

```
Minix: PID 413 exited
# ls
Minix: PID 414 created
.git          bin          external    log.txt     schedule.c  usr.sb
LICENSE      build.sh    games       minix       share
Makefile     common     gnu         params      sys
Makefile.inc distrib    include     releasetools tests
Part-I       docs       lib         run.sh      tools
Part-II      etc        libexec     sbin        usr.bin
Minix: PID 414 exited
# bash run.sh
```

Right Ctrl

Copied files and command to run the run.sh file



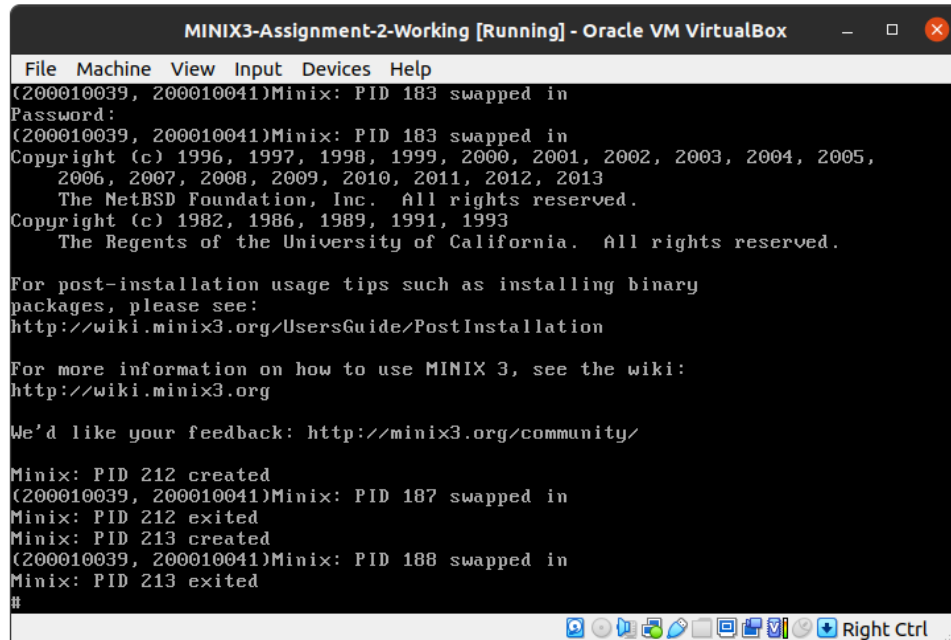
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

```
Minix: PID 5165 exited
Minix: PID 5166 created
Minix: PID 97 swapped in
Minix: PID 5166 exited
Minix: PID 5167 created
Minix: PID 98 swapped in
Minix: PID 5167 exited
Minix: PID 5112 exited
Minix: PID 5078 exited
Minix: PID 5001 exited
Minix: PID 5000 exited
Minix: PID 5168 created
Minix: PID 99 swapped in
Build started at: Mon Jan 23 04:02:24 IST 2023
Minix: PID 5168 exited
Minix: PID 5169 created
Minix: PID 100 swapped in
Build finished at: Minix: PID 5170 created
Minix: PID 101 swapped in
Mon Jan 23 04:11:45 IST 2023
Minix: PID 5170 exited
Minix: PID 5169 exited
Minix: PID 10477 exited
# Minix: PID 91 swapped in
```

Right Ctrl

Successful build



Changes after reboot

Part-2

In this section, we have used the **UnixBench** benchmark suite to test various work-load combinations in order to understand and analyse the minix scheduler and scheduling orders. The sections that follow discuss the various workloads that are used.

