

ECE 4310
Operating Systems for Embedded Application

Project 1

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1 Unix login server

1.1 ls -l /

Figure 1: Output of ls -l /

```
PS C:\Users\Antony Yung> ssh choiyung@login.cpp.edu

Unauthorized use of Cal Poly Pomona computer and networking resources is
prohibited. If you log on to this computer system, you acknowledge your
awareness of and concurrence with the Cal Poly Pomona Acceptable Use Policy.
The University will prosecute violators to the full extent of the law.

choiyung@login.cpp.edu's password:
choiyung@costello ~ $ ls -l /
total 2858
-rw-r--r-- 1 root root 2724527 Jan 29 14:58 System.map
drwxr-xr-x 2 root root 3072 Feb 15 11:49 bin
drwxr-xr-x 4 root root 1024 Feb 15 11:32 boot
drwxr-xr-x 14 root root 3700 Feb 15 12:20 dev
drwxr-xr-x 72 root root 5120 Feb 15 12:20 etc
drwxr-xr-x 2 root root 0 Feb 16 14:04 group
drwxr-xr-x 3 root root 1024 May 8 2013 home
drwxr-xr-x 10 root root 3072 Feb 15 11:23 lib
drwxr-xr-x 6 root root 9216 Feb 15 12:13 lib64
drwx----- 2 root root 12288 Jun 10 2016 lost+found
drwxr-xr-x 2 root root 1024 May 8 2013 media
drwxr-xr-x 2 root root 1024 May 8 2013 mnt
drwxr-xr-x 4 root root 1024 Feb 15 11:48 opt
dr-xr-xr-x 423 root root 0 Feb 15 12:20 proc
drwx----- 3 root root 1024 Feb 22 13:39 root
drwxr-xr-x 12 root root 880 Feb 15 12:20 run
drwxr-xr-x 2 root root 7168 Feb 15 12:13 sbin
dr-xr-xr-x 12 root root 0 Feb 16 05:15 sys
drwxrwxrwt 146 root root 139264 Mar 1 16:44 tmp
drwxr-xr-x 45 root root 0 Mar 1 16:44 user
drwxr-xr-x 16 root root 4096 Nov 12 2019 usr
drwxr-xr-x 13 root root 4096 Jul 1 2020 var
dr-xr-xr-x 4 root root 1024 Mar 27 2017 www
dr-xr-xr-x 4 root root 1024 Mar 27 2017 www-dev
dr-xr-xr-x 4 root root 1024 Mar 27 2017 www-test
```

