

Lab No. 05

Managing Processes, and Writing, Compiling & Executing C++ on Linux

Objective:

This lab is designed to demonstrate the basic task management related activities along with an introduction to Writing C++ programs in Linux.

Activity Outcomes:

On completion of this lab students will be able to:

- How to manage processes in Linux
- Perform Compiling and Executing C++ programs using command-line in Linux

Instructor Notes

As pre-lab activity, read Chapter 10 from the book “The Linux Command Line”, William E. Shotts, Jr.

1) Useful Concepts

Process management in Linux

A process is the instance of a computer program that is being executed. While a computer program is a passive collection of instructions, a process is the actual execution of those instructions. Several processes may be associated with the same program; for example, opening up several instances of the same program often results in more than one process being executed. When a system starts up, the kernel initiates a few of its own activities as processes and launches a program called `init`. `init`, in turn, runs a series of shell scripts (located in `/etc`) called `init` scripts, which start all the system services. Many of these services are implemented as daemon programs, programs that just sit in the background and do their thing without having any user interface. So even if we are not logged in, the system is at least a little busy performing routine stuff.

The kernel maintains information about each process to help keep things organized. For example, each process is assigned a number called a process ID or PID. PIDs are assigned in ascending order, with `init` always getting PID 1. The kernel also keeps track of the memory assigned to each process, as well as the processes' readiness to resume execution. Like files, processes also have owners and user IDs, effective user IDs, etc. In the following, we will discuss the most common commands; available in Linux to manage processes.

Displaying Processes in the System

Static view: The most commonly used command to view processes is `ps`. This command displays the processes for the current shell. We can use the `ps` command as given below

```

Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ ps
  PID TTY          TIME CMD
 4887 pts/0        00:00:00 bash
 4901 pts/0        00:00:00 ps
ubuntu@ubuntu:~$

```

We can display all of the processes owned by the current user by using the x option.

```

Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ ps x
  PID TTY          STAT TIME   COMMAND
 1602 ?        Ss     0:00   /lib/systemd/systemd --user
 1603 ?        S       0:00   (sd-pam)
 1609 ?        Ss     0:00   /usr/bin/dbus-daemon --session --ad
 1646 ?        SsL    0:00   /usr/lib/at-spi2-core/at-spi-bus-la
 1651 ?        S       0:00   /usr/bin/dbus-daemon --config-file=
 1657 ?        SsL    0:00   /usr/lib/at-spi2-core/at-spi2-regis
 1661 ?        SsL    0:00   /usr/lib/gvfs/gvfsd
 1666 ?        SsL    0:00   /usr/lib/gvfs/gvfsd-fuse /run/user/
 1710 ?        SsL    0:00   /usr/bin/pulseaudio --start --log-t
 4103 ?        SsL    0:00   /usr/lib/dconf/dconf-service

```

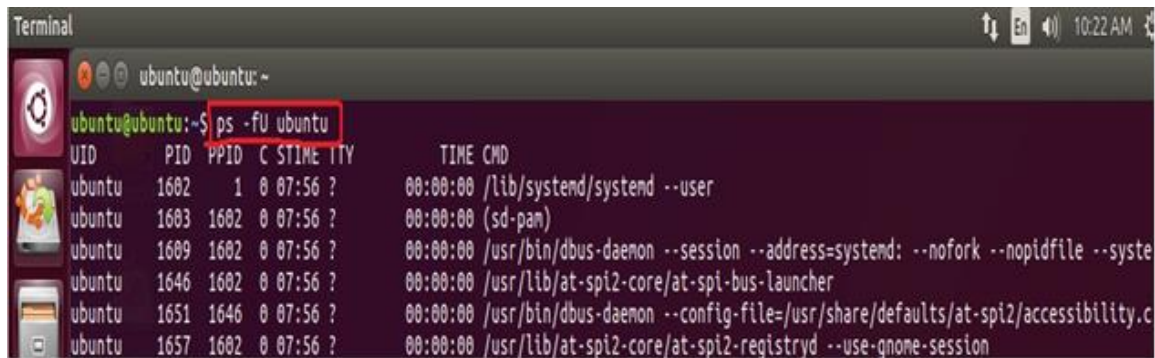
Here, a new column is also added in the output that is STAT. This column shows the current state of the process. The most common states are given below.

State	Meaning
R	Running
S	Sleeping or waiting for an event such as keystroke
D	Uninterruptible Sleep. Process is waiting for I/O such as a disk drive
T	Stopped
Z	A difunctional or zombie process
l	multithreaded
s	Session leader
+	Foreground process
<	A high priority process
N	A low priority process

Following are the most common option that can be used with ps command.

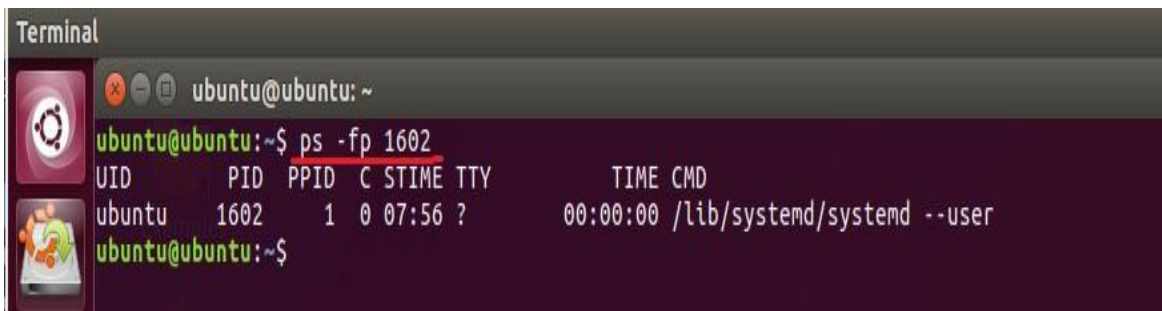
Option	Description
-A or -e	Display every active process on a Linux system
-x	Display all of the processes owned by the user
-F	Perform a full-format listing
-U	Select by real user ID or name
-u	Select by effective user ID or name
-p	Select process by pid
-r	Display only running processes
-L	Show number of threads in a process
-G	Show processes by Group

