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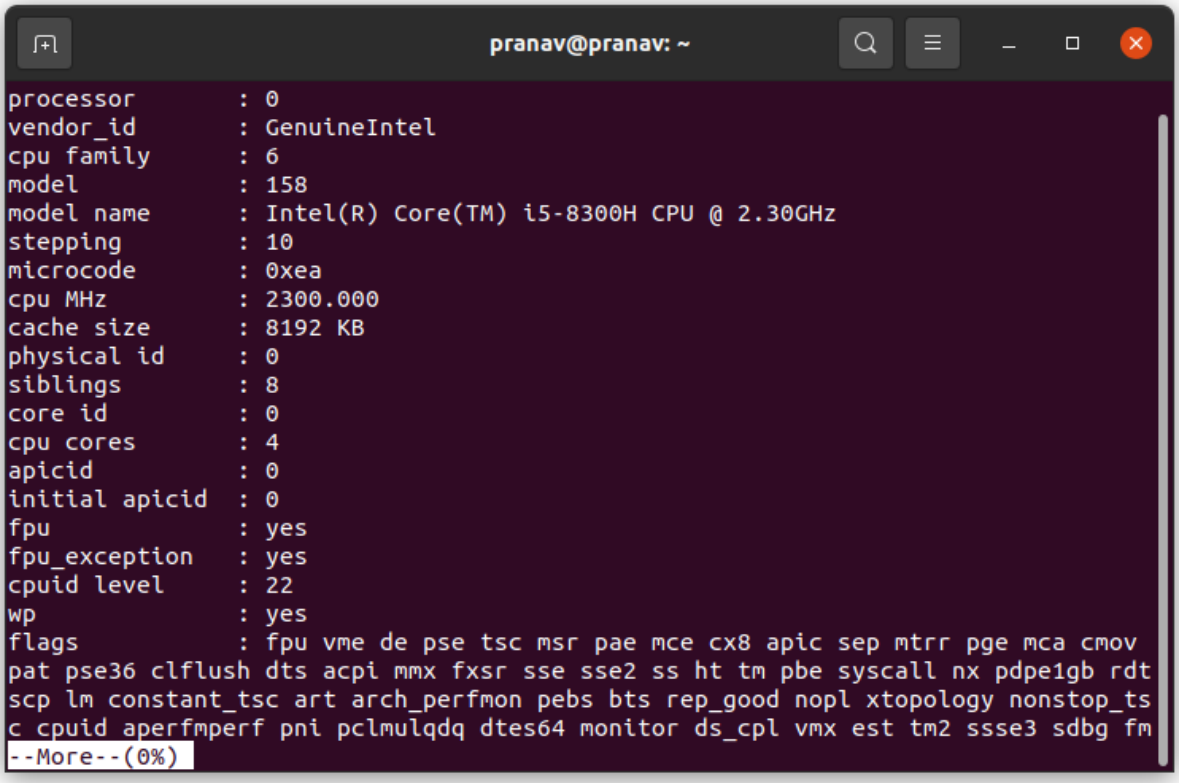
OS LAB ASSIGNMENT 1

1.

(a) Processor: It is a device that runs or executes the instructions.
Core: It is a processing unit. In general, a core may operate two processes at once, hence one core counts as two processors.