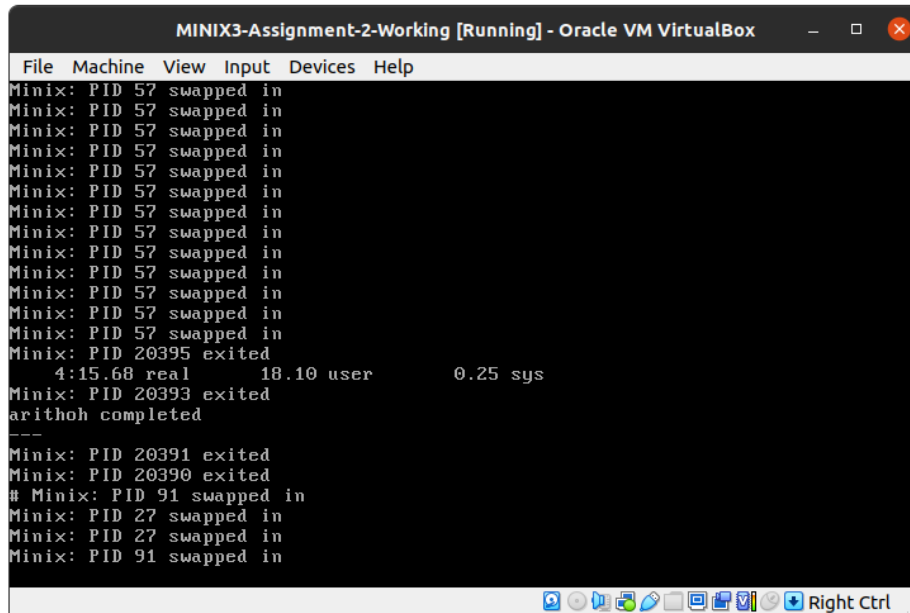
a. workload_mix1.sh

The code for the workload_mix1.sh is as follows:

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

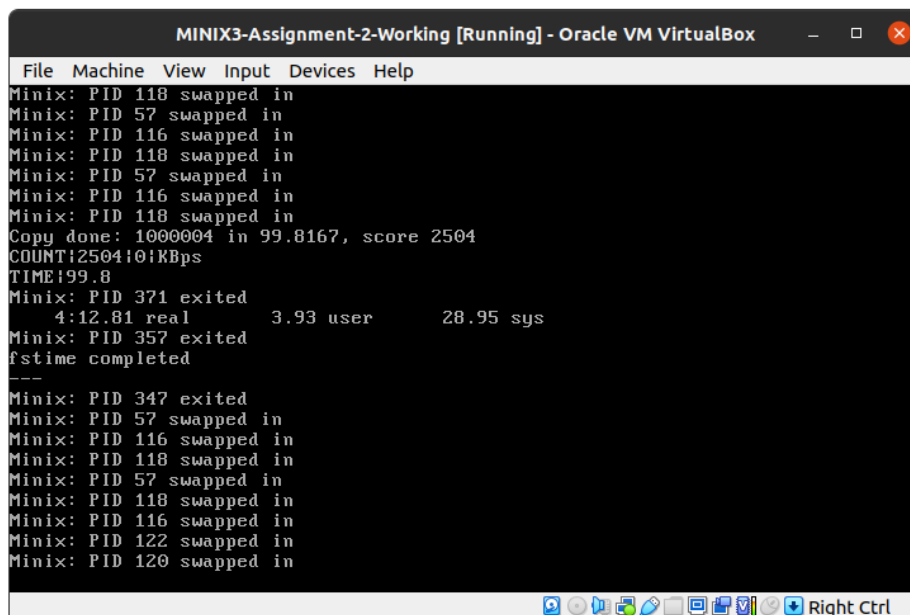
In this workload we have used two workloads, namely ***arithoh.sh*** and ***fstime.sh***.

After inspecting their source code and scheduling order, we discovered that ***arithoh.sh*** is *CPU bound* and does certain CPU bound arithmetic calculations, whereas ***fstime.sh*** is *I/O bound* and reads and writes some buffer data into memory.



```
File Machine View Input Devices Help
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 57 swapped in
Minix: PID 20395 exited
4:15.68 real 18.10 user 0.25 sys
Minix: PID 20393 exited
arithoh completed
---
Minix: PID 20391 exited
Minix: PID 20390 exited
# Minix: PID 91 swapped in
Minix: PID 27 swapped in
Minix: PID 27 swapped in
Minix: PID 91 swapped in
```