In the following example, we display processes that are related to the user ubuntu.



```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ ps -fu ubuntu
  UID    PID  PPID  C  STIME  TTY      TIME   CMD
  ubuntu  1602    1   0   07:56 ?        00:00:00 /lib/systemd/systemd --user
  ubuntu  1603  1602   0   07:56 ?        00:00:00 (sd-pam)
  ubuntu  1609  1602   0   07:56 ?        00:00:00 /usr/bin/dbus-daemon --session --address=systemd: --nofork --nopidfile --systemd
  ubuntu  1646  1602   0   07:56 ?        00:00:00 /usr/lib/at-spi2-core/at-spi-bus-launcher
  ubuntu  1651  1646   0   07:56 ?        00:00:00 /usr/bin/dbus-daemon --config-file=/usr/share/defaults/at-spi2/accessibility.c
  ubuntu  1657  1602   0   07:56 ?        00:00:00 /usr/lib/at-spi2-core/at-spi2-registryd --use-gnome-session
```

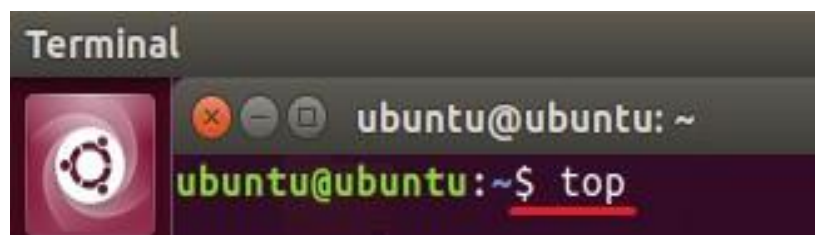
Now, we select a process with id 1602



```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ ps -fp 1602
  UID    PID  PPID  C  STIME  TTY      TIME   CMD
  ubuntu  1602    1   0   07:56 ?        00:00:00 /lib/systemd/systemd --user
ubuntu@ubuntu:~$
```

Dynamic view: The top command is the traditional way to view your system's resource usage and see the processes that are taking up the most system resources. Top displays a list of processes, with the ones using the most CPU at the top. An improved version of top command is htop but it is usually not pre-installed in most distributions. When a top program is running, we can highlight the running programs by pressing **z**. we can quit the top program by press **q** or **Ctrl + c**.

In the following example we display the dynamic view of the system process and resource usage.



```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ top
```

The output of the above command is given below:

```

Terminal
ubuntu@ubuntu: ~
top - 10:31:21 up 2:35, 1 user, load average: 0.11, 0.05, 0.01
Tasks: 154 total, 1 running, 153 sleeping, 0 stopped, 0 zombie
%Cpu(s): 1.0 us, 0.3 sy, 0.0 ni, 98.7 id, 0.0 wa, 0.0 hi, 0.0 si, 0.0 st
KiB Mem : 1824112 total, 528424 free, 396636 used, 899052 buff/cache
KiB Swap: 0 total, 0 free, 0 used. 1158012 avail Mem

  PID USER      PR  NI   VIRT   RES   SHR  S  %CPU  %MEM     TIME+ COMMAND
 4649 ubuntu    20   0 329848 158392 74144 S   1.0   8.7   2:07.72 compiz
 5087 ubuntu    20   0   9816   3476   3024 R   0.7   0.2   0:00.16 top
 4973 root      20   0     0     0     0 S   0.3   0.0   0:02.57 kworker/0:2
    1 root      20   0  28308   6724   5348 S   0.0   0.4   0:08.24 systemd
    2 root      20   0     0     0     0 S   0.0   0.0   0:00.00 kthreadd
    4 root       0 -20     0     0     0 S   0.0   0.0   0:00.00 kworker/0:0H
    6 root      20   0     0     0     0 S   0.0   0.0   0:00.09 ksoftirqd/0
    7 root      20   0     0     0     0 S   0.0   0.0   0:00.26 rcu_sched

```

Some of the basic options available with top commands are given below

Options	Description
-u	display specific User process details
-d	To set the screen refresh frequency

Displaying processes in Treelike structure: The pstree command is used to display processes in tree-like structure showing the parent/child relationships between processes.

```

Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ pstree
systemd--ModemManager--{gdbus}
                        {gmain}
--NetworkManager--dhclient
                    {gdbus}
                    {gmain}
--accounts-daemon--{gdbus}
                    {gmain}
--acpid
--agetty
--avahi-daemon--avahi-daemon
--colord--{gdbus}
          {gmain}
--cron
--cups-browsed--{gdbus}
                {gmain}
--cupsd
--dbus-daemon
--ibus-daemon--ibus-dconf--{dconf worker}
                  {gdbus}

```

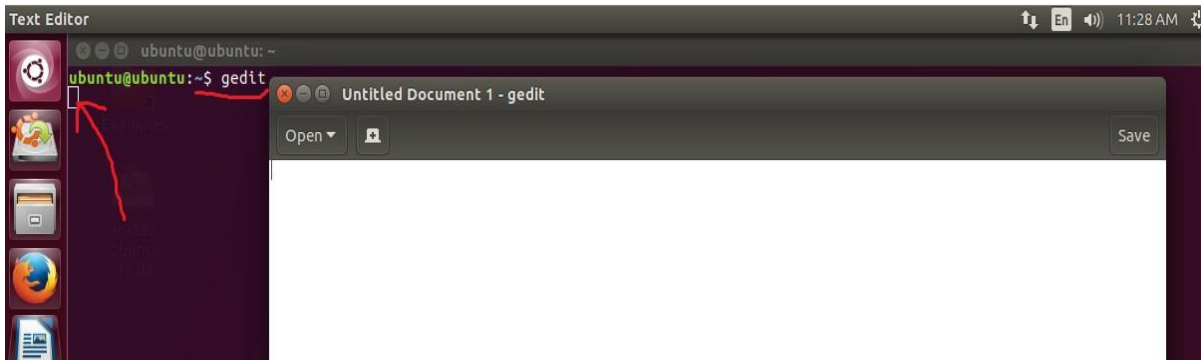
Interrupting A Process

A program can be interrupted by pressing Ctrl + C. This will interrupt the given processes and stop the process. Ctrl+C essentially sends a SIGINT signal from the controlling terminal to the process, causing it to be killed.

