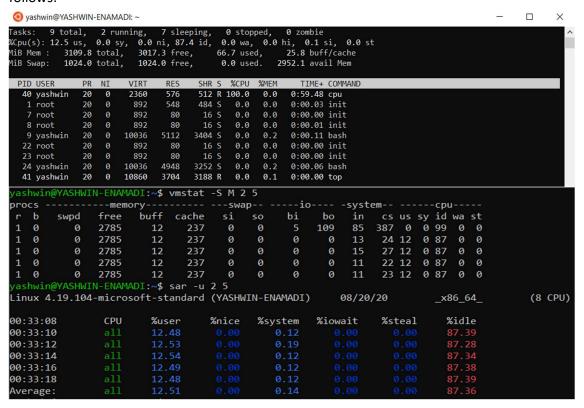
18CS01057 Date of Submission: 23.08.2020

Date of Issue: 18.08.2020

Assignment – 1 : Operating Systems Laboratory

- 1. The following are known using procfs:
 - a. My machine has 8 cores. (cat /proc/cpuinfo)
 - b. Total memory is 3184424 kB of which 2927296 kB is free. (cat /proc/meminfo)
 - c. 228164 context switches happened since system booted. (cat /proc/stat) ctxt line in the above command gives the number
 - d. 830 processes have been forked. (cat /proc/stat) processes line in the above command gives the number
- 2. The following are known using various commands shown:
 - a. cpu : CPU is the bottleneck for this process. The output for the top command is as follows:



It is clearly evident that cpu(PID: 40) is using 100% of CPU.

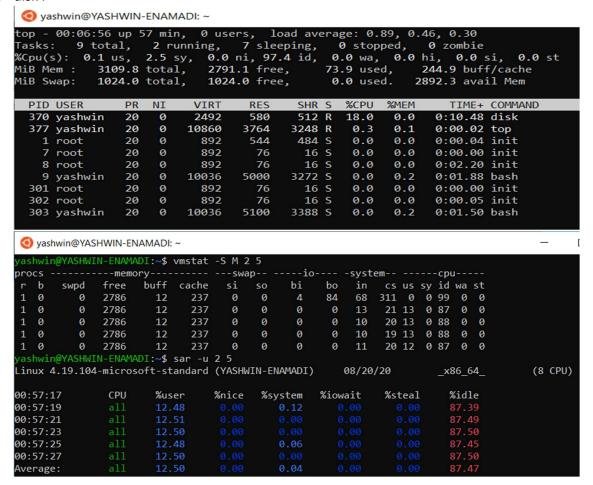
As this program is highly computational in nature, without accessing any other resources such as I/O devices and disk, it is quite expected that the bottleneck for this process is CPU.

b. cpu-print:

- 1	ν .																	
yashwin@YASHWIN-ENAMADI:~ \$ top																		
top - 00:26:03 up 1:16, 0 users, load average: 0.08, 0.33, 0.32																		
Tasks: 9 total, 2 running, 7 sleeping, 0 stopped, 0 zombie																		
%Cpu(s): 0.8 us, 5.1 sy, 0.0 ni, 94.1 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 s														st				
MiB Mem : 3109.8			total, 2785			.3 free, 7			74. 9 used, 24			19.7 buff/cache						
Μi	B S	wap:	1024.6	tota	1,	1024.	0 fre	ee,	0	.0 us	ed.	289	90.6	ava	ail Men	1		
	PID	USER	PF	NI	VII	RT	RES	SHF	S	%CPU	%MEM	1	T	IME-	- COMMA	ND		
	548	yashw	in 20	0	249	92	712	644		32.3					cpu-p		t	
		root	26	0			76				0.0				2 init			
		root					544			0.0					1 init			
		root					76) init			
	9 yashwin								3272 S						l bash			
		root					76				0.0) init			
			26								0.0				init			
			in 20					3388										
	549	yashw	in 20	0	108	50	3816	3260) R	0.0	0.1		0:0	0.00	top			
yashwin@YASHWIN-ENAMADI:~ \$ vmstat -S M 2 5																		
			memo															
r	b	swpd	free		cache						cs us							
1	0	0	2785					5			366 0							
0	0		2785			0	0	0										
0	0	0				0	0	0	0	13846	46698	0	6 93	0	0			
0	0	0	2785	12	237	0	0	0	0	16003	53258	1	6 94	0	0			
0	0	0	2785	12		0	0	0	0	15652	53069	0	7 92	0	0			
va	shwir	n@YASHW	IN-ENAMA	DI:~\$	sar -u	2 5												
			4-micros				WIN-E	NAMADI)		08/20	/20		x86	64		(8 (CPU)	
										,,								
aa	00:26:32		CPU	%us	er	%nice		%system		vait	%steal		%idle					
	00:26:34										0.00							
	00:26:36		all				7.29											
	00:26:38		all				6.30											
	00:26:40 00:26:42		all	0.31 0.38			6.46											
			all					5.32										
Αv	erage	e:	all	0.	45	0.00		6.34	(00.6	0.00	ð	9	3.21				

In this case, it is very evident from the output of vmstat cmd that, high number of interrupts and context switches are occurred during the execution. So, the bottleneck for this process is I/O operations. In the cpu section, we also notice CPU is idle for most of the time. Hence, CPU is definitely not the bottleneck for this process. As the program prints output for every short duration of time, it is quite expected that either CPU or I/O operations must be the bottleneck for this process. But user time is very less for the process. So, it is clear that I/O operations become the bottleneck.

c. disk:



In this process, the disk is the bottleneck. Since, the process accesses the disk for reading every file among 10k files, each of size 2MB, the disk becomes the bottleneck of the process.

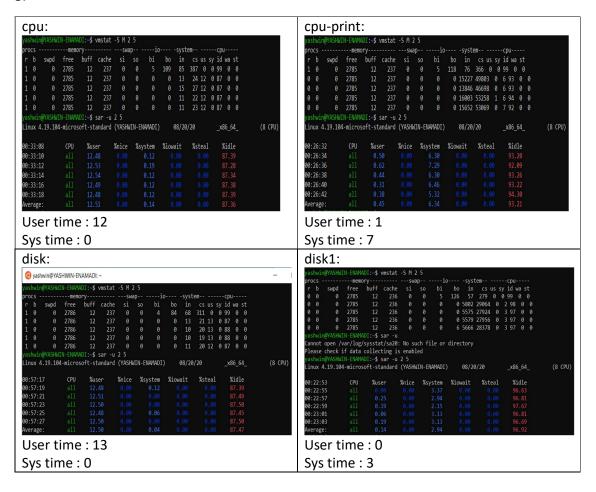
d. disk1:

```
top - 00:21:04 up 1:11, 0 users, load aver
Tasks: 9 total, 1 running, 8 sleeping,
                                        load average: 0.35, 0.22, 0.26
                                                    0 stopped, 0 zombie
Tasks: 9 total, 1 running, 8 sleeping, %Cpu(s): 0.2 us, 2.4 sy, 0.0 ni, 97.4 id,
                                                    0.0 wa, 0.0 hi, 0.0 si, 0.0 st
             3109.8 total,
                                2785.3 free,
                                                   75.2 used,
                                                                   249.3 buff/cache
MiB Mem :
MiB Swap:
             1024.0 total,
                                1024.0 free,
                                                    0.0 used.
                                                                  2890.3 avail Mem
 PID USER
                  PR NI
                             VIRT
                                      RES
                                              SHR S %CPU %MEM
                                                                       TIME+ COMMAND
  538 yashwin
                  20
                       0
                              2492
                                       520
                                               456 D
                                                       18.7
                                                               0.0
                                                                      0:04.36 disk1
    1 root
                  20
                       0
                               892
                                       544
                                               484 S
                                                        0.0
                                                               0.0
                                                                      0:00.04 init
    7 root
                               892
                                        76
                                                16 S
                                                                      0:00.00 init
                  20
                       0
                                                        0.0
                                                               0.0
    8 root
                  20
                       0
                               892
                                        76
                                                        0.0
                                                               0.0
                                                                      0:02.24 init
    9 yashwin
                  20
                       0
                            10036
                                      5000
                                              3272 S
                                                        0.0
                                                               0.2
                                                                      0:02.50 bash
  301 root
                                                16 S
                  20
                       0
                               892
                                        76
                                                        0.0
                                                               0.0
                                                                      0:00.00
                                                                               init
  302 root
                  20
                       0
                               892
                                        76
                                                16 S
                                                        0.0
                                                               0.0
                                                                      0:00.68 init
                       0
                            10036
                                      5100
                                              3388 S
                                                                      0:01.57 bash
  303 yashwin
                  20
                                                        0.0
                                                               0.2
                            10860
                                              3216 R
                                                                      0:00.01 top
  543 yashwin
                  20
                                      3768
                                                        0.0
                                                               0.1
```

```
/ashwin@YASHWIN-ENAMADI:~$ vmstat -S M 2 5
              ---memory-----
                                  ---swap--
                                                --io---- -system--
               free
                      buff
                                               bi
                                                     bo
        swpd
                            cache
                                                               cs us sy id wa st
               2785
                              236
                                          0
                                                              279 0
                                                                      0 99 0 0
 0
   0
           0
                                     0
                                                    126
 0
   0
               2785
                        12
                              236
                                     0
                                          0
                                                      0 5802 29064
                                                                    0
                                                                       2 98
                                                                             0 0
                        12
                                                      0 5575 27924
 0
   0
           0
               2785
                              236
                                     0
                                          0
                                                0
                                                                    0
                                                                       3 97
                                                                              0
                                                                                0
           0
                                          0
                                                0
                                                      0 5579 27956
                                                                    0 3 97
                                                                              0 0
 0
   0
               2785
                                     0
 0
   0
           0
               2785
                        12
                              236
                                     0
                                          0
                                                0
                                                      6 5666 28378 0 3 97
 rashwin@YASHWIN-ENAMADI:∼$ sar -u
Cannot open /var/log/sysstat/sa20: No such file or directory
Please check if data collecting is enabled
 vashwin@YASHWIN-ENAMADI:~$ sar -u 2 5
Linux 4.19.104-microsoft-standard (YASHWIN-ENAMADI)
                                                        08/20/20
                                                                         _x86_64_
                                                                                         (8 CPU)
                CPU
                                          %system
00:22:53
                        %user
                                  %nice
                                                    %iowait
                                                               %steal
                                                                           %idle
00:22:55
                                                                           96.63
00:22:57
00:22:59
                                                                           96.81
00:23:01
                         0.06
00:23:03
                                                                           96.69
Average:
                         0.14
```

We see that there are large number of context switches happening, during the execution of the process. These are due to the process accessing the disk quite often. So, disk access is the bottleneck of this process.

3.



```
/ASHWIN-ENAMADI:~$ ps
                  TIME CMD
                                                         PID TTY
                                                                          TIME CMD
               00:00:00 init
                                                                      00:00:00 init
               00:00:00 init
                                                                      00:00:00 init
               00:00:00 init
                                                                      00:00:00 init
    9 pts/0
              00:00:00 bash
                                                           9 pts/0
                                                                      00:00:00 bash
   89 ?
90 ?
              00:00:00 init
                                                          89 ?
                                                                      00:00:00 init
                                                          90 ?
                                                                      00:00:00 init
              00:00:00 init
                                                                      00:00:00 bash
                                                          91 pts/1
   91 pts/1
              00:00:00 bash
                                                                      00:00:00 disk
              00:00:11 cpu
                                                         113 pts/0
  104 pts/0
                                                                      00:00:00 ps
                                                         114 pts/1
  105 pts/1
              00:00:00 ps
                                                         ashwin@YASHWIN-ENAMADI:~$ grep ctxt /proc/113/status
  shwin@YASHWIN-ENAMADI:~$ grep ctxt /proc/104/status
 voluntary_ctxt_switches:
                                                        oluntary_ctxt_switches:
                                                                                       17570
                                                        onvoluntary_ctxt_switches:
nonvoluntary_ctxt_switches:
                                                                                       0
This process (cpu) involves only
                                                       This process (disk) reads from the disk
computation and hence there are
                                                       regularly. So, whenever it accesses the disk,
```

significant nonvoluntary context switches as the OS interrupts the process to give space to other processes as well.

it voluntarily makes a context switch. Hence, there is no any need for the OS to interrupt the process.

5. The pid for the bash shell is 9

```
yashwin@YASHWIN-ENAMADI:~$ ps -A
 PID TTY
                   TIME CMD
   1 ?
              00:00:00 init
   7 ?
              00:00:00 init
   8 ?
              00:00:00 init
   9 pts/0
              00:00:00 bash
  89 pts/0
              00:00:00 ps
```

The output for the pstree command is as follows:

```
/ashwin@YASHWIN-ENAMADI:~$ pstree
      -init—
            —init——bash—
      {init}
```

Initially, the init process with pid = 1, is created. It has two children as shown above. Process with pid = 1 has a child with pid = 7 and this inturn has a child with pid = 8 and this child with pid = 8 creates the bash shell (pid = 9)

6. The pid of cpu-print is 106

```
shwin@YASHWIN-ENAMADI:~$ ps -A
PID TTY
                 TIME CMD
 1 ?
             00:00:00 init
 7 ?
             00:00:00 init
 8 ?
             00:00:00 init
 9 pts/0
             00:00:00 bash
90 ?
             00:00:00 init
91 ?
             00:00:00 init
92 pts/1
             00:00:00 bash
106 pts/0
             00:00:08 cpu-print
107 pts/1
             00:00:00 ps
```

The file descriptors are as shown

```
yashwin@YASHWIN-ENAMADI:~$ ls -l /proc/106/fd
total 0
lrwx----- 1 yashwin yashwin 64 Aug 19 10:36 0 -> /dev/pts/0
l-wx----- 1 yashwin yashwin 64 Aug 19 10:36 1 -> /tmp/tmp.txt
lrwx----- 1 yashwin yashwin 64 Aug 19 10:36 2 -> /dev/pts/0
```

We issued the output redirection command ">" to the file /tmp/tmp.txt. So, the file descriptor 1, which usually points to stdout is changed to point to the mentioned file.

7. Here, we used inter-process communication. The pipe allows the output of the first command (./cpu-print) to be passed on to the input of the second command(grep hello).

The file descriptors are as shown:

```
shwin@YASHWIN-ENAMADI:~$ ps
  PID TTY
                    TIME CMD
    1 ?
                00:00:00 init
             00:00:00 init
   8 ? 00:00:00 init
9 pts/0 00:00:01 bash
   90 ?
               00:00:00 init
   91 ?
               00:00:00 init
  92 pts/1
              00:00:00 bash
  121 pts/0 00:00:07 cpu-print
              00:00:04 grep
  122 pts/0
 123 pts/1 00:00:00 ps
vashwin@YASHWIN-ENAMADI:~$ ls -1 /proc/121/fd
total 0
lrwx----- 1 yashwin yashwin 64 Aug 19 10:49 0 -> /dev/pts/0
l-wx----- 1 yashwin yashwin 64 Aug 19 10:49 1 -> 'pipe:[14624]'
lrwx----- 1 yashwin yashwin 64 Aug 19 10:49 2 -> /dev/pts/0
yashwin@YASHWIN-ENAMADI:~$ ls -l /proc/122/fd
total 0
lr-x----- 1 yashwin yashwin 64 Aug 19 10:49 0 -> 'pipe:[14624]
lrwx----- 1 yashwin yashwin 64 Aug 19 10:49 1 -> /dev/pts/0
lrwx----- 1 yashwin yashwin 64 Aug 19 10:49 2 -> /dev/pts/0
```