My laptop has an i5-8300H processor. It has 4 cores.



```
pranav@pranav:~$ lscpu
Architecture:                    x86_64
CPU op-mode(s):                  32-bit, 64-bit
Byte Order:                      Little Endian
Address sizes:                   39 bits physical, 48 bits virtual
CPU(s):                          8
On-line CPU(s) list:             0-7
Thread(s) per core:              2
Core(s) per socket:              4
Socket(s):                       1
NUMA node(s):                    1
Vendor ID:                       GenuineIntel
CPU family:                      6
Model:                           158
Model name:                      Intel(R) Core(TM) i5-8300H CPU @ 2.30GHz
Stepping:                        10
CPU MHz:                         2300.000
CPU max MHz:                     2300.0000
CPU min MHz:                     800.0000
BogoMIPS:                        4599.93
Virtualization:                  VT-x
L1d cache:                       128 KiB
L1i cache:                       128 KiB
L2 cache:                        1 MiB
L3 cache:                        8 MiB
NUMA node0 CPU(s):               0-7
Vulnerability Itlb multihit:     KVM: Mitigation: VMX disabled
Vulnerability L1tf:              Mitigation; PTE Inversion; VMX conditional cach
                                 e flushes, SMT vulnerable
Vulnerability Mds:               Mitigation; Clear CPU buffers; SMT vulnerable
Vulnerability Meltdown:          Mitigation; PTI
Vulnerability Spec store bypass: Mitigation; Speculative Store Bypass disabled v
                                 ia prctl and seccomp
Vulnerability Spectre v1:        Mitigation; usercopy/swapgs barriers and __user
                                  pointer sanitization
Vulnerability Spectre v2:        Mitigation; Full generic retpoline, IBPB condit
                                 ional, IBRS_FW, STIBP conditional, RSB filling
Vulnerability Srbds:             Mitigation; Microcode
Vulnerability Tsx async abort:   Not affected
Flags:                           fpu vme de pse tsc msr pae mce cx8 apic sep mtr
                                 r pge mca cmov pat pse36 clflush dts acpi mmx f
                                 xsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rd
                                 tscp lm constant_tsc art arch_perfmon pebs bts
                                 rep_good nopl xtopology nonstop_tsc cpuid aperf
                                 mperf pni pclmulqdq dtes64 monitor ds_cpl vmx e
                                 st tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid sse4_
                                 1 sse4_2 x2apic movbe popcnt tsc_deadline_timer
                                  aes xsave avx f16c rdrand lahf_lm abm 3dnowpre
                                 fetch cpuid_fault epb invpcid_single pti ssbd i
                                 brs ibpb stibp tpr_shadow vnmi flexpriority ept
                                  vpid ept_ad fsgsbase tsc_adjust bmi1 avx2 smep
                                  bmi2 erms invpcid mpx rdseed adx smap clflusho
                                 pt intel_pt xsaveopt xsavec xgetbv1 xsaves dthe
                                 rm ida arat pln pts hwp hwp_notify hwp_act_wind
                                 ow hwp_epp md_clear flush_l1d
pranav@pranav:~$
```

(b) My machine has 4 cores.

(c) My machine has 8 processors.

```
pranav@pranav:~$ nproc
8
```

(d) Frequency of each processor is as below:

```
pranav@pranav:~$ cat /proc/cpuinfo | grep "MHz"
cpu MHz         : 883.153
cpu MHz         : 2300.000
cpu MHz         : 2300.000
cpu MHz         : 2300.000
cpu MHz         : 2300.000
cpu MHz         : 2300.000
cpu MHz         : 1262.712
cpu MHz         : 866.497
```

(e) My system has 7982220 kB physical memory.

```
pranav@pranav:~$ cat /proc/meminfo
MemTotal:        7982220 kB
MemFree:         3003848 kB
MemAvailable:    4297584 kB
Buffers:           92296 kB
Cached:          1505084 kB
```

(f) 3003848 kB memory is free.

(g) Total number of forks from last boot is 99924.

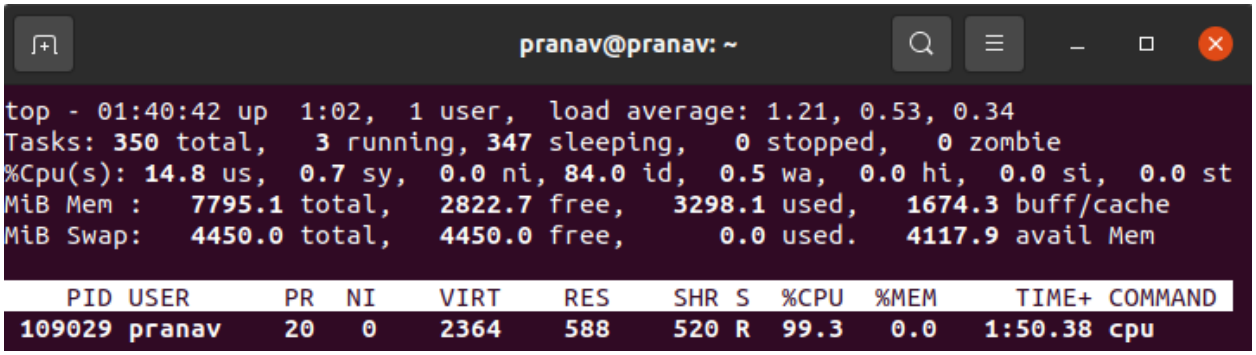
```
pranav@pranav:~$ cat /proc/stat | grep processes
processes 99924
```