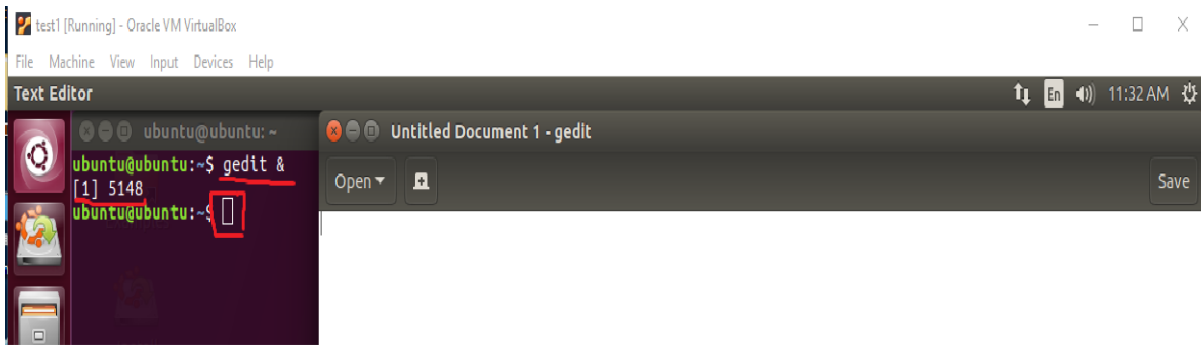
Putting a Process in the Background

A foreground process is any command or task you run directly and wait for it to complete. Unlike with a foreground process, the shell does not have to wait for a background process to end before it can run more processes. Normally, we start a program by entering its name in the CLI. However, if we want to start a program in background, we will put an & after its name.

In the following example, first we open the gedit program normally as given below.



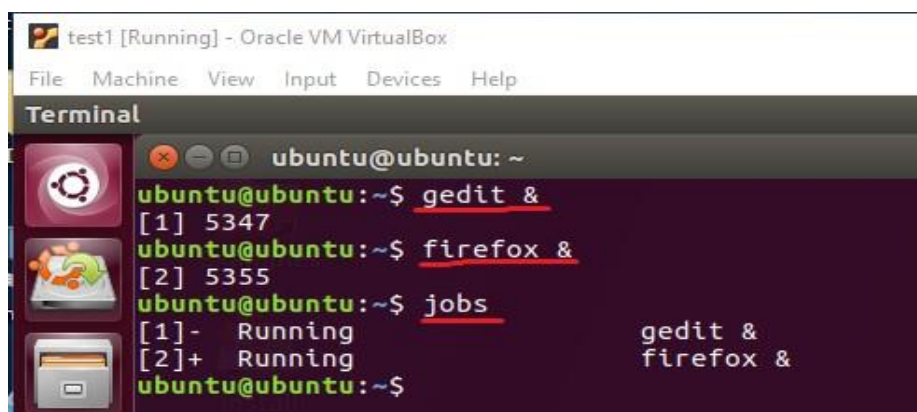
It can be noted that gedit is opened as foreground process and control does not return to terminal unless it is closed. Now, we start the gedit again as a background process.



It can be seen that after starting the gedit program control returns to the terminal and user can interact with both terminal and gedit.

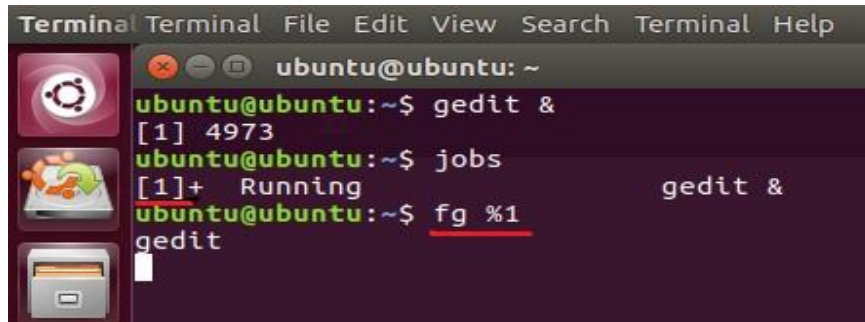
jobs command

The shell's job control facility also gives us a way to list the jobs that have been launched from our terminal. Using the **jobs** command, we can see this list. In the following example, we first launch two jobs in background and then use the jobs command to view the running jobs.



Bringing a process to the foreground

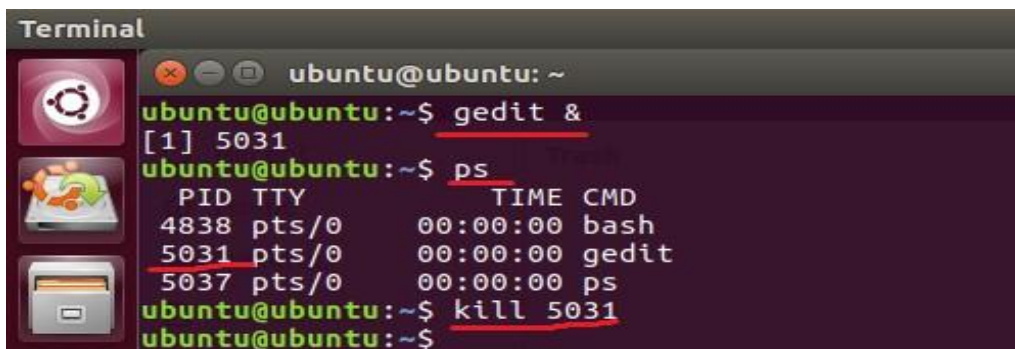
A process in the background is immune from keyboard input, including any attempt to interrupt it with a Ctrl-c. `fg` command is used to bring a process to the foreground. In the following example, we start the `gedit` editor in background. Then use the `jobs` command to see the list of jobs launched and then, bring this process to the foreground.

