

DevOps

Is a set of practices that combines software development(Dev) and information-technology operations(Ops) which aims to shorten the systems development life cycle and provide continuous delivery with high software quality.

Wikipedia

Part 1 : Lab Setup

- Install VirtualBox : <https://www.virtualbox.org/>
- Windows : Add "C:\Program Files\Oracle\VirtualBox\" to Environment Variable PATH
- Download Ubuntu : <http://releases.ubuntu.com/14.04/>
- Install OS
- Install ssh

```
sudo apt-get install ssh
```

- Poweroff VM
- Go to Terminal/CMD
- List available VMs

```
Alems-MacBook-Pro:~ alemabreha$ VBoxManage list vms
"alemUbuntu" {01b67cc2-ed02-484f-a751-0104170db0c1}
Alems-MacBook-Pro:~ alemabreha$
```

- Power start your VM in headless mode (NOTE : Starting VMs with Graphical UI consumes more resources and slows down your computer)

```
Alems-MacBook-Pro:~ alemabreha$ VBoxManage startvm alemUbuntu --type headless
Waiting for VM "alemUbuntu" to power on...
VM "alemUbuntu" has been successfully started.
Alems-MacBook-Pro:~ alemabreha$
```

Now Practice how to control your VM

- Starting a VM

```
VBoxManage startvm <"VM Name"> --type headless
```

- Pausing a VM

```
VBoxManage controlvm <"VM Name"> pause --type headless
```

- Un-pausing (Resuming) a VM

```
VBoxManage controlvm <"VM Name"> resume --type headless
```

- Shutting down a VM

```
VBoxManage controlvm <"VM Name"> poweroff --type headless
```

Tip : Learn about Vagrant : <https://www.vagrantup.com/intro/index.html>

Part 2 : Introduction to Linux

Why Linux ?

- More than 80% of new smartphones sold run Android, based on the Linux kernel.
- All of the top 500 supercomputers in the world run on Linux.
- Most of the global markets run on Linux, including the New York Stock Exchange and NASDAQ.
- The majority of consumer electronics devices use Linux for its small footprint.
- More than 75% of cloud-enabled enterprises use Linux as their primary cloud platform.
- Linux is the go-to infrastructure supporting the world's eCommerce leaders, including Amazon, eBay, PayPal, Walmart, and others.
- Open Source

Source: <https://blogs.oracle.com/oracleuniversity/linux-experts-are-in-demand%3a-how-to-improve-your-linux-skills>

What is the best way to learn Linux ?

Doing it! Hands-on !

Job Market



Source: <https://www.linuxfoundation.org/publications/2018/06/open-source-jobs-report-2018/>

What is (Free) Open Source Software ?

- source code is released under a license in which the copyright holder grants users the rights to study, change, and distribute the software to anyone and for any purpose.
(https://en.wikipedia.org/wiki/Open-source_software)
- Based on “giving” rather than “protecting”
- “Copyleft” rather than Copyright

Open Source Software Vs Free Software



Source : <http://www.rpubs.com/RCRUZ104/303601>

Licensing Models :

Free Software foundation(FSF) : https://en.wikipedia.org/wiki/Free_Software_Foundation

GNU GPL (General Public License) : Example : Linux Kernel

Open Source Initiative(OSI) : <https://opensource.org/>

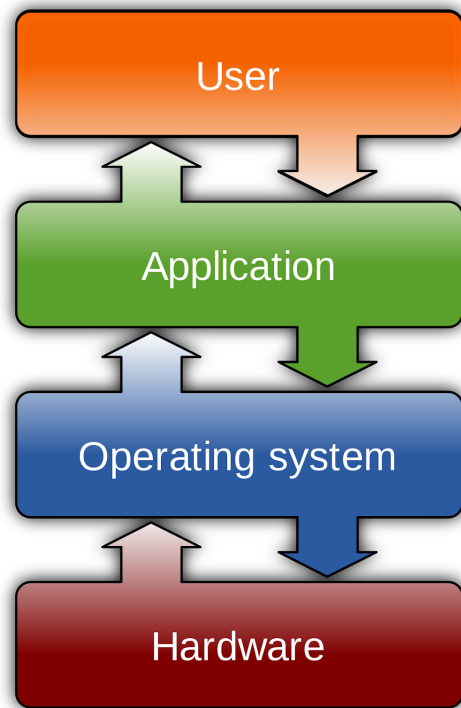
Creative Commons : Software , music, books