(h) Since bootup the system has performed 10538964 context switches.

```
pranav@pranav:~$ cat /proc/stat | grep ctxt
ctxt 10538964
```

2.

```
pranav@pranav:~/Desktop/OS_lab/intro-code$ gcc cpu.c -o cpu
pranav@pranav:~/Desktop/OS_lab/intro-code$ ./cpu
```

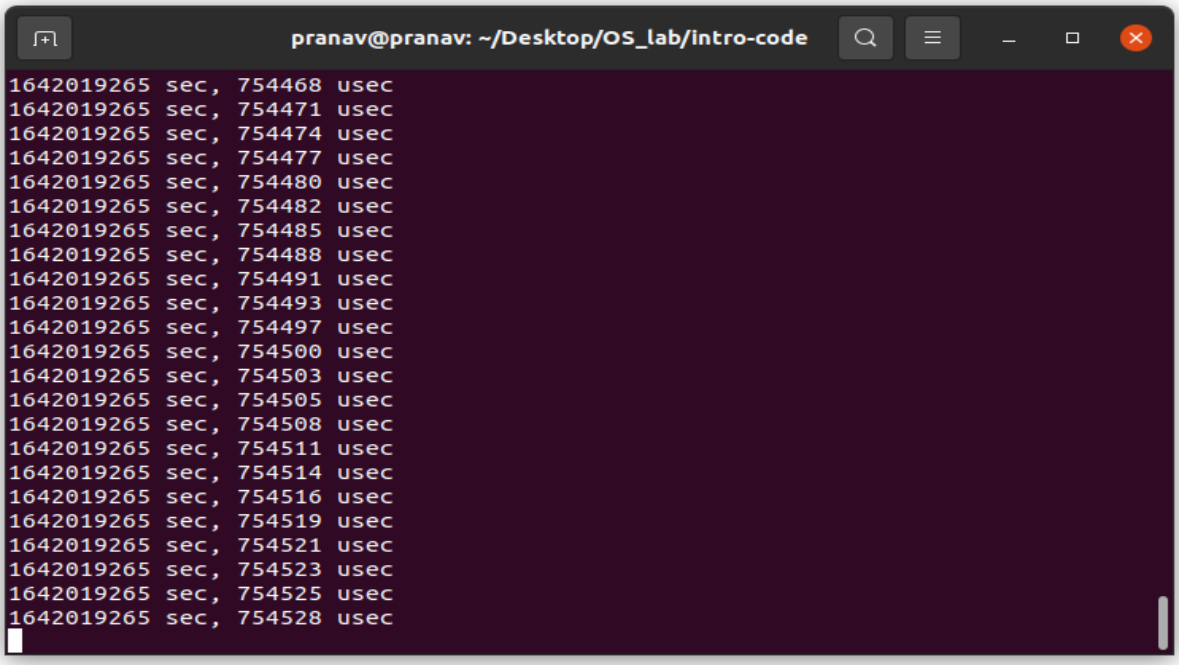


(a) PID is 109029

(b) CPU used is 99.3% and memory used is 0.0%.

(c) Current state of the process is running.

