Operating Systems - Lab 1 15 Jan 2024

Aryaman Srivastava 2210110206

Q1.

Output of running processes

```
kaalachor@DESKTOP-4MHM220:~$ ./a.out
PID     USER                COMMAND
  PID USER     COMMAND
    1 root     /init
    9 root     /init
   10 kaalach+ -bash
  204 kaalach+ dbus-launch --autolaunch=2362bbb3000a4a20f538354e63347102 --binary-syntax --close-stderr
  205 kaalach+ /usr/bin/dbus-daemon --syslog-only --fork --print-pid 5 --print-address 7 --session
  209 kaalach+ /usr/libexec/at-spi-bus-launcher
  215 kaalach+ /usr/bin/dbus-daemon --config-file=/usr/share/defaults/at-spi2/accessibility.conf --nofork --print-address 3
  218 kaalach+ /usr/libexec/dconf-service
  225 kaalach+ /usr/libexec/at-spi2-registryd --use-gnome-session
  241 kaalach+ ./a.out
  242 kaalach+ sh -c ps -eo pid,user,args
  243 kaalach+ ps -eo pid,user,args
```

Output of **“ps -A”** command

```
kaalachor@DESKTOP-4MHM220: ~
voluntary_ctxt_switches:        150
nonvoluntary_ctxt_switches:     545
kaalachor@DESKTOP-4MHM220:~$ ps -A
  PID TTY          TIME CMD
    1 ?        00:00:00 init
    9 tty1     00:00:00 init
   10 tty1     00:00:00 bash
   76 tty1     00:00:00 ps
kaalachor@DESKTOP-4MHM220:~$
```

Similarities:

Both methods provide information about currently running processes on Linux

Differences:

The C program directly reads information from the /proc filesystem but “ps -A” command gathers the process information from the kernel.

Q2.

(a) Output of **more /proc/cpuinfo**

```
kaalachor@DESKTOP-4MHM220:~$  more /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 58
model name      :       Intel(R) Core(TM) i5-3230M CPU @ 2.60GHz
stepping        : 9
microcode       : 0xffffffff
cpu MHz         : 2601.000
cache size      : 256 KB
physical id     : 0
siblings        : 4
core id         : 0
cpu cores       : 2
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 6
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx rdtscp lm pni pclmulqdq
 est tm2 ssse3 cx16 xtpr pdcm pcid sse4_1 sse4_2 popcnt aes xsave osxsave avx f16c rdrand hypervisor lahf_lm fsgsbase smep erms ibrs ibpb stibp ssbd
bogomips        : 5202.00
clflush size    : 64
cache_alignment : 64
address sizes   : 36 bits physical, 48 bits virtual
power management:

processor       : 1
vendor_id       : GenuineIntel
cpu family      : 6
model           : 58
model name      :       Intel(R) Core(TM) i5-3230M CPU @ 2.60GHz
stepping        : 9
microcode       : 0xffffffff
cpu MHz         : 2601.000
cache size      : 256 KB
physical id     : 0
```

Output of **lscpu**

```
kaalachor@DESKTOP-4MHM220:~$ lscpu
Architecture:        x86_64
CPU op-mode(s):      32-bit, 64-bit
Byte Order:          Little Endian
Address sizes:       36 bits physical, 48 bits virtual
CPU(s):              4
On-line CPU(s) list: 0-3
Thread(s) per core:  2
Core(s) per socket:  2
Socket(s):           1
Vendor ID:           GenuineIntel
CPU family:          6
Model:               58
Model name:          Intel(R) Core(TM) i5-3230M CPU @ 2.60GHz
Stepping:            9
CPU MHz:             2601.000
CPU max MHz:         2601.0000
BogoMIPS:            5202.00
Hypervisor vendor:   Windows Subsystem for Linux
Virtualization type: container
Flags:               fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx rdtscp lm pni pclmul
                     qdq est tm2 ssse3 cx16 xtpr pdcm pcid sse4_1 sse4_2 popcnt aes xsave osxsave avx f16c rdrand hypervisor lahf_lm fsgsbase smep erms ibrs ibpb stibp
                     ssbd
```

Processors: Processor number assigned to each CPU core

Cores: Number of physical CPU cores on each processor.