A terminal window titled 'Terminal' with a menu bar (Terminal, File, Edit, View, Search, Terminal, Help). The prompt is 'ubuntu@ubuntu: ~'. The user enters 'gedit &', which returns '[1] 4973'. Then the user enters 'jobs', which returns '[1]+ Running gedit &'. Finally, the user enters 'fg %1', which returns 'gedit'.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ gedit &
[1] 4973
ubuntu@ubuntu:~$ jobs
[1]+  Running                  gedit &
ubuntu@ubuntu:~$ fg %1
gedit
```

Killing a process

We can kill a process using the `kill` command. To kill a process, we provide the process id as an argument (We could have also specified the process using a jobspec). In the following example, we start the `gedit` program and then kill it using `kill` command.

A terminal window titled 'Terminal' with a menu bar (Terminal, File, Edit, View, Search, Terminal, Help). The prompt is 'ubuntu@ubuntu: ~'. The user enters 'gedit &', which returns '[1] 5031'. Then the user enters 'ps', which returns a list of processes: 'PID TTY TIME CMD', '4838 pts/0 00:00:00 bash', '5031 pts/0 00:00:00 gedit', and '5037 pts/0 00:00:00 ps'. The PID '5031' is highlighted. Finally, the user enters 'kill 5031', which returns 'ubuntu@ubuntu:~\$'.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ gedit &
[1] 5031
ubuntu@ubuntu:~$ ps
PID TTY TIME CMD
4838 pts/0 00:00:00 bash
5031 pts/0 00:00:00 gedit
5037 pts/0 00:00:00 ps
ubuntu@ubuntu:~$ kill 5031
ubuntu@ubuntu:~$
```

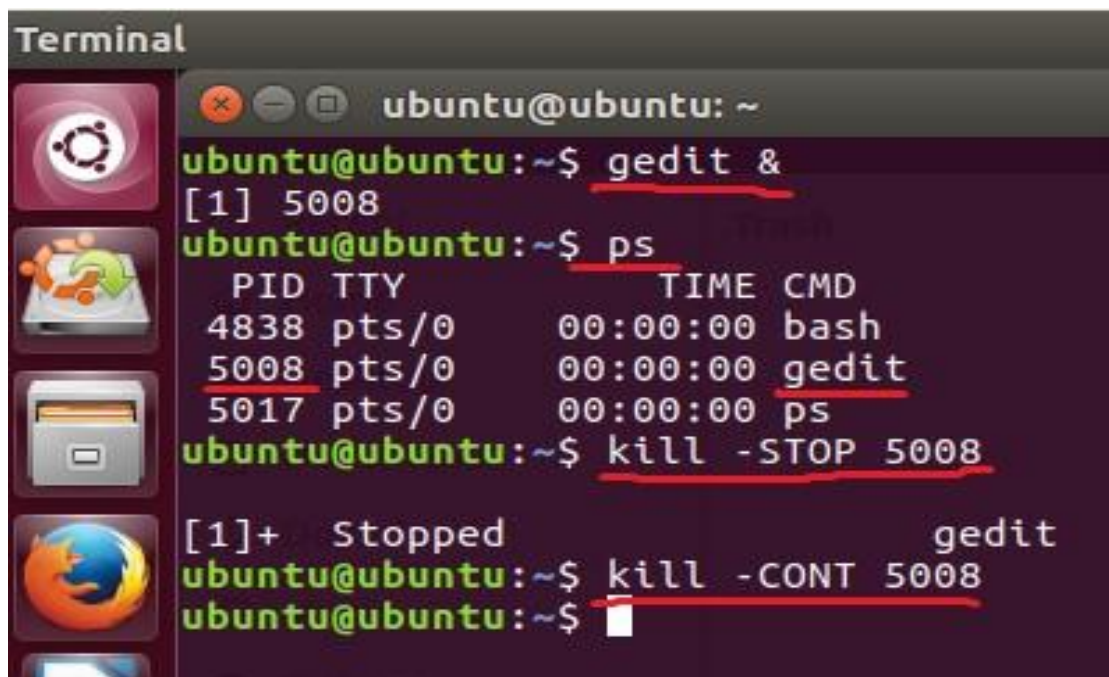
The `kill` command doesn't exactly "kill" processes, rather it sends them *signals*. Signals are one of several ways that the operating system communicates with programs. Programs, in turn, "listen" for signals and may act upon them as they are received. Following are most common signals that can be send with `kill` command.

Signal	Meaning
INT	INT Interrupt. Performs the same function as the Ctrl-c key sent from the terminal. It will usually terminate a program.
TERM	Terminate. This is the default signal sent by the <code>kill</code> command. If a program is still "alive" enough to receive signals, it will terminate.
STOP	Stop. This signal causes a process to pause without terminating.
CONT	Continue. This will restore a process after a STOP signal.

Pausing a process

Linux allows you to pause a running process rather than quitting or killing it. Pausing a process just suspends all of its operation so it stops using any of your processor power even while it still resides in memory. This may be useful when you want to run some sort of a processor intensive task, but don't wish to completely terminate another process you may have running. Pausing it would free up valuable processing time while you need it, and then continue it afterwards.

We can pause a process by using kill command with STOP option. The process id is required as an argument in kill command. In the following example, we start the gedit program in the background. Then we find the pid of gedit using ps command and then; we pause the process using kill command. Later, we can resume the process by using the kill command with CONT option.