3.



```
pranav@pranav:~$ ps axo ppid,pid,pcpu,comm
   PPID     PID %CPU COMMAND
      0       1  0.7 systemd
      0       2  0.0 kthreadd
      2       3  0.0 rcu_gp
      2       4  0.0 rcu_par_gp
      2       5  0.0 kworker/0:0-events
      2       6  0.0 kworker/0:0H-events_highpri
      2       7  0.0 kworker/0:1-cgroup_destroy
      2       8  0.0 kworker/u16:0-nvme-wq
      2       9  0.0 mm_percpu_wq
      2      10  0.0 rcu_tasks_rude_
      2      11  0.0 rcu_tasks_trace
      2      12  0.0 ksoftirqd/0
      2      13  0.0 rcu_sched
      2      14  0.0 migration/0
      2      15  0.0 idle_inject/0
      2      16  0.0 cpuhp/0
      2      17  0.0 cpuhp/1
      2      18  0.0 idle_inject/1
      2      19  0.0 migration/1
      2      20  0.0 ksoftirqd/1
      2      21  0.0 kworker/1:0-events
      2      22  0.0 kworker/1:0H-events_highpri
      2      23  0.0 cpuhp/2
      2      24  0.0 idle_inject/2
      2      25  0.0 migration/2
      2      26  0.0 ksoftirqd/2
      2      27  0.0 kworker/2:0-events
      2      28  0.0 kworker/2:0H-events_highpri
      2      29  0.0 cpuhp/3
   2721    3111  0.0 gsd-a11y-settin
   2721    3112  0.0 gsd-color
   2721    3114  0.0 gsd-datetime
   2721    3117  0.0 gsd-housekeepin
   2721    3119  0.0 gsd-keyboard
   2721    3121  0.1 gsd-media-keys
   2721    3122  0.1 gsd-power
   2721    3125  0.0 gsd-print-notif
   2721    3126  0.0 gsd-rfkill
   2721    3127  0.0 gsd-screensaver
   2721    3128  0.0 gsd-sharing
   2721    3129  0.0 gsd-smartcard
   2721    3131  0.0 gsd-sound
   2721    3134  0.0 gsd-usb-protect
   2721    3136  0.0 gsd-wacom
   2721    3137  0.0 gsd-wwan
   2721    3138  0.1 gsd-xsettings
   2974    3179  0.0 gsd-disk-utilit
   2974    3187  0.1 evolution-alarm
   3011    3204  0.0 ibus-engine-sim
   2721    3278  0.0 xdg-document-po
   2721    3305  0.0 gsd-printer
   2721    5849  0.0 gvfsd-metadata
   2974    5850  0.2 update-notifier
   2721    6731  7.2 gnome-terminal-
   6731    6739  0.0 bash
   6731    6762  0.0 bash
   2974    8117  0.2 deja-dup-monito
   6762    8125 50.6 cpu-print
   6739    8835  0.0 ps
```

(a) PID of cpu-print is 8125.

(b) PPID of cpu-print is 6762.

PIDs of ancestors of cpu-print: PID 0 (init) -> PID 1 (systemd) -> PID 2721 (systemd) -> PID 6731 (gnome-terminal-) -> PID 6762 (bash) -> PID 8125 (cpu-print)

(c)

```
pranav@pranav:~/Desktop/OS_lab/intro-code$ ./cpu-print > /tmp/tmp.txt
^C
```

```
pranav@pranav:~$ ps -aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  0.0  0.1 167788 11756 ?        Ss   02:56   0:01 /sbin/init s
root           2  0.0  0.0      0     0 ?        S    02:56   0:00 [kthreadd]
root           3  0.0  0.0      0     0 ?        I<   02:56   0:00 [rcu_gp]
root           4  0.0  0.0      0     0 ?        I<   02:56   0:00 [rcu_par_gp]
root           5  0.0  0.0      0     0 ?        I    02:56   0:00 [kworker/0:0
root           6  0.0  0.0      0     0 ?        I<   02:56   0:00 [kworker/0:0
root           9  0.0  0.0      0     0 ?        I<   02:56   0:00 [mm_percpu_w
root          10  0.0  0.0      0     0 ?        S    02:56   0:00 [rcu_tasks_r
root          11  0.0  0.0      0     0 ?        S    02:56   0:00 [rcu_tasks_t
root          12  0.0  0.0      0     0 ?        S    02:56   0:00 [ksoftirqd/0
root          13  0.0  0.0      0     0 ?        I    02:56   0:00 [rcu_sched]
root          14  0.0  0.0      0     0 ?        S    02:56   0:00 [migration/0
root          15  0.0  0.0      0     0 ?        S    02:56   0:00 [idle_inject
root       61096  0.0  0.0      0     0 ?        I    03:26   0:00 [kworker/4:1-events]
root       62377  0.0  0.0      0     0 ?        I    03:26   0:00 [kworker/u16:1-events_unbou
root       64380  0.0  0.0      0     0 ?        I    03:28   0:00 [kworker/3:2-events]
root       64388  0.0  0.0      0     0 ?        I    03:28   0:00 [kworker/0:2]
root       64733  0.0  0.0      0     0 ?        I    03:28   0:00 [kworker/5:2-events]
root       65410  0.0  0.0      0     0 ?        I    03:29   0:00 [kworker/7:0-events]
root       66113  0.0  0.0      0     0 ?        I    03:30   0:00 [kworker/1:2-events]
root       66452  0.0  0.0      0     0 ?        I    03:30   0:00 [kworker/6:0-events]
root       69512  0.3  0.0      0     0 ?        I    03:33   0:00 [kworker/u16:2-events_unbou
root       69518  0.0  0.0      0     0 ?        I    03:33   0:00 [kworker/3:1]
pranav     69532  109  0.0   2496   716 pts/1    R+   03:35   0:05 ./cpu-print
root       69533  0.0  0.0      0     0 ?        I    03:35   0:00 [kworker/4:0-mm_percpu_wq]
pranav     69534  0.0  0.0  11688  3496 pts/0    R+   03:35   0:00 ps -aux
pranav@pranav:/proc/69510/fd$ cd /proc/69532
pranav@pranav:/proc/69532$ cd fd
pranav@pranav:/proc/69532/fd$ ls
0  1  2
pranav@pranav:/proc/69532/fd$ ls
pranav@pranav:/proc/69532/fd$
```