(b) CPU cores: 8

(c) Processor: 4

(d) 2.601 GHz

(e) Model name: Intel Core i5-3230M

(f)

```
kaalachor@DESKTOP-4MHM220:~$ cat /proc/meminfo
MemTotal:        8258684 kB
MemFree:         2622084 kB
Buffers:           34032 kB
Cached:           188576 kB
SwapCached:            0 kB
Active:           167556 kB
Inactive:         157876 kB
Active(anon):     103104 kB
Inactive(anon):    17440 kB
Active(file):      64452 kB
Inactive(file):   140436 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:      25165824 kB
SwapFree:       24732384 kB
Dirty:                 0 kB
Writeback:             0 kB
AnonPages:        102824 kB
Mapped:            71404 kB
Shmem:             17720 kB
Slab:              13868 kB
SReclaimable:       6744 kB
SUnreclaim:         7124 kB
KernelStack:        2848 kB
PageTables:         2524 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:      515524 kB
Committed_AS:    3450064 kB
VmallocTotal:     122880 kB
VmallocUsed:       21296 kB
VmallocChunk:      66044 kB
HardwareCorrupted:     0 kB
AnonHugePages:      2048 kB
HugePages_Total:       0
HugePages_Free:        0
```

Physical memory : 8258684 kB

(g) Free memory : 2622084 kB

(h)

```
kaalachor@DESKTOP-4MHM220:~$ cat /proc/stat | grep -i 'processes\|ctxt'
ctxt 494453
processes 132
```

The total number of forks since the system booted up is 494,453, and the total number of context switches is 132.

Q3.

```
top - 14:50:00 up 16:46,  0 users,  load average: 0.52, 0.58, 0.59
Tasks:  13 total,   2 running,  11 sleeping,   0 stopped,   0 zombie
%Cpu(s): 37.9 us,  6.3 sy,  0.0 ni, 55.7 id,  0.0 wa,  0.1 hi,  0.0 si,  0.0 st
MiB Mem :   8065.1 total,   2153.0 free,   5688.1 used,    224.0 buff/cache
MiB Swap:  24576.0 total,  24239.9 free,    336.1 used.   2246.4 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
  271 kaalach+  20   0   10404    448    324 R 100.0   0.0   1:57.18 cpu
    1 root      20   0    9312    740    696 S   0.0   0.0   0:47.65 init
    9 root      20   0    8960    160    108 S   0.0   0.0   0:00.00 init
   10 kaalach+  20   0   18096   2912   2820 S   0.0   0.0   0:00.44 bash
  204 kaalach+  20   0   15076    712    540 S   0.0   0.0   0:00.00 dbus-launch
  205 kaalach+  20   0   15276   1380   1180 S   0.0   0.0   0:00.02 dbus-daemon
  209 kaalach+  20   0  387064   4016   3608 S   0.0   0.0   0:00.04 at-spi-bus-laun
  215 kaalach+  20   0   15156   2300   2172 S   0.0   0.0   0:00.02 dbus-daemon
  218 kaalach+  20   0  237908   3360   2716 S   0.0   0.0   0:00.03 dconf-service
  225 kaalach+  20   0  242604   4372   3536 S   0.0   0.1   0:00.10 at-spi2-registr
  272 root      20   0    9312    252    200 S   0.0   0.0   0:00.00 init
  273 kaalach+  20   0   18096   3656   3564 S   0.0   0.0   0:00.29 bash
  338 kaalach+  20   0   18916   2232   1552 R   0.0   0.0   0:00.10 top
```

(a) 271

(b) 100% and 0%

(c) Running

Q4.

```
1706002127 sec, 411124 usec
1706002127 sec, 422444 usec
1706002127 sec, 422603 usec
1706002127 sec, 422735 usec
1706002127 sec, 422865 usec
1706002127 sec, 422995 usec
1706002127 sec, 423125 usec
1706002127 sec, 423254 usec
1706002127 sec, 423382 usec
1706002127 sec, 423511 usec
1706002127 sec, 423657 usec
1706002127 sec, 423786 usec
1706002127 sec, 423914 usec
1706002127 sec, 424043 usec
1706002127 sec, 424172 usec
1706002127 sec, 424301 usec
1706002127 sec, 424430 usec
1706002127 sec, 424561 usec
1706002127 sec, 424690 usec
1706002127 sec, 424818 usec
1706002127 sec, 424946 usec
1706002127 sec, 425075 usec
1706002127 sec, 425204 usec
1706002127 sec, 425332 usec
1706002127 sec, 425460 usec
1706002127 sec, 425602 usec
1706002127 sec, 425731 usec
1706002127 sec, 425860 usec
1706002127 sec, 425988 usec
1706002127 sec, 426117 usec
1706002127 sec, 426246 usec
1706002127 sec, 426970 usec
1706002127 sec, 427146 usec
1706002127 sec, 427312 usec
1706002127 sec, 427480 usec
1706002127 sec, 427656 usec
1706002127 sec, 428052 usec
1706002127 sec, 428201 usec
1706002127 sec, 428330 usec
```

```
kaalachor@DESKTOP-4MHM220:~$ ps aux | grep cpu-print
kaalach+   367 26.0  0.0  10536   576 tty1     R    17:38   0:03 ./cpu-print
kaalach+   370  0.0  0.0  16212  1300 tty2     S    17:38   0:00 grep --color=auto cpu-print
```