Figure 2: Output of `ls -l /lib`

```
choiyung@costello ~ $ ls -l /lib
total 3739
lrwxrwxrwx 1 root root      32 Feb 15 11:21 cpp -> /usr/bin/x86_64-pc-linux-gnu-cpp
drwxr-xr-x 2 root root    1024 Feb 15 11:29 gentoo
drwxr-xr-x 3 root root    1024 Jun 14 2013 grub
-rwxr-xr-x 1 root root   175192 Dec 23 19:23 ld-2.32.so
lrwxrwxrwx 1 root root      10 Dec 23 19:21 ld-linux.so.2 -> ld-2.32.so
-rwxr-xr-x 1 root root   13528 Dec 23 19:22 libBrokenLocale-2.32.so
lrwxrwxrwx 1 root root      23 Dec 23 19:21 libBrokenLocale.so.1 -> libBrokenLocale-2.32.so
-rwxr-xr-x 1 root root   21788 Dec 23 19:23 libSegFault.so
-rwxr-xr-x 1 root root   17912 Dec 23 19:23 libanl-2.32.so
lrwxrwxrwx 1 root root      14 Dec 23 19:21 libanl.so.1 -> libanl-2.32.so
-rwxr-xr-x 1 root root  1986896 Dec 23 19:22 libc-2.32.so
lrwxrwxrwx 1 root root      12 Dec 23 19:21 libc.so.6 -> libc-2.32.so
-rwxr-xr-x 1 root root   42328 Dec 23 19:23 libcrypt-2.32.so
lrwxrwxrwx 1 root root      16 Dec 23 19:21 libcrypt.so.1 -> libcrypt-2.32.so
-rwxr-xr-x 1 root root   17716 Dec 23 19:23 libdl-2.32.so
lrwxrwxrwx 1 root root      13 Dec 23 19:21 libdl.so.2 -> libdl-2.32.so
-rw-r--r-- 1 root root    92376 Jul 11 2017 libgcc_s.so.1
lrwxrwxrwx 1 root root    824656 Dec 23 19:23 libm-2.32.so
-rwxr-xr-x 1 root root      12 Dec 23 19:21 libm.so.6 -> libm-2.32.so
-rwxr-xr-x 1 root root   17744 Dec 23 19:23 libmman.so
-rwxr-xr-x 1 root root   95880 Dec 23 19:23 libnsl-2.32.so
lrwxrwxrwx 1 root root      14 Dec 23 19:21 libnsl.so.1 -> libnsl-2.32.so
-rwxr-xr-x 1 root root   34392 Dec 23 19:23 libnss_compat-2.32.so
lrwxrwxrwx 1 root root      21 Dec 23 19:21 libnss_compat.so.2 -> libnss_compat-2.32.so
-rwxr-xr-x 1 root root   38252 Dec 23 19:23 libnss_db-2.32.so
lrwxrwxrwx 1 root root      17 Dec 23 19:21 libnss_db.so.2 -> libnss_db-2.32.so
-rwxr-xr-x 1 root root   21852 Dec 23 19:23 libnss_dns-2.32.so
lrwxrwxrwx 1 root root      18 Dec 23 19:21 libnss_dns.so.2 -> libnss_dns-2.32.so
-rwxr-xr-x 1 root root   58592 Dec 23 19:23 libnss_files-2.32.so
lrwxrwxrwx 1 root root      20 Dec 23 19:21 libnss_files.so.2 -> libnss_files-2.32.so
-rwxr-xr-x 1 root root   21872 Dec 23 19:23 libnss_hesiod-2.32.so
lrwxrwxrwx 1 root root      21 Dec 23 19:21 libnss_hesiod.so.2 -> libnss_hesiod-2.32.so
-rwxr-xr-x 1 root root   13540 Dec 23 19:23 libpcprofile.so
-rwxr-xr-x 1 root root   149872 Dec 23 19:21 libpthread-2.32.so
lrwxrwxrwx 1 root root      18 Dec 23 19:21 libpthread.so.0 -> libpthread-2.32.so
-rwxr-xr-x 1 root root   83592 Dec 23 19:23 libresolv-2.32.so
lrwxrwxrwx 1 root root      17 Dec 23 19:21 libresolv.so.2 -> libresolv-2.32.so
-rwxr-xr-x 1 root root   38664 Dec 23 19:23 librt-2.32.so
lrwxrwxrwx 1 root root      13 Dec 23 19:21 librt.so.1 -> librt-2.32.so
-rwxr-xr-x 1 root root   34432 Dec 23 19:23 libthread_db-1.0.so
lrwxrwxrwx 1 root root      19 Dec 23 19:21 libthread_db.so.1 -> libthread_db-1.0.so
-rwxr-xr-x 1 root root   13684 Dec 23 19:23 libutil-2.32.so
lrwxrwxrwx 1 root root      15 Dec 23 19:21 libutil.so.1 -> libutil-2.32.so
drwxr-xr-x 2 root root    1024 Feb 15 11:33 modprobe.d
drwxr-xr-x 7 root root    1024 Feb 15 11:32 modules
drwxr-xr-x 4 root root    1024 Feb 15 11:50 netifrc
drwxr-xr-x 8 root root    1024 Jul 1 2020 rc
drwxr-xr-x 4 root root    1024 Feb 15 11:49 systemd
drwxr-xr-x 4 root root    1024 Feb 15 11:50 udev
```

Figure 3: Output of `ls -l /var/log`

```
choiyung@costello ~ $ ls -l /var/log
total 26100
drwxr-xr-x 2 root root      4096 Dec 10 2019 aide
drwx----- 2 root root      4096 Mar 1 04:02 archive
drwx----- 2 root root      4096 Feb 21 00:23 audit
-rw-r--r-- 1 root root          0 Nov 12 2019 boot
-rw-r----- 1 root tenshi     6300 Mar 1 16:01 cron.log
-rw-r----- 1 root root    86098 Feb 15 12:20 dmesg
-rw-r--r-- 1 root root          0 Feb 15 12:13 emerge-fetch.log
-rw-rw---- 1 portage portage 2859770 Feb 15 12:13 emerge.log
-rw-r----- 1 root tenshi    1418448 Mar 1 16:19 iptables.log
-rw-r--r-- 1 root root    191292412 Mar 1 16:44 lastlog
-rw-r----- 1 root tenshi       978 Mar 1 15:30 mail.log
-rw-r----- 1 root tenshi    11750281 Mar 1 16:47 messages
drwxr-xr-x 3 munin munin      4096 Feb 15 11:49 munin
-rw-r----- 1 root tenshi          0 Feb 28 04:02 ntpd.log
drwxrwsr-x 3 portage portage 122880 Feb 22 13:03 portage
-rw-r----- 1 root tenshi          0 Feb 16 04:02 rc.log
drwxrwx--- 2 root portage      4096 Feb 15 11:31 sandbox
drwxr-xr-x 3 root root      4096 Feb 28 04:02 sssd
-rw----- 1 root root      24192 Feb 15 11:34 tallylog
-rw----- 1 root root        696 Feb 15 12:20 vmware-vmttoolsd-root.log
-rw-rw-r-- 1 root utmp      99456 Mar 1 16:44 wtmp
```

1.2 `uname -a`

Figure 4: Output of `uname -a`

```
choiyung@costello ~ $ uname -a
Linux costello 5.4.87-gentoo #2 SMP Fri Jan 29 14:58:05 PST 2021 x86_64 Intel(R) Xeon(R) Gold 6126 CPU @ 2.60GHz GenuineIntel GNU/Linux
```

It uses 5.4.87-gentoo release of the Linux kernel. It was compiled on Fri Jan 29 14:58:05 PST 2021 for x86_64 architecture.

1.3 `cat /proc/meminfo`

Figure 5: Output of `cat /proc/meminfo`

```
choiyung@costello ~ $ cat /proc/meminfo
MemTotal:      8156064 kB
MemFree:       212524 kB
MemAvailable:  7239728 kB
Buffers:       211396 kB
Cached:        6602112 kB
SwapCached:    5484 kB
Active:        4907836 kB
Inactive:      2282860 kB
Active(anon):  174472 kB
Inactive(anon): 203004 kB
Active(file):  4733364 kB
Inactive(file): 2079856 kB
Unevictable:   0 kB
Mlocked:       0 kB
SwapTotal:     4194300 kB
SwapFree:      4157180 kB
Dirty:         48 kB
Writeback:     0 kB
AnonPages:     363968 kB
Mapped:        82340 kB
Shmem:         288 kB
KReclaimable:  519868 kB
Slab:          593020 kB
SReclaimable:  519868 kB
SUnreclaim:    73152 kB
KernelStack:   10260 kB
PageTables:    14292 kB
NFS_Unstable:  0 kB
Bounce:        0 kB
WritebackTmp:  0 kB
CommitLimit:   8272332 kB
Committed_AS:  1674728 kB
VmallocTotal:  34359738367 kB
VmallocUsed:    15580 kB
VmallocChunk:   0 kB
Percpu:        37888 kB
AnonHugePages:  79872 kB
ShmemHugePages: 0 kB
ShmemPmdMapped: 0 kB
FileHugePages: 0 kB
FilePmdMapped: 0 kB
HugePages_Total: 0
HugePages_Free: 0
HugePages_Rsvd: 0
HugePages_Surp: 0
Hugepagesize:  2048 kB
Hugetlb:        0 kB
DirectMap4k:   1480512 kB
DirectMap2M:   6907904 kB
DirectMap1G:   2097152 kB
```

212524 MB memory is free and $8156064 - 212524 = 7943540$ MB memory is used.

```
1.4 cat /proc/cpuinfo
```

Figure 6: Output of `cat /proc/cpuinfo`

[illegible]

Figure 7: Output of `cat /proc/cpuinfo` cont.