The PID of the process is 69532. Folder proc/69532 is created when the process is ready. Inside of /proc/69532/fd we have three files (namely 0, 1, 2) that are only present when the process is running. The three files are automatically removed after the process is terminated.

➔ 0 (Standard input)

This is an input file. By default, shell is used to accept input, however we may use the '>' operator to redirect input from a file.

➔ 1 (Standard output)

Here the program output is printed. By default, it is displayed on the shell, but can be redirected using '>'.

➔ 2 (Standard error)

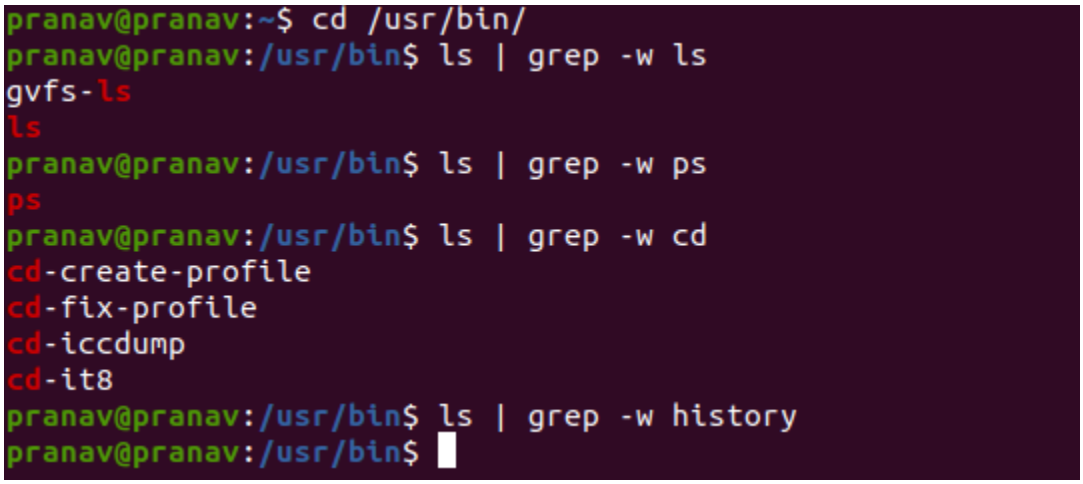
Any error encountered is stored here. By default, error messages are displayed on the shell, but can be redirected using '2>'.

