

Lab 1: Introduction

1- Understanding the hardware configuration of the running machine:

a)

```
hasan@hasan-VirtualBox:~$ more /proc/cpuinfo
processor       : 0
vendor_id      : GenuineIntel
cpu family     : 6
model          : 142
model name     : Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz
stepping      : 10
cpu MHz        : 1800.002
cache size     : 6144 KB
physical id    : 0
siblings       : 1
core id        : 0
cpu cores      : 1
apicid         : 0
initial apicid : 0
fpu            : yes
fpu_exception  : yes
cpuid level    : 22
wp             : yes
flags          : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ht syscall nx rdtsc
cp_lm constant_tsc rep_good nopl xtopology nonstop_tsc cpuid tsc_known_freq pni pclmulqdq monitor ssse3 cx16 pcid sse4_1 sse4_2 x2apic
movbe popcnt aes xsave avx rdrand hypervisor lahf_lm abm 3dnowprefetch invpcid_single pti fsgsbase avx2 invpcid rdseed clflushopt md_
clear_flush_lid
bugs           : cpu_meltdown spectre_v1 spectre_v2 spec_store_bypass l1tf mds swapgs itlb_multihit srbds
bogomips       : 3600.00
clflush size   : 64
cache_alignment : 64
address sizes   : 39 bits physical, 48 bits virtual
power management:
```

→ **Processor:** Also known as the CPU, provides the instructions and processing power the computer needs to do its work.

→ **Core/s:** Is a small CPU or processor built into a big CPU or CPU socket. It can independently perform or process all computational tasks. From this perspective, we can consider a core to be a smaller CPU or a smaller processor within a big processor.

```
hasan@hasan-VirtualBox:~$ 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):                1
On-line CPU(s) list:   0
Thread(s) per core:    1
Core(s) per socket:    1
Socket(s):             1
NUMA node(s):          1
Vendor ID:             GenuineIntel
CPU family:            6
Model:                 142
Model name:            Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz
Stepping:              10
CPU MHz:               1800.002
BogoMIPS:              3600.00
Hypervisor vendor:     KVM
Virtualization type:    full
L1d cache:             32 KiB
L1i cache:             32 KiB
L2 cache:              256 KiB
L3 cache:              6 MiB
NUMA node0 CPU(s):     0
Vulnerability Itlb multihit: KVM: Vulnerable
Vulnerability L1tf:      Mitigation; PTE Inversion
Vulnerability Mds:       Mitigation; Clear CPU buffers; SMT Host state unknown
Vulnerability Meltdown:  Mitigation; PTI
Vulnerability Spec store bypass: Vulnerable
```

```

Vulnerability Spectre v1: Mitigation; usercopy/swapgs barriers and __user pointer sanitization
Vulnerability Spectre v2: Mitigation; Full generic retpoline, STIBP disabled, RSB filling
Vulnerability Srbds: Unknown: Dependent on hypervisor status
Vulnerability Tsx async abort: Not affected
Flags:
fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ht
syscall nx rdtscp lm constant_tsc rep_good nopl xtopology nonstop_tsc cpuid tsc_known_freq pni pclmul
qdq monitor ssse3 cx16 pcid sse4_1 sse4_2 x2apic movbe popcnt aes xsave avx rdrand hypervisor lahf_lm
abm 3dnowprefetch invpcid_single pti fsgsbase avx2 invpcid rdseed clflushopt md_clear flush_lid

```

b) Number of cores = 1

c) Number of processors = 1

d) Frequency of processor = 1800.002 MHz

e) Total = 1.5 GB

```

hasan@hasan-VirtualBox:~$ free -h --si
              total        used        free      shared  buff/cache   available
Mem:          1.5G          1.0G          99M           87M          385M          253M
Swap:          947M          478M          469M

```

f) Free = 99 MB

g) Number of forks since boot = 46767

```

hasan@hasan-VirtualBox:~$ vmstat -f
46767 forks

```

h) Number of context switches since boot up = 64448444

```

hasan@hasan-VirtualBox:~$ procinfo
Memory:      Total      Used      Free      Buffers
RAM:         1527604    1401648    125956    61824
Swap:        969960     827348    142612

Bootup: Mon Mar 15 09:24:13 2021   Load average: 0.01 0.24 0.20 1/579 58608

user  :    01:57:16.82   13.5%  page in :           7860300
nice  :    00:00:22.65    0.0%  page out:           3876992
system:  00:16:00.84    1.8%  page act:           2191473
IOwait:  00:23:14.76    2.7%  page dea:           2127951
hw irq:  00:00:00.00    0.0%  page flt:          34523556
sw irq:  00:00:24.22    0.0%  swap in :             86033
idle  :   11:52:01.36   81.9%  swap out:           302470
uptime:  14:43:40.38          context :          64448444

irq 0:         30 2-edge timer      irq 15:         53031 15-edge ata_piix
irq 1:        11507 1-edge i8042      irq 18:        249752 18-fasteoi vmwgfx
irq 8:          0 8-edge rtc0         irq 19:        519149 19-fasteoi enp0s3
irq 9:          0 9-fasteoi acpi      irq 20:        142569 20-fasteoi vboxgu
irq 12:        11326 12-edge i8042    irq 21:        935018 21-fasteoi ahci[0
irq 14:          0 14-edge ata_piix    irq 22:          30 22-fasteoi ohci_h

enp0s3      TX 28.21MiB      RX 326.27MiB      lo              TX 288.88KiB      RX 288.88KiB

```

2- understanding how to monitor the status of a running process using the top

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ gcc cpu.c -o cpu
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ./cpu
```

```
top - 00:29:04 up 15:04, 1 user, load average: 1.20, 1.08, 0.77
Tasks: 211 total, 2 running, 203 sleeping, 0 stopped, 6 zombie
%Cpu(s): 97.7 us, 2.3 sy, 0.0 ni, 0.0 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
MiB Mem : 1491.8 total, 78.3 free, 875.7 used, 537.8 buff/cache
MiB Swap: 947.2 total, 227.4 free, 719.8 used. 400.1 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
58836	hasan	20	0	2356	524	460	R	94.7	0.0	11:06.68	cpu
1746	hasan	20	0	3807420	201696	53148	S	2.3	13.2	21:06.59	gnome-shell
1527	hasan	20	0	684200	118536	44664	S	1.0	7.8	8:03.51	Xorg
44991	hasan	20	0	819592	28280	17776	S	1.0	1.9	0:14.86	gnome-terminal-
43159	hasan	20	0	4651392	97132	49544	S	0.3	6.4	1:15.39	opera
58917	hasan	20	0	12568	3960	3324	R	0.3	0.3	0:00.32	top
1	root	20	0	168944	7640	4928	S	0.0	0.5	0:11.74	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.01	kthreadd
3	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_gp
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	rcu_par_gp
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	kworker/0:0H-kblockd
9	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	mm_percpu_wq
10	root	20	0	0	0	0	S	0.0	0.0	0:02.49	ksoftirqd/0
11	root	20	0	0	0	0	I	0.0	0.0	0:12.99	rcu_sched
12	root	rt	0	0	0	0	S	0.0	0.0	0:00.43	migration/0
13	root	-51	0	0	0	0	S	0.0	0.0	0:00.00	idle_inject/0
14	root	20	0	0	0	0	S	0.0	0.0	0:00.00	cpuhp/0
15	root	20	0	0	0	0	S	0.0	0.0	0:00.00	kdevtmpfs
16	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	netns
17	root	20	0	0	0	0	S	0.0	0.0	0:00.00	rcu_tasks_kthre
18	root	20	0	0	0	0	S	0.0	0.0	0:00.00	kauditd

command:

- PID of CPU = 58836
- CPU consumption = 94.7%, Memory consumption = 0.0%
- The CPU process state is R which means that it is running.

3- Understanding how the Linux shell runs user commands by spawning new child processes to execute the various commands:

a)

```
1615841373 sec, 754086 usec
1615841373 sec, 754097 usec
1615841373 sec, 754107 usec
1615841373 sec, 754117 usec
1615841373 sec, 754128 usec
1615841373 sec, 754139 usec
1615841373 sec, 754247 usec
1615841373 sec, 754267 usec
1615841373 sec, 754284 usec
1615841373 sec, 754306 usec
1615841373 sec, 754328 usec
1615841373 sec, 754344 usec
1615841373 sec, 754359 usec
1615841373 sec, 754502 usec
1615841373 sec, 754533 usec
1615841373 sec, 754552 usec
1615841373 sec, 754570 usec
1615841373 sec, 754594 usec
1615841373 sec, 754651 usec
1615841373 sec, 754806 usec
1615841373 sec, 754825 usec
1615841373 sec, 754840 usec
1615841373 sec, 754856 usec
1615841373 sec, 754872 usec
1615841373 sec, 754887 usec
1615841373 sec, 754902 usec
1615841373 sec, 754919 usec
1615841373 sec, 754935 usec
```

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -e
```

PID	TTY	TIME	CMD
1	?	00:00:12	systemd
2	?	00:00:00	kthreadd
3	?	00:00:00	rcu_gp
4	?	00:00:00	rcu_par_gp
6	?	00:00:00	kworker/0:0H-kblockd
9	?	00:00:00	mm_percpu_wq
10	?	00:00:02	ksoftirqd/0
11	?	00:00:13	rcu_sched
12	?	00:00:00	migration/0
13	?	00:00:00	idle_inject/0
14	?	00:00:00	cpuhp/0
15	?	00:00:00	kdevtmpfs
16	?	00:00:00	netns
17	?	00:00:00	rcu_tasks_kthre
18	?	00:00:00	kauditd
19	?	00:00:00	khungtaskd
20	?	00:00:00	oom_reaper
21	?	00:00:00	writeback
22	?	00:00:00	kcompactd0
23	?	00:00:00	ksmd
24	?	00:00:00	khugepaged
70	?	00:00:00	kintegrityd
71	?	00:00:00	kblockd
72	?	00:00:00	blkcg_punt_bio
73	?	00:00:00	tpm_dev_wq

```
59280 pts/1 00:02:07 cpu-print
59281 ? 00:00:40 kworker/u2:2-events_unbound
59329 ? 00:00:09 kworker/u2:3-events_power_efficient
59519 pts/2 00:00:00 ps
```

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -p 59280
```

PID	TTY	TIME	CMD
59280	pts/1	00:07:19	cpu-print

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$
```

b)

```
60176 ?          00:00:03 kworker/u2:0-events_unbound
60390 pts/1       00:00:42 cpu-print
60406 ?          00:00:06 kworker/u2:1-events_unbound
60436 pts/2       00:00:00 ps
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 60390
58801
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 58801
44991
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 44991
1434
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 1434
1
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 1
0
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -o ppid= -p 0
error: process ID out of range

Usage:
ps [options]

Try 'ps --help <simple|list|output|threads|misc|all>'
or 'ps --help <s|l|o|t|m|a>'
for additional help text.

For more details see ps(1).
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$
```

c)

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ./cpu-print | grep hello &
[2] 61715
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -p 61715
  PID TTY          TIME CMD
 61715 pts/2      00:00:00 grep
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$
```

→ A pipe is a form of redirection (transfer of standard output to some other destination) that is used in Linux and other Unix-like operating systems to send the output of one command/program/process to another command/program/process for further processing.

d)

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ./cpu-print | grep hello &
[2] 61715
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ ps -p 61715
  PID TTY          TIME CMD
 61715 pts/2      00:00:00 grep
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$
```


→ Shells implement piping in a manner very similar to how they implement redirection. Basically, the parent process calls pipe(2) once for each two processes that get piped together.

e)

```
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ type cd
cd is a shell builtin
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ type ls
ls is aliased to `ls --color=auto'
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ type history
history is a shell builtin
hasan@hasan-VirtualBox:~/Desktop/OS/Lab 1/intro-code$ type ps
ps is hashed (/bin/ps)
```

→ Internal commands: cd, history

→ External commands: ls, ps

4-

```
hasan@hasan-VirtualBox:/mnt/0F68-9AE9/OS/Lab 1/intro-code$ ./memory1

Program : 'memory_1'
-----

PID : 4436
Size of int : 4

Press Enter Key to exit.
█
```

```
hasan@hasan-VirtualBox:/mnt/0F68-9AE9/OS/Lab 1/intro-code$ ./memory2

Program : 'memory_2'
-----

PID : 4543
Size of int : 4

Press Enter Key to exit.
█
```

5-

```
Total DISK READ:      20.81 M/s | Total DISK WRITE:      11.82 K/s
Current DISK READ:    20.81 M/s | Current DISK WRITE:    39.39 K/s
  TID  PRIO  USER      DISK READ  DISK WRITE  SWAPIN      IO>   COMMAND
  4638 be/4  hasan      20.77 M/s    0.00 B/s    0.00 % 74.91 % ./disk
```

```
hasan@hasan-VirtualBox:/mnt/0F68-9AE9/OS/Lab 1/intro-code$ top
```

```
top - 17:01:20 up 21 min,  1 user,  load average: 0.83, 0.72, 1.12
Tasks: 191 total,   3 running, 188 sleeping,   0 stopped,   0 zombie
%Cpu(s): 75.8 us, 24.2 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem : 1491.8 total,   73.2 free,  886.2 used,  532.4 buff/cache
MiB Swap:  947.2 total,  917.6 free,   29.6 used.  434.7 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
3840	hasan	20	0	2488	520	452	R	98.7	0.0	1:04.36	disk1