A terminal window titled 'Terminal' with a dark background and light text. The prompt is 'ubuntu@ubuntu: ~'. The user enters 'gedit &', and the response is '[1] 5008'. Then the user enters 'ps', showing a list of processes: PID 4838 (bash), PID 5008 (gedit), and PID 5017 (ps). The PID 5008 is underlined. Then the user enters 'kill -STOP 5008', and the response is '[1]+ Stopped gedit'. Finally, the user enters 'kill -CONT 5008', and the prompt returns to 'ubuntu@ubuntu: ~\$'.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ gedit &
[1] 5008
ubuntu@ubuntu:~$ ps
  PID TTY          TIME CMD
 4838 pts/0        00:00:00 bash
 5008 pts/0        00:00:00 gedit
 5017 pts/0        00:00:00 ps
ubuntu@ubuntu:~$ kill -STOP 5008
[1]+  Stopped                  gedit
ubuntu@ubuntu:~$ kill -CONT 5008
ubuntu@ubuntu:~$
```

Changing process priority

Every running process in Linux has a priority assigned to it. We can change the process priority using nice and renice utility. Nice command will launch a process with a user defined scheduling priority. Renice command will modify the scheduling priority of a running process. In Linux system priorities are 0 to 139 in which 0 to 99 for real time and 100 to 139 for users. nice value range is -20 to +19 where -20 is highest, 0 default and +19 is lowest. Relation between nice value and priority is:

$$PR = 20 + NI$$

So, the value of $PR = 20 + (-20 \text{ to } +19)$ is 0 to 39 that maps to 100-139.

In the following example, we start the gedit program in background and see its nice value using ps command.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ gedit &
[1] 5104
ubuntu@ubuntu:~$ ps -lf
F S UID      PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu   4838  4830  0  80   0 - 2231 wait  09:26 pts/0    00:00:00 bash
0 S ubuntu   5104  4838  3  80   0 - 33618 poll_s 10:40 pts/0    00:00:00 gedit
0 R ubuntu   5113  4838  0  80   0 - 2407 -    10:40 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$
```

Now, we start the gedit program again using nice command.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ nice -10 gedit &
[1] 5117
ubuntu@ubuntu:~$ ps -lf
F S UID      PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu   4838  4830  0  80   0 - 2231 wait  09:26 pts/0    00:00:00 bash
0 S ubuntu   5117  4838  4  90  10 - 33652 poll_s 10:42 pts/0    00:00:00 gedit
0 R ubuntu   5127  4838  0  80   0 - 2407 -    10:42 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$
```

We can change the priority of a running process using renice command. In the following example, we first start the gedit program in background. Then we change its priority using renice command.

```
Terminal Terminal File Edit View Search Terminal Help
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ gedit &
[1] 5161
ubuntu@ubuntu:~$ ps -lf
F S UID      PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu   4838  4830  0  80   0 - 2231 wait  09:26 pts/0    00:00:00 bash
0 S ubuntu   5161  4838  6  80   0 - 33618 poll_s 10:54 pts/0    00:00:00 gedit
0 R ubuntu   5170  4838  0  80   0 - 2407 -    10:54 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$ sudo renice -n -12 -p 5161
5161 (process ID) old priority 0, new priority -12
ubuntu@ubuntu:~$ ps -lf
F S UID      PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu   4838  4830  0  80   0 - 2231 wait  09:26 pts/0    00:00:00 bash
0 S ubuntu   5161  4838  1  68  -12 - 33618 poll_s 10:54 pts/0    00:00:00 gedit
0 R ubuntu   5174  4838  0  80   0 - 2407 -    10:55 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$
```

We can also use the renice command to change the priority of all of the processes belonging to a user or a group. In the following example, we change the nice value of all of the process belonging to user ubuntu.


```

Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ ps -lf
F S UID          PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu      4838   4830  0  80   0 - 2231 wait   09:26 pts/0    00:00:00 bash
0 S ubuntu      5161   4838  0  68  -12 - 33618 poll_s 10:54 pts/0    00:00:00 gedit
0 R ubuntu      5178   4838  0  80   0 - 2407 -      11:01 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$ sudo renice -n -12 -u ubuntu
999 (user ID) old priority -12, new priority -12
ubuntu@ubuntu:~$ ps -lf
F S UID          PID  PPID  C PRI  NI ADDR SZ WCHAN  STIME TTY          TIME CMD
0 S ubuntu      4838   4830  0  68  -12 - 2231 wait   09:26 pts/0    00:00:00 bash
0 S ubuntu      5161   4838  0  68  -12 - 33618 poll_s 10:54 pts/0    00:00:00 gedit
0 R ubuntu      5181   4838  0  68  -12 - 2407 -      11:02 pts/0    00:00:00 ps -l
ubuntu@ubuntu:~$

```

Few more useful commands related to processes

vmstat command

Outputs a snapshot of system resource usage including, memory, swap and disk I/O. To see a continuous display, follow the command with a time delay (in seconds) for updates. For example: vmstat 5.