PID of the process : 360

(b) PIDs of all ancestors

```
kaalachor@DESKTOP-4MHM220:~$ ps aux | grep cpu-print
kaalach+   360 19.7  0.0  10536   576 tty1     S    14:58   0:00 ./cpu-print
kaalach+   362  0.0  0.0  16212  1296 tty2     S    14:58   0:00 grep --color=auto cpu-print
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 360
  PID  PPID CMD
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 360
  PID  PPID CMD
kaalachor@DESKTOP-4MHM220:~$ ps aux | grep cpu-print
kaalach+   367 26.0  0.0  10536   576 tty1     R    17:38   0:03 ./cpu-print
kaalach+   370  0.0  0.0  16212  1300 tty2     S    17:38   0:00 grep --color=auto cpu-print
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 367
  PID  PPID CMD
  367    10 ./cpu-print
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 10
  PID  PPID CMD
   10     9 -bash
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 9
  PID  PPID CMD
    9     1 /init
kaalachor@DESKTOP-4MHM220:~$ ps -o pid,ppid,cmd --forest -p 1
  PID  PPID CMD
    1     0 /init
```

(c)

```
kaalachor@DESKTOP-4MHM220:~$ ls -l /proc/367/fd
total 0
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:42 0 -> /dev/tty1
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:42 1 -> /dev/tty1
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:38 2 -> /dev/tty1
```

The file descriptors 0, 1, and 2 for the process with PID 367 are pointing to the terminal device /dev/pts/2. This indicates that the process is directly interacting with the terminal.

(d)

```
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ ./cpu-print | grep hello &
[1] 420
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ pgrep -af grep
420 grep --color=auto hello
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ ls -l /proc/367/fd
total 0
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:42 0 -> /dev/tty1
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:42 1 -> /dev/tty1
lrwx------ 1 kaalachor kaalachor 0 Jan 23 17:38 2 -> /dev/tty1
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ ls -l /proc/420/fd
total 0
lr-x------ 1 kaalachor kaalachor 0 Jan 23 18:18 0 -> 'pipe:[400]'
lrwx------ 1 kaalachor kaalachor 0 Jan 23 18:18 1 -> /dev/tty2
lrwx------ 1 kaalachor kaalachor 0 Jan 23 18:18 2 -> /dev/tty2
```

ls -l /proc/367/fd command indicates the file descriptors for the cpu-print process (PID 367), and it has its standard output and standard error redirected to a pipe ('pipe: [400]'). Additionally, the output of **ls -l /proc/420/fd** shows that the grep process (PID 420) is reading from the same pipe.

Pipes in the shell are implemented by redirecting the standard output of one process to the standard input of another process, allowing the output of one command to serve as the input for another.

(e)

```
kaalachor@DESKTOP-4MHM220:~$ which cd
kaalachor@DESKTOP-4MHM220:~$ which ls
/usr/bin/ls
kaalachor@DESKTOP-4MHM220:~$ which history
kaalachor@DESKTOP-4MHM220:~$ which ps
/usr/bin/ps
```

Bash implements **cd** and **history** as built-in commands.

External executables (**ls** and **ps**) are in the Linux kernel directory tree.

Q5.

```
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ gcc memory1.c
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ ./a.out


Program : 'memory_1'
____________________


PID : 446
Size of int : 4

Press Enter Key to exit.

kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ gcc memory2.c
kaalachor@DESKTOP-4MHM220:~/ASSIGNMENT 1$ ./a.out


Program : 'memory_2'
____________________


PID : 452
Size of int : 4

Press Enter Key to exit.
```

memory1.c - Allocates an array of integers with ARRAY_SIZE elements but does not access or modify any element.