(d)

```
pranav@pranav:~/Desktop/OS_lab/intro-code$ ./cpu-print | grep hello
^C
pranav@pranav:~$ ps aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  0.0  0.1 167788 11756 ?        Ss   02:56   0:01 /sbin/init spla
root           2  0.0  0.0      0     0 ?        S    02:56   0:00 [kthreadd]
root           3  0.0  0.0      0     0 ?        I<   02:56   0:00 [rcu_gp]
root           4  0.0  0.0      0     0 ?        I<   02:56   0:00 [rcu_par_gp]
root           5  0.0  0.0      0     0 ?        I    02:56   0:00 [kworker/0:0-ev
root           6  0.0  0.0      0     0 ?        I<   02:56   0:00 [kworker/0:0H-e
root           9  0.0  0.0      0     0 ?        I<   02:56   0:00 [mm_percpu_wq]
root          10  0.0  0.0      0     0 ?        S    02:56   0:00 [rcu_tasks_rude
pranav     69905  0.0  0.0 360064  5792 ?        Sl   04:07   0:00 /usr/lib/speech
pranav     69908  0.0  0.0 159732  2224 ?        Ssl  04:07   0:00 /usr/bin/speech
root       69985  0.0  0.0      0     0 ?        I    04:12   0:00 [kworker/7:0]
root       69986  0.0  0.0      0     0 ?        I    04:12   0:00 [kworker/0:2-ev
root       69987  0.0  0.0      0     0 ?        I    04:12   0:00 [kworker/5:2-ev
root       69998  0.0  0.0      0     0 ?        I    04:14   0:00 [kworker/3:2-ev
root       70010  0.0  0.0      0     0 ?        I    04:16   0:00 [kworker/6:1-ev
root       70032  0.0  0.0      0     0 ?        I    04:19   0:00 [kworker/u16:0]
pranav     70045  0.0  0.9 2389500 72380 ?       Sl   04:20   0:00 /usr/lib/firefo
root       70073  0.0  0.0      0     0 ?        I    04:20   0:00 [kworker/3:0-ev
pranav     70116  114  0.0   2496   648 pts/1    R+   04:23   0:05 ./cpu-print
pranav     70117 23.2  0.0   8908  2644 pts/1    S+   04:23   0:01 grep --color=au
pranav     70118  0.0  0.0  11500  3180 pts/0    R+   04:23   0:00 ps aux
pranav@pranav:~$ cd /proc/70116/fd
pranav@pranav:/proc/70116/fd$ ls
0  1  2
pranav@pranav:/proc/70116/fd$ cd --
pranav@pranav:~$ cd /proc/70117/fd
pranav@pranav:/proc/70117/fd$ ls
0  1  2
pranav@pranav:/proc/70117/fd$ ls
pranav@pranav:/proc/70117/fd$
```

Pipes serve as an inter-process communication channel process. They have only one direction of travel. Between two instructions, one end of the pipe is used to read and the other is used to write. Here the output of 'cpu-print' is piped as input to the grep command. This is proved by the fact that 1 (standard output) of 'cpu-print' and 0 (standard input) of grep are both highlighted in red in the terminal.

(e)



If we go in /usr/bin/ we can see codes for ‘ls’ and ‘ps’. It means that both ‘ls’ and ‘ps’ are programs executed by bash, whereas ‘cd’ and ‘history’ are commands executed by the shell itself.

4.

For memory1.c

```
pranav@pranav:~/Desktop/OS_lab/intro-code$ ./memory1


Program : 'memory_1'
--------------------


PID : 70503
Size of int : 4

Press Enter Key to exit.
```

```
pranav@pranav:/usr/bin$ ps ef -o command,rss
COMMAND                      RSS
bash SSH_AUTH_SOCK=/run/use  4624
 \_ ./memory1 SHELL=/bin/ba  4856
bash GJS_DEBUG_TOPICS=JS ER  4676
 \_ ps ef -o command,rss SH  3172
/usr/lib/gdm3/gdm-x-session  6600
 \_ /usr/libexec/gnome-sess 13528
```

For memory1.c

```
pranav@pranav:~/Desktop/OS_lab/intro-code$ ./memory2


Program : 'memory_2'
---------------------


PID : 70560
Size of int : 4

Press Enter Key to exit.
```

```
pranav@pranav:/usr/bin$ ps ef -o command,rss
COMMAND                      RSS
bash SSH_AUTH_SOCK=/run/use  4676
 \_ ./memory2 SHELL=/bin/ba  4952
bash GJS_DEBUG_TOPICS=JS ER  4676
 \_ ps ef -o command,rss SH  3216
/usr/lib/gdm3/gdm-x-session  6600
 \_ /usr/libexec/gnome-sess 13528
pranav@pranav:/usr/bin$
```

RSS for memory1.c is less compared to memory2.c as memory1.c doesn't access the memory but the other does. This is also evident from the above images.

5.

Before:

```
pranav@pranav:~$ iostat
Linux 5.11.0-40-generic (pranav)        13/01/22        _x86_64_        (8 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           7.89    0.64    2.89    0.47    0.00   88.12

Device             tps    kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
loop0             0.07         0.09         0.00         0.00         17          0          0
loop1             0.22         1.81         0.00         0.00        347          0          0
loop10            0.31         5.64         0.00         0.00       1083          0          0
loop11            0.31         2.01         0.00         0.00        387          0          0
loop12            0.22         1.81         0.00         0.00        347          0          0
loop13            0.35         5.78         0.00         0.00       1110          0          0
loop14            0.22         1.81         0.00         0.00        348          0          0
loop15            0.29         5.61         0.00         0.00       1077          0          0
loop16            3.14       109.65         0.00         0.00      21069          0          0
loop17            0.06         0.09         0.00         0.00         18          0          0
loop2             1.41        13.42         0.00         0.00       2579          0          0
loop3             0.22         1.82         0.00         0.00        350          0          0
loop4             0.80         6.59         0.00         0.00       1267          0          0
loop5             0.30         5.50         0.00         0.00       1056          0          0
loop6             0.23         1.84         0.00         0.00        353          0          0
loop7             0.32         5.55         0.00         0.00       1067          0          0
loop8             0.25         1.87         0.00         0.00        359          0          0
loop9             0.25         1.88         0.00         0.00        362          0          0
nvme0n1         193.26      5915.28       853.34         0.00    1136561     163961          0
sda               0.92        22.47         0.00         0.00       4316          0          0
```

After running disk.c:

```
pranav@pranav:~$ iostat
Linux 5.11.0-40-generic (pranav)        13/01/22        _x86_64_        (8 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.55    0.04    6.57    0.06    0.00   87.79

Device             tps    kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
loop0             0.00         0.01         0.00         0.00         17          0          0
loop1             0.01         0.10         0.00         0.00        347          0          0
loop10            0.02         0.32         0.00         0.00       1083          0          0
loop11            0.02         0.12         0.00         0.00        387          0          0
loop12            0.01         0.10         0.00         0.00        347          0          0
loop13            0.02         0.33         0.00         0.00       1110          0          0
loop14            0.01         0.10         0.00         0.00        348          0          0
loop15            0.02         0.32         0.00         0.00       1077          0          0
loop16            0.19         6.64         0.00         0.00      22292          0          0
loop17            0.00         0.01         0.00         0.00         18          0          0
loop2             0.08         0.77         0.00         0.00       2579          0          0
loop3             0.01         0.10         0.00         0.00        350          0          0
loop4             0.05         0.38         0.00         0.00       1267          0          0
loop5             0.02         0.31         0.00         0.00       1056          0          0
loop6             0.01         0.11         0.00         0.00        353          0          0
loop7             0.02         0.32         0.00         0.00       1067          0          0
loop8             0.01         0.11         0.00         0.00        359          0          0
loop9             0.01         0.11         0.00         0.00        362          0          0
nvme0n1          28.85      1879.02        53.63         0.00    6311181     180133          0
sda               0.06         1.29         0.00         0.00       4324          0          0
```

After running disk1.c:

```
pranav@pranav:~$ iostat
Linux 5.11.0-40-generic (pranav)        13/01/22        _x86_64_        (8 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.95    0.03    6.28    0.04    0.00   87.70

Device             tps    kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
loop0             0.00         0.00         0.00         0.00         17          0          0
loop1             0.01         0.07         0.00         0.00        347          0          0
loop10            0.01         0.22         0.00         0.00       1083          0          0
loop11            0.01         0.08         0.00         0.00        387          0          0
loop12            0.01         0.07         0.00         0.00        347          0          0
loop13            0.01         0.23         0.00         0.00       1110          0          0
loop14            0.01         0.07         0.00         0.00        348          0          0
loop15            0.01         0.22         0.00         0.00       1077          0          0
loop16            0.13         4.60         0.00         0.00      22292          0          0
loop17            0.00         0.00         0.00         0.00         18          0          0
loop2             0.06         0.53         0.00         0.00       2579          0          0
loop3             0.01         0.07         0.00         0.00        350          0          0
loop4             0.03         0.26         0.00         0.00       1267          0          0
loop5             0.01         0.22         0.00         0.00       1056          0          0
loop6             0.01         0.07         0.00         0.00        353          0          0
loop7             0.01         0.22         0.00         0.00       1067          0          0
loop8             0.01         0.07         0.00         0.00        359          0          0
loop9             0.01         0.07         0.00         0.00        362          0          0
nvme0n1          20.17      1301.95        38.68         0.00    6311233     187509          0
sda               0.04         0.89         0.00         0.00       4328          0          0
```

The kB read/s fluctuates when the two programs are running, as seen in the images. Because 'disk.c' starts at a random point, it requires data to be retrieved from the hard disc, whereas disk1.c starts at the 0th position and hence has a slower read speed.