```

Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ vmstat 3
procs-----memory-----swap--  ---io---  -system--  -----cpu-----
r  b   swpd   free   buff   cache   si   so    bi   bo    in   cs  us  sy  id  wa  st
2   0       0 520200 169728 744484    0    0    70    0   42  340  3  1 96  0  0
0   0       0 519936 169728 744484    0    0     0    0   37  303  4  1 95  0  0
0   0       0 519936 169728 744484    0    0     0    0   35  287  4  1 96  0  0
0   0       0 519936 169728 744484    0    0     0    0   39  284  4  1 95  0  0
0   0       0 519960 169728 744484    0    0     0    0   36  239  2  1 97  0  0

```

xload command

Displays the system load over time.

tload command

This command is similar to xload but displays output in the terminal.

Compiling and Executing C++ Programs

Compiling is the way toward making an interpretation of source code into the local language of the PC's processor. The PC's processor works at an extremely basic level, executing programs in what is called machine language. This is a numeric code that portrays extremely little activities, for example, "include this byte," "point to this area in memory," or "duplicate this byte". Each of these instructions is expressed in binary which were hard to write. This issue was overwhelmed by the appearance of assembly language, which supplanted the numeric codes with (marginally) simpler to utilize character mnemonics, for example, CPY (for duplicate) and MOV (for move). Programs written in assembly language are processed into machine language by a program called an assembler.

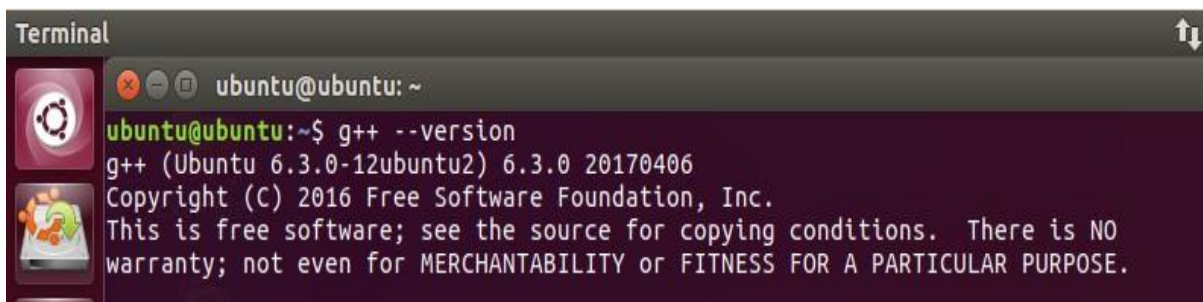
We next come to what are called high-level languages. They are called this since they enable the developer to be less worried about the details of what the processor is doing and more with taking care of the current issue. Programs written in high-level programming languages are converted into machine language by processing them with another program, called a compiler.

C++ compiler for Linux

C++ is a general-purpose programming language and widely used nowadays for competitive programming. It has imperative, object-oriented and generic programming features. C++ runs on lots of platforms like Windows, Linux, Unix, Mac etc. Before we start programming with C++. We will need an environment to be set-up on our local computer to compile and run our C++ programs successfully. GNU C++ Compiler (g++) is a compiler in Linux which is used to compile C++ programs. It compiles both files with extension .c and .cpp as C++ files.

Installing g++ compiler

By default, g++ is provided with most of the Linux distributions. We can find the details of installed g++ compiler by writing the following command:

A terminal window titled 'Terminal' with a dark background. The prompt is 'ubuntu@ubuntu: ~'. The command 'g++ --version' has been entered and executed. The output shows the version as 'g++ (Ubuntu 6.3.0-12ubuntu2) 6.3.0 20170406' and includes copyright information for the Free Software Foundation, Inc. The window has standard Ubuntu window controls (minimize, maximize, close) and a terminal icon in the title bar.

```
Terminal
ubuntu@ubuntu: ~
ubuntu@ubuntu:~$ g++ --version
g++ (Ubuntu 6.3.0-12ubuntu2) 6.3.0 20170406
Copyright (C) 2016 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

If g++ is not installed on your system; then it can be installed by writing the following commands

```
$ sudo apt-get update
```

```
$ sudo apt install g++
```

Compiling C++ program

We can compile a C++ program using the following command

```
$ sudo g++ source-file.cpp
```

The above command will generate an executable file a.out. We can use -o option to specify the output file name for the executable.

```
$ sudo g++ source-file.cpp -o executable-file
```

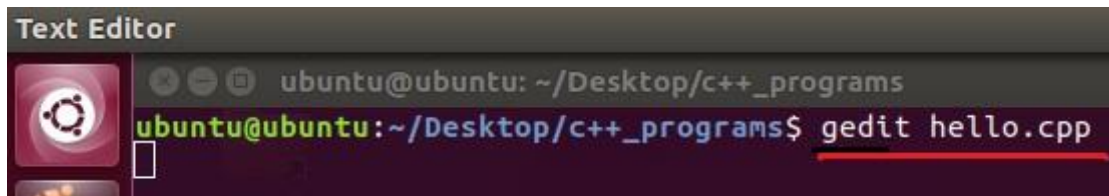
Running a C++ program

Once a C++ program is successfully compiled, we can execute the created executable file by using the following command:

```
$ ./executable-file
```

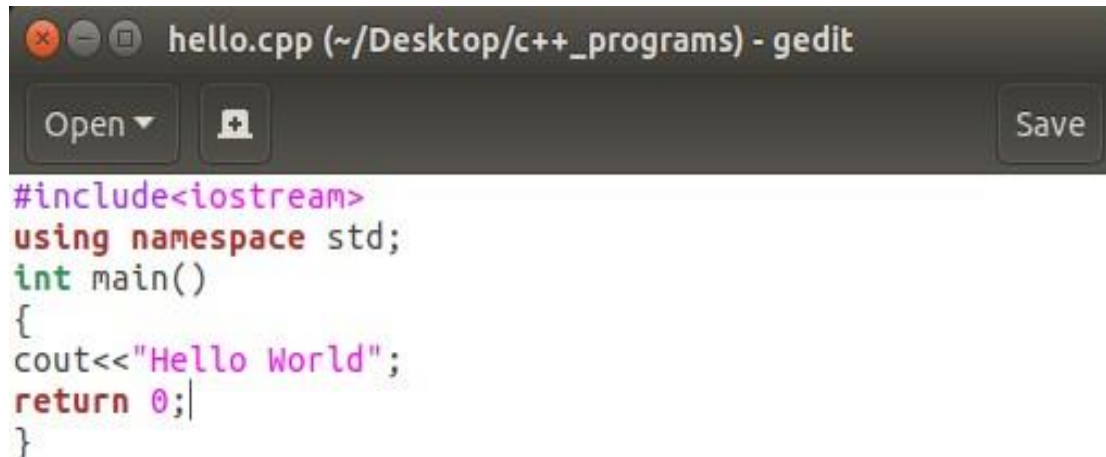
In the following example, we write a simple C++ program that displays a Hello World message and then compile and execute this program using the above commands. To write the program, we use the gedit text editor. The source code file is saved with .cpp extension.