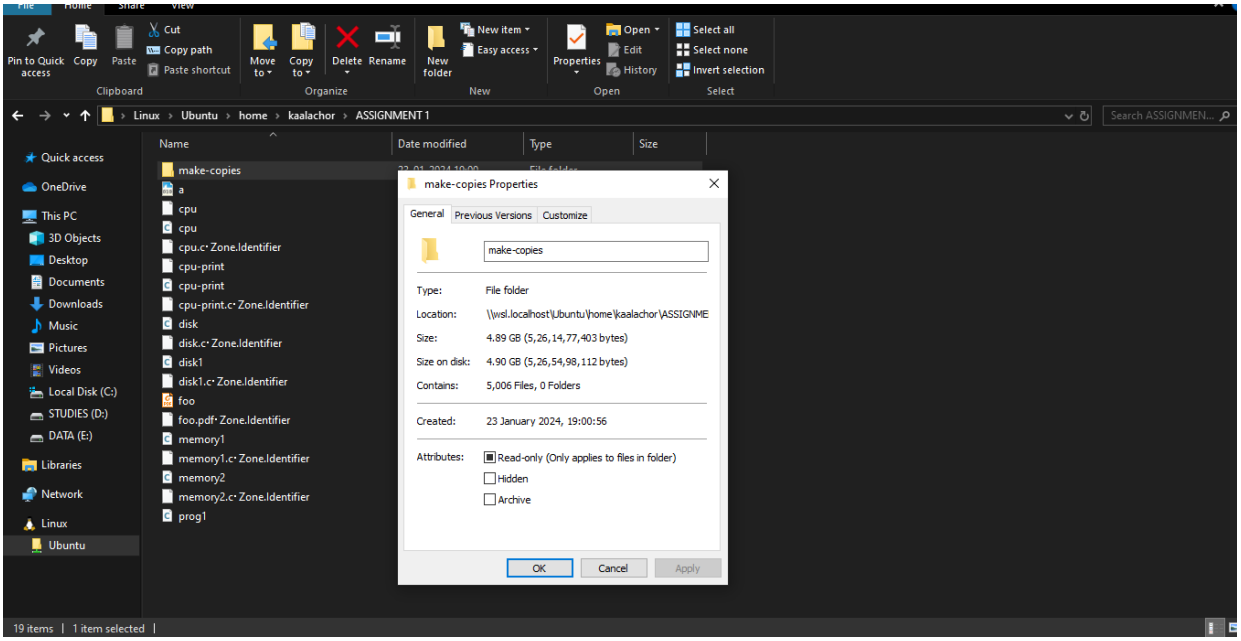
memory2.c - Allocates an array of integers with ARRAY_SIZE elements and initializes/modifies the first half of the array.

Expected Memory Behavior:

memory1.c is expected to have **relatively low memory usage** since it only allocates an array but doesn't perform any substantial operations on it.

memory2.c is expected to have **higher memory usage** due to the array operations, as it initializes and performs arithmetic operations on a significant portion of the array.

Q6.




```
Device            r/s     rkB/s   rrqm/s  %rrqm r_await rareq-sz     w/s     wkB/s   wrqm/s  %wrqm w_await wareq-sz     d/s     dkB/s   drqm/s  %drqm d_await dareq-sz     f/s f_await  aqu-s
z  %util
sda              0.49     32.49     0.25  33.24    0.34    65.88    0.00      0.00     0.00   0.00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.0
0   0.03
```

```
Device            r/s     rkB/s   rrqm/s  %rrqm r_await rareq-sz     w/s     wkB/s   wrqm/s  %wrqm w_await wareq-sz     d/s     dkB/s   drqm/s  %drqm d_await dareq-sz     f/s f_await  aqu-s
z  %util
sda              0.49     32.40     0.24  33.24    0.34    65.88    0.00      0.00     0.00   0.00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.0
0   0.03
```

The script **make-copies.sh** is used to create 5000 copies of the **foo.pdf** file with different filenames in the make-copies folder, then we clear the disk buffer cache.

We use tools such as **iostat** to measure disk utilization while running each program.

%util column indicates the percentage of time the disk is busy.