[illegible]

There are a total of 8 CPUs that the operating system see and they are all Intel Xeon Gold 6126.

1.5 nano -w project1-choiyung

Figure 8: Output of ls after nano

```
choiyung@costello ~ $ nano -w project1-choiyung
choiyung@costello ~ $ ls
project1-choiyung
choiyung@costello ~ $ cat project1-choiyung
Choi Tim Antony Yung
March 1st 2021
```

1.6 ifconfig eth0

Figure 9: Output of ifconfig eth0

```
choiyung@costello ~ $ ifconfig eth0
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 134.71.246.204 netmask 255.255.255.192 broadcast 134.71.246.255
    inet6 fe80::250:56ff:fe89:24d0 prefixlen 64 scopeid 0x20<link>
    inet6 2620:df:8000:ff14:0:1:246:204 prefixlen 64 scopeid 0x0<global>
    ether 00:50:56:89:24:d0 txqueuelen 1000 (Ethernet)
    RX packets 508422499 bytes 86350049980 (80.4 GiB)
    RX errors 0 dropped 1051 overruns 0 frame 0
    TX packets 321063979 bytes 1043348663741 (971.6 GiB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

IPv4 address is 134.71.246.204, IPv6 address is 2620:df:8000:ff14:0:1:246:204,
MAC address is 00:50:56:89:24:d0

2 ps

Figure 10: Output of `ps -ef`

```
choiyung@castle ~$ ps -ef
```

UID	PID	PPID	C	STIME	TTY	TIME	CMD
root	1	0	0	Feb15 ?		00:01:06	init [3]
root	2	0	0	Feb15 ?		00:00:01	[kthreadd]
root	3	2	0	Feb15 ?		00:00:00	[rcu_gp]
root	4	2	0	Feb15 ?		00:00:00	[rcu_par_gp]
root	6	2	0	Feb15 ?		00:00:00	[kworker/0:0H-kblockd]
root	8	2	0	Feb15 ?		00:00:00	[mm_percpu_wq]
root	9	2	0	Feb15 ?		00:00:11	[ksftirqd/0]
root	10	2	0	Feb15 ?		00:05:22	[rcu_sched]
root	11	2	0	Feb15 ?		00:00:00	[migration/0]
root	12	2	0	Feb15 ?		00:00:00	[cpuhp/0]
root	13	2	0	Feb15 ?		00:00:00	[cpuhp/1]
root	14	2	0	Feb15 ?		00:00:00	[migration/1]
root	15	2	0	Feb15 ?		00:00:28	[ksftirqd/1]
root	17	2	0	Feb15 ?		00:00:00	[kworker/1:0H-kblockd]
root	18	2	0	Feb15 ?		00:00:00	[cpuhp/2]
root	19	2	0	Feb15 ?		00:00:00	[migration/2]
root	20	2	0	Feb15 ?		00:01:46	[ksftirqd/2]
root	22	2	0	Feb15 ?		00:00:00	[kworker/2:0H-kblockd]
root	23	2	0	Feb15 ?		00:00:00	[cpuhp/3]
root	24	2	0	Feb15 ?		00:00:00	[migration/3]
root	25	2	0	Feb15 ?		00:01:06	[ksftirqd/3]
root	27	2	0	Feb15 ?		00:00:00	[kworker/3:0H-kblockd]
root	28	2	0	Feb15 ?		00:00:00	[cpuhp/4]
root	29	2	0	Feb15 ?		00:00:00	[migration/4]
root	30	2	0	Feb15 ?		00:02:41	[ksftirqd/4]
root	32	2	0	Feb15 ?		00:00:00	[kworker/4:0H-kblockd]
root	33	2	0	Feb15 ?		00:00:00	[cpuhp/5]
root	34	2	0	Feb15 ?		00:00:00	[migration/5]
root	35	2	0	Feb15 ?		00:00:14	[ksftirqd/5]
root	37	2	0	Feb15 ?		00:00:00	[kworker/5:0H-kblockd]
root	38	2	0	Feb15 ?		00:00:00	[cpuhp/6]
root	39	2	0	Feb15 ?		00:00:00	[migration/6]
root	40	2	0	Feb15 ?		00:00:10	[ksftirqd/6]
root	42	2	0	Feb15 ?		00:00:00	[kworker/6:0H-kblockd]
root	43	2	0	Feb15 ?		00:00:00	[cpuhp/7]
root	44	2	0	Feb15 ?		00:00:00	[migration/7]
root	45	2	0	Feb15 ?		00:06:37	[ksftirqd/7]
root	47	2	0	Feb15 ?		00:00:00	[kworker/7:0H-kblockd]
root	48	2	0	Feb15 ?		00:00:00	[kdevtmpfs]
root	49	2	0	Feb15 ?		00:00:00	[netns]
root	52	2	0	Feb15 ?		00:00:00	[kauditd]
root	200	2	0	Feb15 ?		00:00:00	[oom_reaper]
root	223	2	0	Feb15 ?		00:00:00	[writeback]
root	253	2	0	Feb15 ?		00:00:01	[kcompactd0]
root	361	2	0	Feb15 ?		00:00:00	[khugepaged]
root	371	2	0	Feb15 ?		00:00:00	[cryptd]
root	386	2	0	Feb15 ?		00:00:00	[kblockd]
root	1700	2	0	Feb15 ?		00:00:00	[edac-poller]
root	1784	2	0	Feb15 ?		00:00:00	[watchdogd]
root	1851	2	0	Feb15 ?		00:00:03	[rpciod]

The `-e` option select all processes and the `-f` option use full-format listing. Processes listed with name in square bracket mean the process arguments are unavailable.

Figure 11: Part of `man ps`

args	COMMAND
	command with all its arguments as a string. Modifications to the arguments may be shown. The output in this column may contain spaces. A process marked <defunct> is partly dead, waiting to be fully destroyed by its parent. Sometimes the process args will be unavailable; when this happens, ps will instead print the executable name in brackets. (alias cmd, command). See also the <code>comm</code> format keyword, the <code>-f</code> option, and the <code>c</code> option.
	When specified last, this column will extend to the edge of the display. If ps can not determine display width, as when output is redirected (piped) into a file or another command, the output width is undefined (it may be 80, unlimited, determined by the <code>TERM</code> variable, and so on). The <code>COLUMNS</code> environment variable or <code>--cols</code> option may be used to exactly determine the width in this case. The <code>w</code> or <code>-w</code> option may be also be used to adjust width.

Figure 12: Output of `ps -f --ppid 2 --pid 2 --deselect`

```

root      1      0  0 p0012 ?    00:01:00 init (3)
root     3119      1  0 p0012 ?    00:00:00 /lib/systemd/systemd-udev
root     4021      1  0 p0012 ?    00:19:15 /usr/bin/ntfsstatd
root     4068      1  0 p0012 ?    00:00:00 /usr/sbin/sshd
root     4069 4068  0 p0012 ?    00:07:10 /usr/sbin/sshd -p /etc/ssh/sshd_config --control
root     4069      1  0 p0012 ?    00:00:00 /usr/sbin/sshd
root     4829      1  0 p0012 ?    00:00:01 /usr/bin/ntfsstatd
root     4865      1  0 p0012 ?    00:00:01 /usr/bin/ntfsstatd
root     5131      1  0 p0012 ?    00:25:34 /usr/sbin/automount -p /var/run/automount.pid
root     5136      1  0 p0012 ?    00:01:17 /usr/bin/part --w /usr/sbin/automount-mode --config /etc/automount/automount-mode
root     5211      1  0 p0012 ?    00:00:00 script practice0.txt
root     5212 5211  0 p0012 pts/0    00:00:00 bash
root     5426      1  0 p0012 ?    00:00:02 /usr/sbin/cron
root     5481      1  0 p0012 ?    00:01:20 /usr/sbin/sshd
root     5581      1  0 p0012 ?    00:00:00 ntpd: ntpd engine
root     5582 5581  0 p0012 ?    00:00:00 ntpd: ntpd engine
root     5584      1  0 p0012 ?    00:00:00 /usr/sbin/ntpd -p /run/ntpd.pid -s
root     5684      1  0 p0012 ?    00:00:00 /usr/libexec/ssh/sshd_ssh -uid 0 --pid 0 --logprefix
root     5684 5684  0 p0012 ?    00:00:00 sshd -s -t uid 0
root     5718      1  0 p0012 ?    00:19:04 sshd /usr/sbin/sshd -o PidFile=/run/ssh.pid -f /etc/ssh/sshd_config
root     5768      1  0 p0012 ?    00:00:00 /usr/libexec/ssh/sshd -p
root     5762 5768  0 p0012 ?    00:12:15 /usr/libexec/ssh/sshd -o domain cpe --uid 0 --pid 0 --logprefix
root     5767 5768  0 p0012 ?    00:00:00 /usr/libexec/ssh/sshd -o uid 0 --pid 0 --logprefix
root     5768 5768  0 p0012 ?    00:00:00 /usr/libexec/ssh/sshd -o uid 0 --pid 0 --logprefix
root     5768 5768  0 p0012 ?    00:00:00 /usr/libexec/ssh/sshd -o uid 0 --pid 0 --logprefix
root     5822      1  0 p0012 ?    00:00:00 /usr/bin/ntfsstatd
root     5880      1  0 p0012 tty1    00:00:00 /bin/ptytty --nucleus 38400 tty1 linux
root     5881      1  0 p0012 tty2    00:00:00 /bin/ptytty 38400 tty2 linux
root     5882      1  0 p0012 tty50   00:00:00 /bin/ptytty 9800 tty50 vlt00
root     6189      1  0 p0012 ?    00:00:00 /usr/bin/ntfsstatd
root     6189 6189  0 p0012 ?    00:00:00 script practice0.txt
choiyung 15569 15568  0 p0012 pts/0    00:00:00 bash
choiyung 15788 15561  0 p0012 pts/0    00:20:10 00 /opt/quantum-bio-4.272_p10/bin/java team
choiyung 15788 15788  0 p0012 ?    00:00:00 sshd: choiyung [priv]
choiyung 15925 15924  0 p0012 ?    00:00:00 sshd: choiyung@pts/126
choiyung 15925 15925  0 p0012 pts/126 00:00:00 -bash
choiyung 15925 15925  0 p0012 pts/126 00:00:00 ps -ef
choiyung 15925 15925  0 p0012 pts/126 00:00:00 grep --colour=auto choiyung

```

Kernel threads are spawned by the kernel thread daemon `kthreadd`, which have `pid` of 2. `--ppid 2` option select all child processes of `kthreadd`, while `--pid 2` option select `kthreadd` itself. The two options combined will select all kernel threads. `--deselect` option will then negates the selection which result in all user-space threads selected.

Figure 13: Output of `ps -ef | grep choiyung`

```

choiyung@costello ~ $ ps -ef | grep choiyung
root      81802   5718   0 16:43 ?        00:00:00 sshd: choiyung [priv]
choiyung  81943   81802   0 16:44 ?        00:00:00 sshd: choiyung@pts/126
choiyung  81944   81943   0 16:44 pts/126    00:00:00 -bash
choiyung  92853   81944   0 17:18 pts/126    00:00:00 ps -ef
choiyung  92854   81944   0 17:18 pts/126    00:00:00 grep --colour=auto choiyung

```

5 processes was associated with my username. Two from the secure shell daemon, one from the bash shell, one from the `ps` command and one from the `grep` command.