arithoh.sh completed



```
File Machine View Input Devices Help
Minix: PID 118 swapped in
Minix: PID 57 swapped in
Minix: PID 116 swapped in
Minix: PID 118 swapped in
Minix: PID 57 swapped in
Minix: PID 116 swapped in
Minix: PID 118 swapped in
Copy done: 1000004 in 99.8167, score 2504
COUNT:2504:0:KBps
TIME:99.8
Minix: PID 371 exited
4:12.81 real 3.93 user 28.95 sys
Minix: PID 357 exited
fstime completed
---
Minix: PID 347 exited
Minix: PID 57 swapped in
Minix: PID 116 swapped in
Minix: PID 118 swapped in
Minix: PID 57 swapped in
Minix: PID 118 swapped in
Minix: PID 116 swapped in
Minix: PID 122 swapped in
Minix: PID 120 swapped in
```

fstime.sh completed

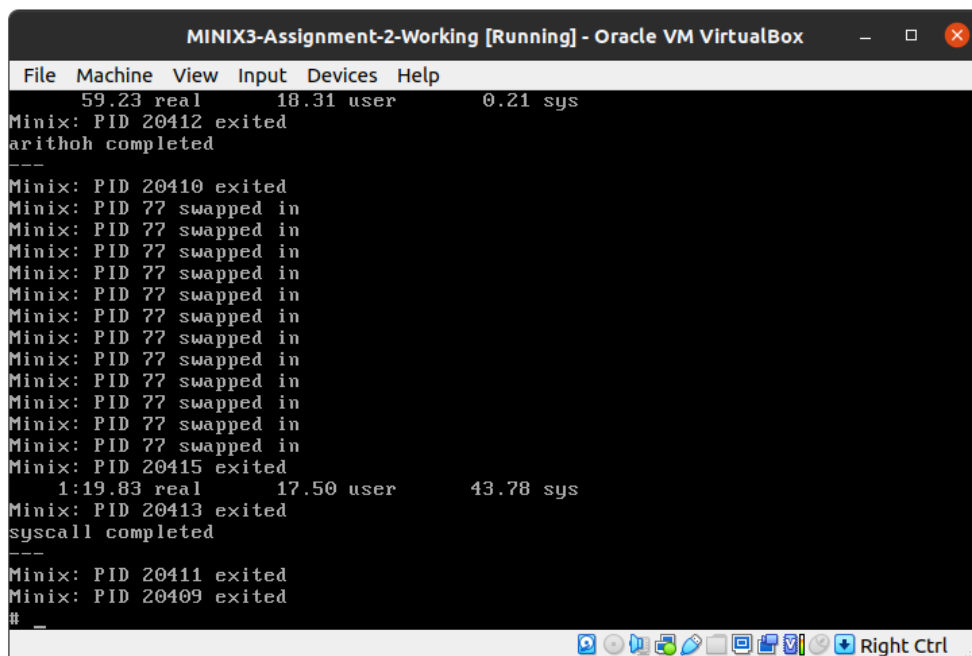
From the above figure we can see that arithoh.sh, with PID 57, being swapped in while fstime.sh, with PID 118 is waiting for I/O response. When fstime.sh becomes ready after I/O response, it is scheduled since it has relatively smaller burst time and it is completed as seen in the above figure After this the arithoh.sh is scheduled until completion as seen from figure.

b. workload_mix2.sh

The code for the workload_mix2.sh is as follows:

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

We used two workloads in this workload: **arithoh.sh** and **syscall.sh**. We discovered that arithoh.sh and syscall.sh are both CPU constrained after inspecting their sources and scheduling order. arithoh.sh performs CPU-bound arithmetic operations, whereas syscall.sh runs a loop that calls the system.



```
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
59.23 real 18.31 user 0.21 sys
Minix: PID 20412 exited
arithoh completed
---
Minix: PID 20410 exited
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 77 swapped in
Minix: PID 20415 exited
1:19.83 real 17.50 user 43.78 sys
Minix: PID 20413 exited
syscall completed
---
Minix: PID 20411 exited
Minix: PID 20409 exited
#
```

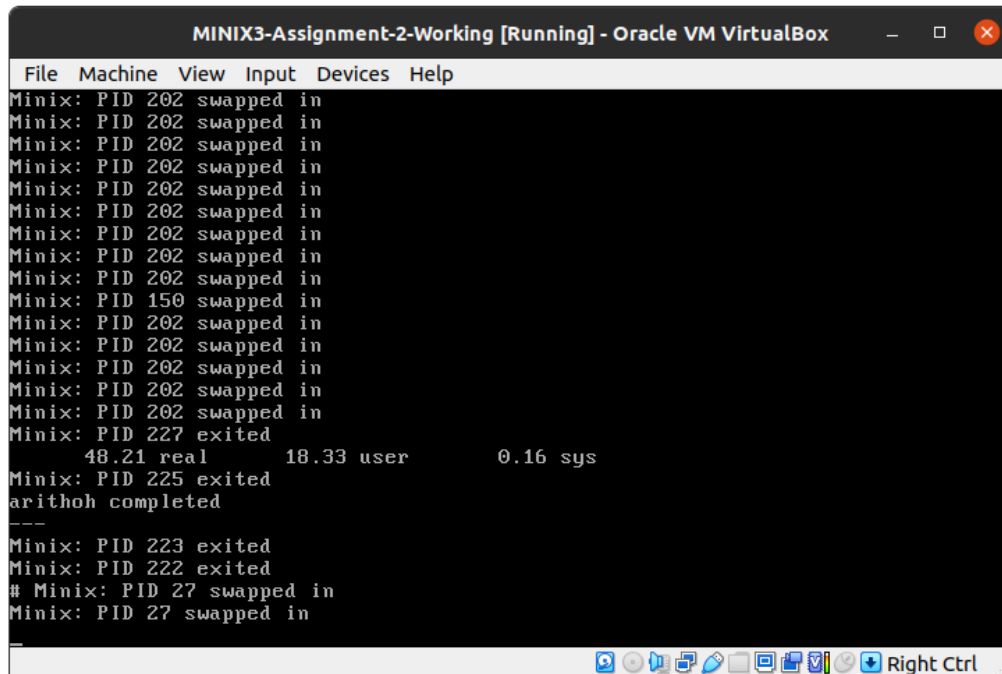
arithoh.sh and syscall.sh completed

From the figure we can see that syscall.sh, with PID 77 being swapped one after the other depending upon their priority. Here arithoh.sh is completed before syscall.sh

c. workload_mix3.sh

The code for the workload_mix3.sh is as follows:

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

arithoh.sh completed

We can see from the above image that spawn.sh is constantly creating new processes and scheduling them to reduce response time. According to the source code, these newly generated processes quit instantly. After a while, spawn.sh and the newly generated process will exit. The arithoh.sh with PID 202 is then scheduled till completion, as seen in the figure.

d. workload_mix4.sh

The code for the workload_mix4.sh is as follows:

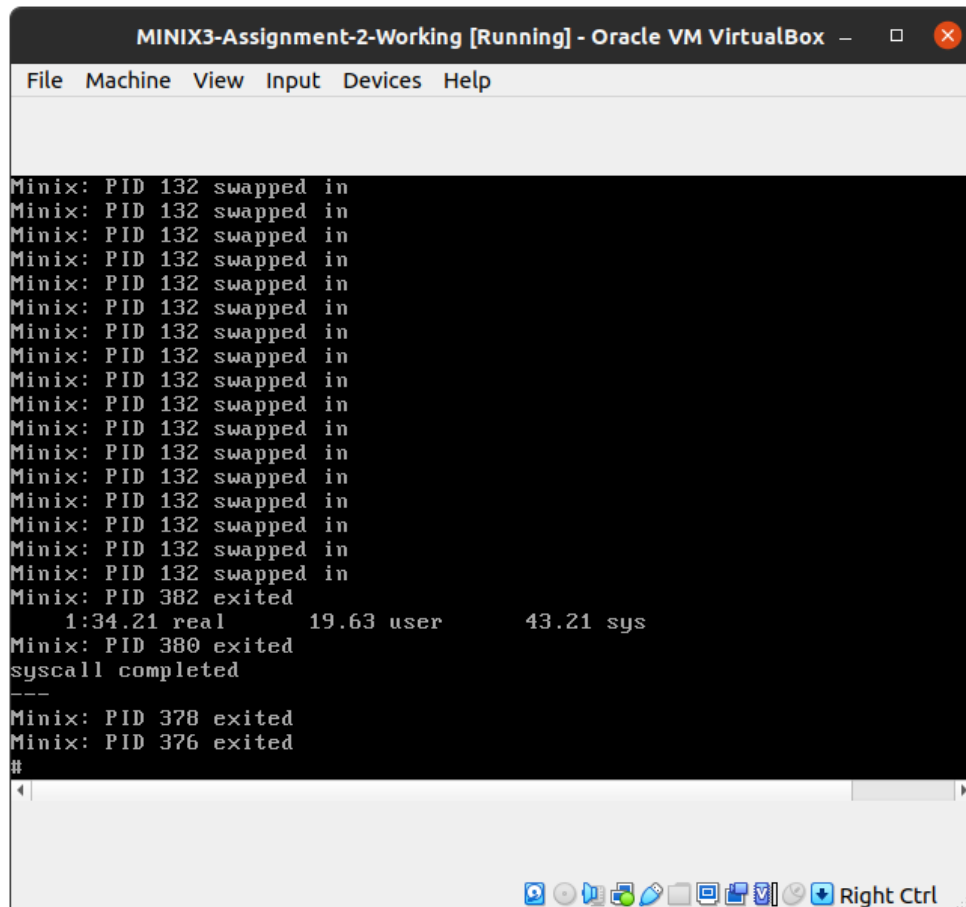
```
#!/bin/sh
./fstime.sh &
./syscall.sh &
wait
```