Open the gedit editor and pass the name of the file (hello.cpp) to be created



```
Text Editor
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ gedit hello.cpp
```

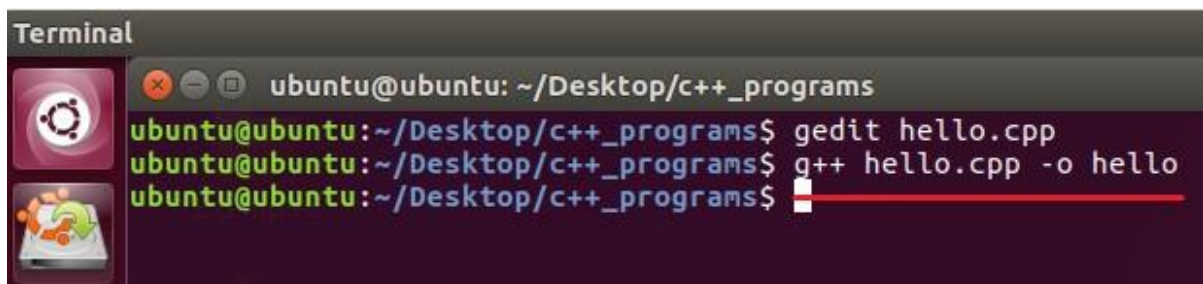
Write the following code



```
hello.cpp (~/Desktop/c++_programs) - gedit
Open Save

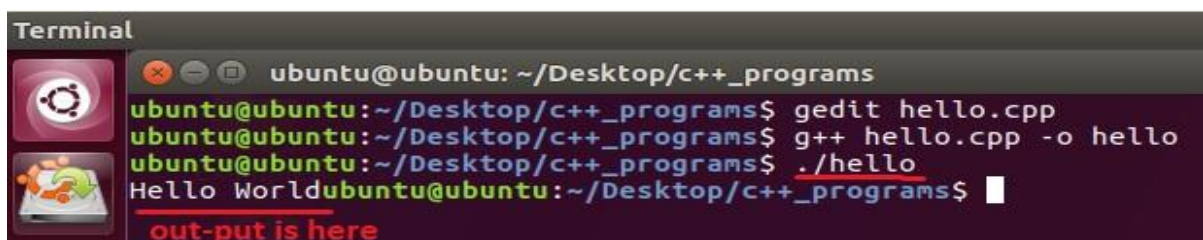
#include<iostream>
using namespace std;
int main()
{
    cout<<"Hello World";
    return 0;
}
```

Now, close the source file and write the following command to compile hello.cpp



```
Terminal
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ gedit hello.cpp
ubuntu@ubuntu:~/Desktop/c++_programs$ g++ hello.cpp -o hello
ubuntu@ubuntu:~/Desktop/c++_programs$
```

To execute the hello executable file, write the following command.



```
Terminal
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ gedit hello.cpp
ubuntu@ubuntu:~/Desktop/c++_programs$ g++ hello.cpp -o hello
ubuntu@ubuntu:~/Desktop/c++_programs$ ./hello
Hello World
out-put is here
```

Passing command-line arguments to a C++ program

Command line argument is a parameter supplied to the program when it is invoked. Command line argument is an important concept in C++ programming. It is mostly used when you need to control your program from outside. Command line arguments are passed to the main () method.

To pass command line arguments, we typically define main () with two arguments: first argument counts the number of arguments on the command line and the second is a pointer array which holds pointers of type char which points to the arguments passed to the program. The syntax to define the main method is

```
int main (int argc, char *argv[])
```

Here, argc variable will hold the number of arguments pass to the program while the argv will contain pointers to those variables. argv[0] holds the name of the program while argv[1]to argv[argc] hold the arguments. Command-line arguments are given after the name of the program in command-line shell of Operating Systems. Each argument separated by a space. If a space is included in the argument, then it is written in “”.

In the following example, we calculate the average of numbers; passed in the command- line. Write the following code and save the file named as avg.cpp. Compile the avg.cpp and create an executable file named avg and execute it. While writing the command to execute avg pass the numbers whose average is required. It is shown below.

The image shows a Text Editor window titled 'avg.cpp (~/Desktop/c++_programs) - gedit' and a Terminal window titled 'ubuntu@ubuntu: ~/Desktop/c++_programs'.

Text Editor Content:

```
#include<iostream>
#include<cstdlib>
using namespace std;
int main(int c, char *v[])
{
    int sum=0;
    float avg;
    cout<<"Total number of arguments are "<<c<<endl;
    cout<<"The name of the program is "<<v[0]<<endl;
    for(int i=1; i<c; i++)
    {
        sum=sum+atoi(v[i]);
    }
    cout<<"Sum of Values is : "<<sum<<endl;
    avg=sum/(c-1);
    cout<<"Average is "<<avg<<endl;
    return 0;
}
```

Terminal Content:

```
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ g++ avg.cpp -o avg
ubuntu@ubuntu:~/Desktop/c++_programs$ ./avg 3 5 7
Total number of arguments are 4
The name of the program is ./avg
Sum of Values is : 15
Average is 5
ubuntu@ubuntu:~/Desktop/c++_programs$
```

2) Solved Lab Activities

Sr.No	Allocated Time	Level of Complexity	CLO Mapping
1	15	Low	CLO-5
2	15	Medium	CLO-5
3	15	Medium	CLO-7

Activity 1:

This activity is related to process monitoring in Linux

- Display all of the process in current shell

- Display every active process in the system
- Provide a full-format listing of process owned by you
- Display a full-format listing of processes owned by user ubuntu
- Display a process with id 1
- Display the dynamic view of the current processes in the system and set the refresh interval 0.5 second
- Display the dynamic view of the processes owned by user with id 999 (or name ubuntu)
- Start the gedit program in background and then bring it foreground
- Suspend the gedit program
- Resume the gedit program

Solution:

1.

```
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ ps
  PID TTY          TIME CMD
  4818 pts/0        00:00:00 bash
  5223 pts/0        00:00:00 ps
```

2.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -A
  PID TTY          TIME CMD
    1 ?            00:00:06 systemd
    2 ?            00:00:00 kthreadd
    4 ?            00:00:00 kworker/0:0H
    6 ?            00:00:00 ksoftirqd/0
```

3.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -lx
F  UID  PID  PPID  PRI  NI   VSZ  RSS  WCHAN  STAT TTY          TIME COMMAND
4  999  1593    1   20    0  9632  6344 ep_pol Ss   ?    0:00 /lib/systemd/systemd --user
5  999  1594  1593   20    0 12972  1472 -      Ss   ?    0:00 (sd-pam)
0  999  1600  1593   20    0  7088  4592 ep_pol Ss   ?    0:01 /usr/bin/dbus-daemon --session --address=systemd: --no
for
```

4.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -lu ubuntu
F S  UID  PID  PPID  C PRI  NI ADDR SZ WCHAN  TTY          TIME CMD
4 S  999  1593    1   0  80   0 -  2408 ep_pol ?    00:00:00 systemd
5 S  999  1594  1593   0  80   0 -  3243 -      ?    00:00:00 (sd-pam)
0 S  999  1600  1593   0  80   0 -  1772 ep_pol ?    00:00:01 dbus-daemon
```

5.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -lp 1
F S  UID  PID  PPID  C PRI  NI ADDR SZ WCHAN  TTY          TIME CMD
4 S   0    1    0   0  80   0 -  6818 -      ?    00:00:06 systemd
```

6.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ top -d 0.5

top - 08:54:14 up 3:34, 1 user, load average: 0.13, 0.04, 0.
Tasks: 153 total, 1 running, 152 sleeping, 0 stopped, 0 z
%Cpu(s): 5.9 us, 2.0 sy, 0.0 ni, 92.2 id, 0.0 wa, 0.0 hi,
KiB Mem : 1823696 total, 444780 free, 390968 used, 98794
KiB Swap: 0 total, 0 free, 0 used. 115920

  PID USER      PR  NI   VIRT   RES   SHR  S  %CPU  %MEM
 4740 ubuntu    20   0 308300 137772 74772 S   4.0   7.6
```

7.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ top -u 999

top - 08:54:36 up 3:34, 1 user, load average: 0.09, 0.04, 0.
Tasks: 153 total, 1 running, 152 sleeping, 0 stopped, 0 z
%Cpu(s): 2.0 us, 0.3 sy, 0.0 ni, 97.7 id, 0.0 wa, 0.0 hi,
KiB Mem : 1823696 total, 444808 free, 390940 used, 98794
KiB Swap: 0 total, 0 free, 0 used. 115923
```

8.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ gedit &
[1] 5230
ubuntu@ubuntu:~/Desktop/c++_programs$ fg %1
gedit
```

9.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ kill -STOP 5249
```

10.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ kill -CONT 5249
```

Activity 2:

Perform the following tasks

- Start the gedit program with priority 90
- Reset the priority of gedit to 65

Solution:

1.

```
ubuntu@ubuntu: ~/Desktop/c++_programs
ubuntu@ubuntu:~/Desktop/c++_programs$ nice -n 10 gedit &
[1] 5310
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -l
F S  UID    PID  PPID  C PRI  NI ADDR SZ  WCHAN  TTY          TIME CMD
0 S   999    4818  4810  0  80   0  -  2231 wait  pts/0    00:00:00 bash
0 S   999    5310  4818  2  90 10 -  33685 poll_s pts/0    00:00:00 gedit
0 R   999    5320  4818  0  80   0  -  2338 -      pts/0    00:00:00 ps
```

2.

```
ubuntu@ubuntu:~/Desktop/c++_programs$ sudo renice -n -15 -p 5310
5310 (process ID) old priority 10, new priority -15
ubuntu@ubuntu:~/Desktop/c++_programs$ ps -l
```

F	S	UID	PID	PPID	C	PRI	NI	ADDR	SZ	WCHAN	TTY	TIME	CMD
0	S	999	4818	4810	0	80	0	-	2231	wait	pts/0	00:00:00	bash
0	S	999	5310	4818	0	65	-15	-	33685	poll_s	pts/0	00:00:00	gedit
0	R	999	5330	4818	0	80	0	-	2338	-	pts/0	00:00:00	ps

Activity 3:

Write a program in C++ that find the maximum and minimum number from an array.

Solution:

```
#include<iostream> using
namespace std; int main ()
{
    int arr[10], n, i, max, min;
    cout << "Enter the size of the array : ";
    cin >> n;
    cout << "Enter the elements of the array : "; for
        (i = 0; i < n; i++)
            cin >> arr[i]; max =
            arr[0];
    for (i = 0; i < n; i++)
    {
        if (max < arr[i]) max =
            arr[i];
    }
    min = arr[0];
    for (i = 0; i < n; i++)
    {
        if (min > arr[i]) min =
            arr[i];
    }
    cout << "Largest element : " << max; cout
    << "Smallest element : " << min; return 0;
}
```

3) Graded Lab Tasks

Note: The instructor can design graded lab activities according to the level of difficult and complexity of the solved lab activities. The lab tasks assigned by the instructor should be evaluated in the same lab.

Task 1:

Change the program given in Activity 3 such that it accepts the input at command-line.

Task 2:

Write a C++ program that accepts a number as input and find whether it is a palindrom or not

Task 3: