Operation Systems Lab 3 (210010032)

Part 1:

Modified file schedule.c in usr/src/minix/servers/sched by inserting print statement inside schedule_process function. As follows.

The condition rmp->priority >= USER_Q is written to ensure that we print only user level processes when it is scheduled.

Part 2:

The task is to run several workmixes of different benchmarks like aritho, fstime, syscall, spawn and pipe.

fstime and pipe seem to be I/O bound. Aritho, syscall and spawn are CPU bound.

1. CPU usage of aritho

```
PID USERNAME PRI NICE
                                SIZE STATE
                                                 TIME
                                                             CPU COMMAND
275 root
                 15
                                708K
                                                 0:03 99.46% arithoh
                               2802K
                                                 0:00
                                                          0.22% kernel
-1 root 0 2802K

9 root 1 0 180K

7 root 5 0 1204K

11 root 2 0 5052K

40 root 7 0 1208K

252 root 7 0 596K

49 service 5 0 8204K
 -1 root
                                                          0.10% tty
                                                 0:00
                                                          0.08% vfs
                                                 0:06
                        0 5052K 0:00
0 1208K RUN 0:00
                                                          0.05% VM
                       0 596K RUN
0 8204K
0 200K
                                                          0.02% procfs
252 root
                                                 0:00
                                                          0.01% top
                                                 0:00
                                                          0.01% mfs
                              8204K
200K
188K
596K
312K
1152K
148K
 79 root
                                                 0:00
                                                          0.01% devman
107 root
                                                 0:00
                                                          0.01% devmand
                      596K
0 312K
0 1152K
0 1494
                  4
                                                 0:00
  5 root
                                                          0.01% pm
                                                 0:00
                                                          0.01% syslogd
174 root
139 service
                                                 0:00
                                                          0.00% inet
155 service
                                                 0:00
                                                          0.00% log
                                  48K
  6 root
                                                 0:00
                                                          0.00% sched
```

2. CPU usage of fstime

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
7	root	5	0	1204K		0:10	17.15%	vfs
-1	root			2802K		0:00	12.73%	kernel
76	service	5	0	4748K		0:06	9.21%	mfs
284	root	7	0	712K	RUN	0:00	2.93%	fstime
11	root	2	Θ	5072K		0:00	0.08%	VM
40	root	7	0	1208K	RUN	0:00	0.07%	procfs
252	root	7	0	596K		0:00	0.04%	top
79	root	7	Θ	200K		0:00	0.02%	devman
49	service	5	Θ	8204K		0:00	0.02%	mfs
107	root	7	0	188K		0:00	0.01%	devmand
5	root	4	0	596K		0:00	0.01%	pm
139	service	7	0	1152K		0:00	0.00%	inet
248	root	7	Θ	2468K		0:00	0.00%	sshd
143	service	7	0	204K		0:00	0.00%	pty
134	root	7	Θ	112K		0:00	0.00%	lance

3. CPU usage of syscall

```
PID USERNAME PRI NICE
                         SIZE STATE
                                               CPU COMMAND
                                      TIME
                                            37.16% vfs
 7 root
                        1204K
                                      0:12
              5
                   0
 -1 root
                        2802K
                                      0:00
                                            27.01% kernel
287 root
                                RUN
                   0
                         708K
                                      0:00
                                            23.55% syscall
 5 root
                   Θ
                        596K
                                      0:00
                                            12.13% pm
11 root
                        5072K
                                             0.05% VM
                   Θ
                                      0:00
 9 root
              1
                   0
                        180K
                                      0:00
                                             0.02% tty
                                RUN
40 root
                  Θ
                        1208K
                                      0:00
                                             0.02% procfs
                                      0:00
                  Θ
                        596K
                                             0.01% top
252 root
49 service
                       8204K
                                      0:00
                                             0.01% mfs
                  0
79 root
                       200K
                                      0:00
                                             0.01% devman
                        188K
                                     0:00
                                             0.01% devmand
107 root
139 service
                      1152K
                  0
                                     0:00
                                             0.00% inet
174 root
                  Θ
                        312K
                                     0:00
                                             0.00% syslogd
248 root
                   0
                       2468K
                                      0:00
                                             0.00% sshd
143 service
                         204K
                                      0:00
                                             0.00% pty
```

4. CPU usage of pipe

JSERNAME	DOT	HERE					
	PKI	NICE	SIZE	STATE	TIME	CPU	COMMAND
oot	5	0	1204K		0:15	48.81%	vfs
oot	0		2802K		0:00	28.18%	kernel
service	5	0	560K		0:00	15.66%	pfs
oot	7	0	708K	RUN	0:00	7.14%	pipe
root	2	0	5072K		0:00	0.09%	VM
oot	7	Θ	1208K	RUN	0:00	0.04%	procfs
root	7	0	596K		0:00	0.03%	top
service	5	0	8204K		0:00	0.01%	mfs
oot	7	0	200K		0:00	0.01%	devman
oot	4	0	596K		0:01	0.01%	pm
oot	7	0	188K		0:00	0.01%	devmand
service	7	0	1152K		0:00	0.00%	inet
service	7	0	204K		0:00	0.00%	pty
oot	7	0	2468K		0:00	0.00%	sshd
root	7	0	112K		0:00	0.00%	lance
	oot ervice oot oot ervice oot oot oot ervice oot oot ervice ervice ervice ervice	oot 0 ervice 5 oot 7 oot 7 ervice 5 oot 7 oot 7 ervice 5 oot 7 oot 4 oot 7 ervice 7 ervice 7	oot 0 ervice 5 0 oot 7 0 oot 7 0 oot 7 0 ervice 5 0 oot 7 0	oot 0 2802K ervice 5 0 560K oot 7 0 708K oot 2 0 5072K oot 7 0 1208K oot 7 0 596K oot 7 0 200K oot 7 0 200K oot 4 0 596K oot 7 0 188K oot 7 0 188K ervice 7 0 1152K ervice 7 0 204K oot 7 0 204K	oot 0 2802K ervice 5 0 560K oot 7 0 708K RUN oot 2 0 5072K oot 7 0 1208K RUN oot 7 0 596K ervice 5 0 8204K oot 7 0 200K oot 4 0 596K oot 7 0 188K ervice 7 0 1152K ervice 7 0 204K oot 7 0 2468K	oot 0 2802K 0:00 oot 7 0 560K 0:00 oot 7 0 708K RUN 0:00 oot 7 0 1208K RUN 0:00 oot 7 0 1208K RUN 0:00 oot 7 0 596K 0:00 oot 7 0 200K 0:00 oot 7 0 200K 0:00 oot 7 0 188K 0:00 oot 7 0 188K 0:00 oot 7 0 188K 0:00 oot 7 0 204K 0:00	oot 0 2802K 0:00 28.18% dervice 5 0 560K 0:00 15.66% oot 7 0 708K RUN 0:00 7.14% oot 2 0 5072K 0:00 0.09% oot 7 0 1208K RUN 0:00 0.04% oot 7 0 596K 0:00 0.03% ervice 5 0 8204K 0:00 0.01% oot 7 0 200K 0:00 0.01% oot 4 0 596K 0:01 0.01% oot 7 0 188K 0:00 0.01% ervice 7 0 152K 0:00 0.00% ervice 7 0 246K 0:00 0.00%

5. CPU usage of spawn

```
PID USERNAME PRI NICE
                        SIZE STATE
                                     TIME
                                             CPU COMMAND
                                          64.17% tty
 9 root 1 0
                        180K
                                     0:01
             0
2 0
5 0
4 0
2 0
                       2802K
                                     0:00
                                          13.10% kernel
 -1 root
                       5136K
                                     0:00
                                           2.18% VM
11 root
                      1204K
                                     0:18
                                            1.02% vfs
 5 root
                       596K
                                     0:01
                                            0.79% pm
155 service
                                           0.71% log
                        148K
                                     0:00
                 0
174 root
                              RUN
                                    0:00
                                            0.48% syslogd
                       312K
                Θ
                        48K
                                    0:00
                                            0.40% sched
 6 root
              5 0 11328K
73 service
                                     0:00
                                            0.19% mfs
293 root
                       708K
                                     0:00
                                            0.14% spawn
                      1208K
                                     0:00
                                            0.07% procfs
139 service
                      1152K
                                     0:00
                                           0.07% inet
147 root
                       544K
                                    0:00
                                           0.05% uds
                 θ
                                    0:00
                       596K
252 root
                                           0.05% top
49 service
                       8204K
                                     0:00
                                          0.03% mfs
```

6. workload_mix1.sh

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

CPU usage:

PID	USERNAME	PRI	NICE	SIZE	STATE	TIME	CPU	COMMAND
10339	root	15	0	712K	RUN	0:04	60.51%	arithoh
7	root	5	0	1204K		0:28	15.95%	vfs
-1	root	Θ		2802K		0:00	11.81%	kernel
76	service	5	0	4772K		0:13	8.81%	mfs
10340	root	7	0	716K	RUN	0:00	2.72%	fstime
9	root	1	Θ	180K		0:13	0.06%	tty
11	root	2	0	5364K		0:01	0.05%	VM
40	root	7	0	1208K	RUN	0:00	0.02%	procfs
252	root	7	0	596K		0:00	0.01%	top
49	service	5	0	8204K		0:00	0.01%	mfs
79	root	7	Θ	200K		0:00	0.01%	devman
107	root	7	0	188K		0:00	0.01%	devmand
5	root	4	0	596K		0:01	0.01%	pm
174	root	7	Θ	312K		0:00	0.00%	syslogd
139	service	7	Θ	1152K		0:00	0.00%	inet

Here process 68 is that of fstime, 67 if of aritho. 67 runs many times since it is CPU intensive while process with PID 68 (fstime) waits until it gets input, since it is I/O bound process.

```
Minix 210010032 : PID 66 swapped in Minix 210010032 : PID 10353 created Minix 210010032 : PID 67 swapped in Minix 210010032 : PID 67 swapped in Minix 210010032 : PID 68 swapped in Minix 210010032 : PID 68 swapped in Minix 210010032 : PID 67 swapped in
```

7. workload_mix2

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

CPU usage:

```
PID USERNAME PRI NICE
                          SIZE STATE
                                      TIME
                                               CPU COMMAND
10373 root
                         712K
                                RUN
                                      0:01 34.74% arithoh
10374 root
              12
                   0
                         712K
                                RUN
                                      0:01 32.41% arithoh
              13
10371 root
                         712K
                                RUN
                                      0:01 32.41% arithoh
              0
1
5
2
                                             0.12% kernel
  -1 root
                         2802K
                                      0:00
   9 root
                         180K
                                      0:13
                                             0.10% tty
                   0
0
   7 root
                        1204K
                                             0.07% vfs
                                      0:33
  11 root
                                             0.05% VM
                       5432K
                                      0:01
                   Θ
  40 root
                       1208K
                                RUN
                                     0:00
                                             0.02% procfs
 252 root
                    0
                        596K
                                      0:00
                                             0.02% top
  49 service 5
                   0 8204K
                                      0:00
                                             0.01% mfs
  79 root
                    0
                                      0:00
                                             0.01% devman
                         200K
 107 root
                    Θ
                         188K
                                      0:00
                                             0.01% devmand
                   Θ
                                      0:00
 174 root
                         312K
                                             0.01% syslogd
                                      0:01
                                             0.01% pm
   5 root
                    0
                         596K
 139 service
                    0 1152K
                                      0:00
                                             0.00% inet
```

```
Minix 210010032 : PID 78 swapped in Minix 210010032 : PID 78 swapped in Minix 210010032 : PID 78 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 77 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 78 swapped in Minix 210010032 : PID 78 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 75 swapped in Minix 210010032 : PID 78 swapped in
```

These 3 processes with PIDs 75,77 and 78 are all three different aritho processes. This is highly CPU intensive and interval between swaps is very less, since other process enters queue after current process spends considerable amount of time in queue.

8. workload_mix3

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

CPU usage:

```
PID USERNAME PRI NICE
                            SIZE STATE
                                          TIME
                                                    CPU COMMAND
    7 root
             5 0
                          1204K
                                          0:34
                                                29.50% vfs
               11 0 712K
0 2802K
10 0 712K
4 0 596K
2 0 5368K
1 0 180K
                                   RUN
10408 root
                11
                            712K
                                         0:01
                                                21.28% arithoh
                                                20.97% kernel
   -1 root
                                          0:00
                                  RUN 0:01
10409 root
                                                18.83% syscall
   5 root
                                         0:02
                                                 9.26% pm
   11 root
                                                 0.05% VM
                                         0:01
                           180K
                                                 0.04% tty
   9 root
                                         0:13
  40 root 7 0 1208K
252 root 7 0 596K
49 service 5 0 8204K
                     0 1208K RUN
                                        0:00
                                                 0.02% procfs
  252 root
                                          0:00
                                                 0.01% top
                                          0:00
                                                 0.01% mfs
                          200K
   79 root
                                          0:00
                                                 0.01% devman
                           188K
  107 root
                                          0:00
                                                 0.01% devmand
                                                 0.00% syslogd
                           312K
                                          0:00
  174 root
  139 service
                          1152K
                                          0:00
                                                 0.00% inet
   73 service
                      0 13780K
                                          0:00
                                                 0.00% mfs
```

```
Minix 210010032 : PID 138 swapped in Minix 210010032 : PID 137 swapped in Minix 210010032 : PID 138 swapped in Minix 210010032 : PID 138 swapped in Minix 210010032 : PID 137 swapped in Minix 210010032 : PID 138 swapped in Minix 210010032 : PID 137 swapped in Minix 210010032 : PID 138 swapped in Minix 210010032 : PID 137 swapped in Minix 210010032 : PID 137 swapped in Minix 210010032 : PID 138 swapped in
```

Syscall is also CPU bound process like aritho. Hence both are in queue one after the other. But it is to be noted that syscall is less CPU intensive than aritho. Hence aritho is scheduled towards the end.