In this workload we have used two workloads, namely ***fstime.sh*** and ***syscall.sh***. After looking at their source and the order of scheduling, we came to know that fstime.sh is I/O bound and syscall.sh is CPU bound.

```
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox - □ ×
File Machine View Input Devices Help

Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 131 swapped in
Minix: PID 131 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 131 swapped in
Minix: PID 131 swapped in
Minix: PID 132 swapped in
Minix: PID 131 swapped in
Minix: PID 132 swapped in
Copy done: 1000004 in 21.9167, score 11406
COUNT:11406:0:KBps
TIME:21.9
Minix: PID 381 exited
      55.03 real      3.63 user      27.71 sys
Minix: PID 379 exited
fstime completed
---
Minix: PID 377 exited
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 27 swapped in
```

fstime.sh completed



```
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 132 swapped in
Minix: PID 382 exited
1:34.21 real 19.63 user 43.21 sys
Minix: PID 380 exited
syscall completed
---
Minix: PID 378 exited
Minix: PID 376 exited
#
```

syscall.sh completed

From the above figure, we can see that fstime.sh, with PID 131 is waiting for I/O response, while syscall.sh, with PID 132 is swapped in. So once fstime.sh is swapped in, it runs until completion. After this, syscall.sh is swapped in and runs until completion.

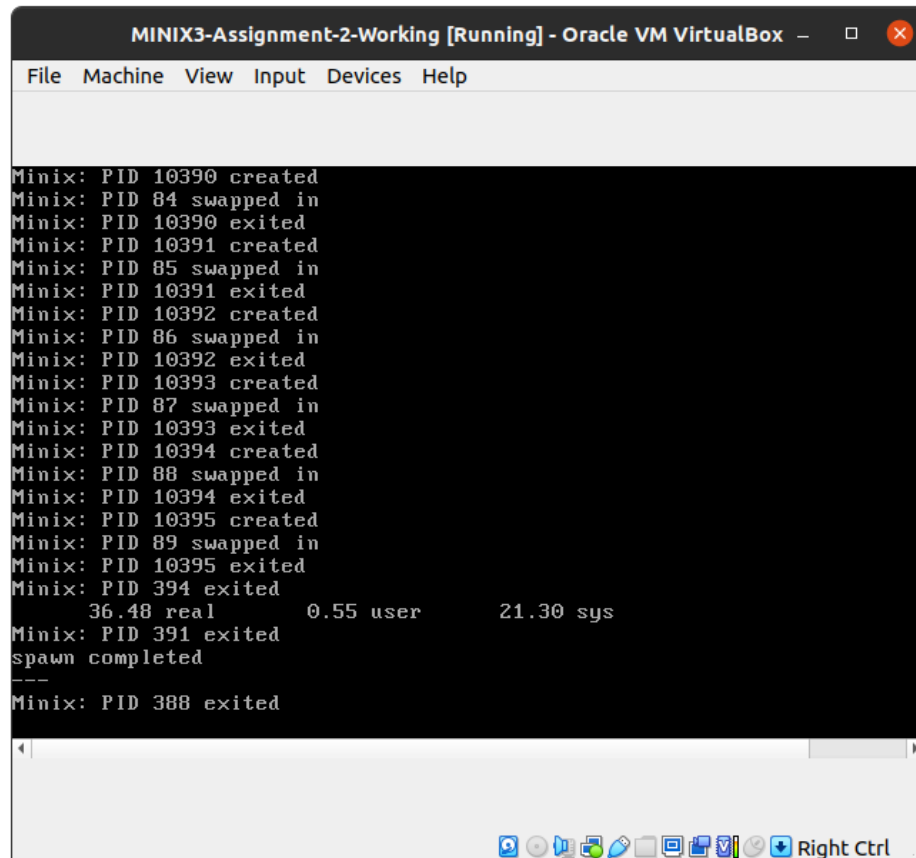
e. workload_mix5.sh

The code for the workload_mix5.sh is as follows:

```
#!/bin/sh
./fstime.sh &
./pipe.sh &
./spawn.sh &
Wait
```

In this workload we have used three workloads, namely fstime.sh, pipe.sh and spawn.sh. After looking at their source and the order of

scheduling, I came to know that both fstime.sh is I/O bound. The pipe.sh does some I/O bound, spawn.sh is CPU bound.



```
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help

Minix: PID 10390 created
Minix: PID 84 swapped in
Minix: PID 10390 exited
Minix: PID 10391 created
Minix: PID 85 swapped in
Minix: PID 10391 exited
Minix: PID 10392 created
Minix: PID 86 swapped in
Minix: PID 10392 exited
Minix: PID 10393 created
Minix: PID 87 swapped in
Minix: PID 10393 exited
Minix: PID 10394 created
Minix: PID 88 swapped in
Minix: PID 10394 exited
Minix: PID 10395 created
Minix: PID 89 swapped in
Minix: PID 10395 exited
Minix: PID 394 exited
      36.48 real      0.55 user      21.30 sys
Minix: PID 391 exited
spawn completed
---
Minix: PID 388 exited
```

MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox

File Machine View Input Devices Help

```
Minix: PID 27 swapped in
Minix: PID 27 swapped in
Minix: PID 143 swapped in
Minix: PID 145 swapped in
Minix: PID 143 swapped in
Minix: PID 145 swapped in
Minix: PID 143 swapped in
Minix: PID 145 swapped in
Minix: PID 143 swapped in
Minix: PID 145 swapped in
Minix: PID 143 swapped in
Minix: PID 145 swapped in
Copy done: 1000004 in 32.7833, score 7625
COUNT: 7625! 0! KBps
TIME: 32.8
Minix: PID 392 exited
      1:44.20 real    3.76 user    28.00 sys
Minix: PID 389 exited
fstime completed
---
Minix: PID 386 exited
Minix: PID 145 swapped in
Minix: PID 9 swapped in
Minix: PID 145 swapped in
```

Right Ctrl

```
MINIX3-Assignment-2-Working [Running] - Oracle VM VirtualBox - □ ×
File Machine View Input Devices Help

Minix: PID 392 exited
      1:44.20 real      3.76 user      28.00 sys
Minix: PID 389 exited
fstime completed
---
Minix: PID 386 exited
Minix: PID 145 swapped in
Minix: PID 9 swapped in
Minix: PID 145 swapped in
Minix: PID 9 swapped in
Minix: PID 145 swapped in
Minix: PID 9 swapped in
Minix: PID 145 swapped in
Minix: PID 393 exited
      2:05.71 real      7.43 user      56.51 sys
Minix: PID 390 exited
pipe completed
---
Minix: PID 387 exited
Minix: PID 385 exited
# Minix: PID 27 swapped in
Minix: PID 28 swapped in
Minix: PID 27 swapped in
Minix: PID 28 swapped in
```

spawn.sh with PID 89 is swapped with fstime.sh with PID 143. The
fstime.sh is swapped with pipe.sh having PID 145.