Attribution, Share-alike, Non-commercial, No Derivative works, public domain

- Most profitable companies are building profitable products using open source software
 - Redhat (Now IBM) - Centos
 - Canonical - Ubuntu
- Check out [Ubuntu](#) and [redhat](#) licensing on their websites

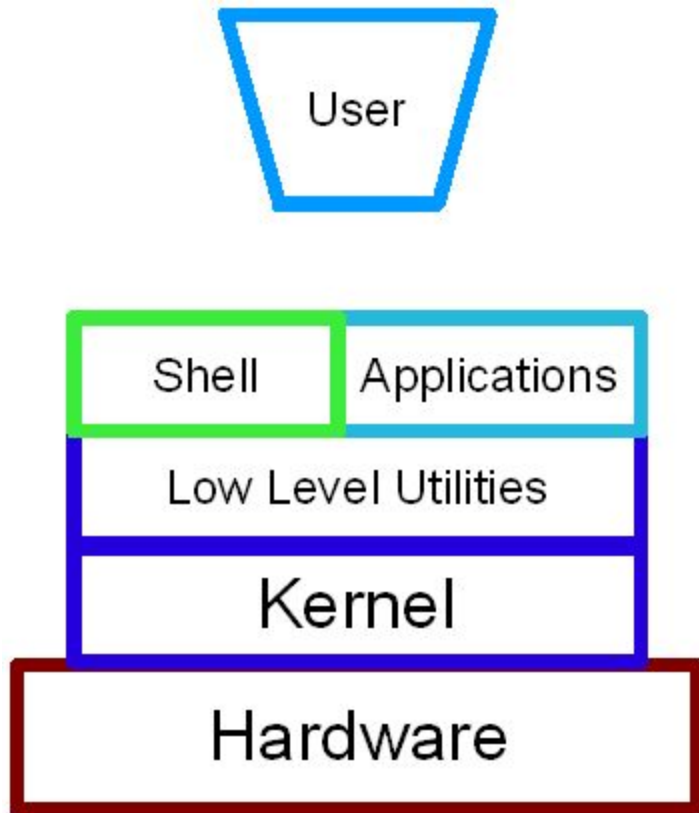
The Original Linux Kernel - Linus Torvalds

- Conceived and created in 1991 by [Linus Torvalds](#)^[9] for his personal computer
- Read about the history : https://en.wikipedia.org/wiki/Linux_kernel
- Linux Kernel: <https://www.kernel.org/doc/html/latest/>



Source :

https://en.wikipedia.org/wiki/Operating_system



- System Calls: Context switches between User Space and Kernel Space (System Call Interface)

Important Feature of Linux Kernel

It is Free (Open Source Software)

- Customization : modify it and recompile
- Flexibility : Embedded systems, Appliance and Entertainment control systems
- Virtualization (Containerization)

Linux Distribution Bundles

Kernel : handles system hardware resources on behalf of the OS User - usually decided by the distribution installed

Desktop : GUI, software designed to manage graphic interface features like windows, menus, and app controls

Distribution specific suite of system tools : package managers, process manager

- Managed software package repos
- Apt - ubuntu
- Yum - Centos

Example: Kdenlive - open source video editing from apt (Free vs Adobe)

Linux distributions (Distros)

- Android - Smartphones
- Redhat/Centos Linux
- SUSE/OpenSUSE
- Scientific Linux - science and math
- Kali Linux - network security
- Raspbian - Raspberry Pi ARM processor Arch
- Ubuntu - server and desktop

Families of Distribution : Parent-child (Upstream -> downstream)

Debian - Ubuntu, [Mint](#) and [Kali Linux](#)

RHEL - CentOS and Fedora

SUSE - [OpenSUSE](#)

[Arch Linux](#) - [LinHES](#) (home entertainment) and [Manjaro](#)

Specialized Distros : IoT , Embeded Systems, Docker Containers

- Linux running inside Fridges, Ovens , Wearables

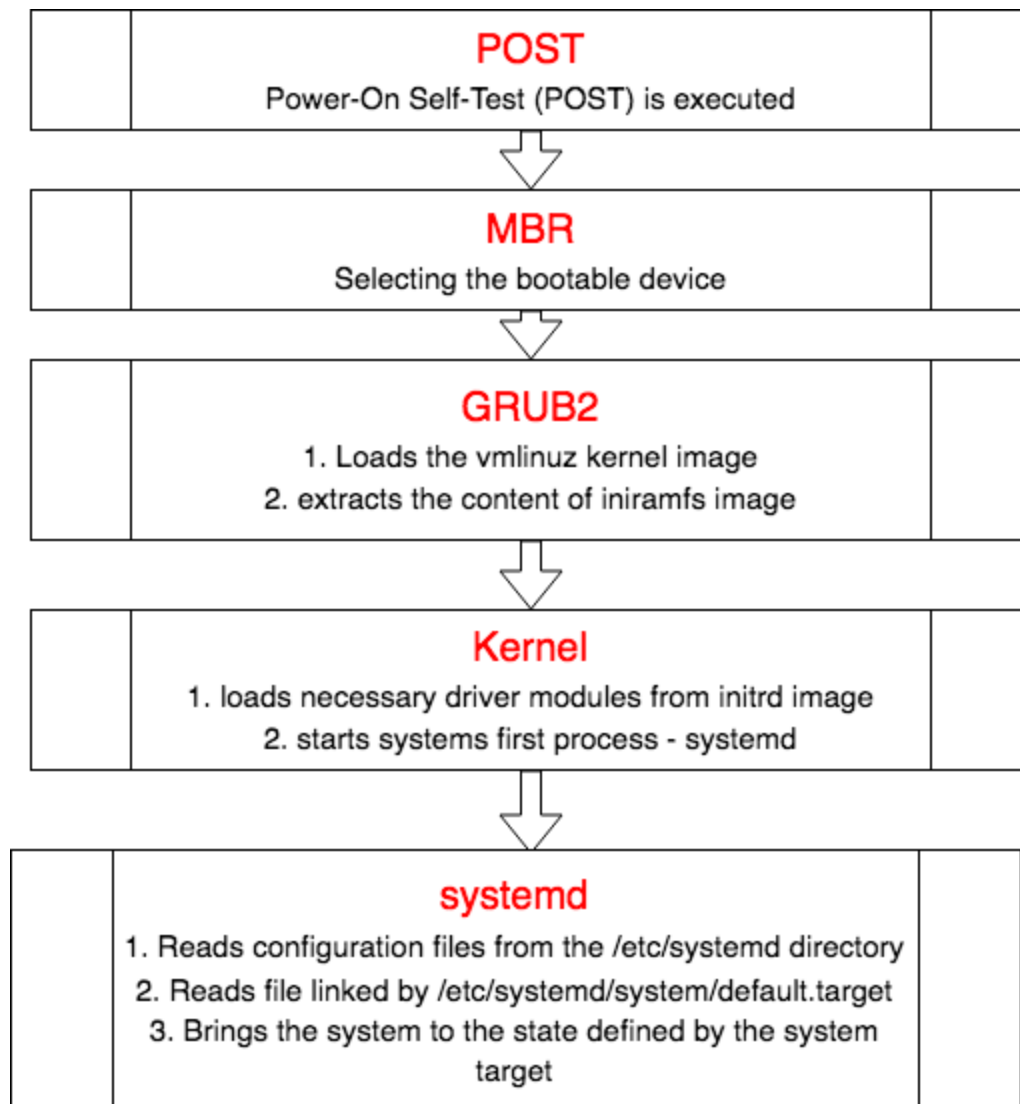
The Cloud

- Linux is the most versatile OS for cloud deployment
- AWS AMI service - example

Question : How do you decide when to upgrade versions of your Linux Distro ?

What's wrong with the latest and greatest version ? Stable is a safe bet

Part 3 : The Linux Boot Process



Source: <https://www.thegeekdiary.com/centos-rhel-7-booting-process/>

1. The computer's BIOS (modern Universal Extended Firmware Interface (**UEFI**) or the classical Basic Input Output System (**BIOS**)) performs POST.
2. BIOS reads the MBR for the bootloader.
3. GRUB 2 bootloader loads the vmlinuz kernel image.
4. GRUB 2 extracts the contents of the initramfs image.
5. The kernel loads driver modules from initramfs.
6. Kernel starts the system's first process, systemd.
7. The systemd process takes over. It:
 - Reads configuration files from the /etc/systemd directory

- Reads file linked by `/etc/systemd/system/default.target`
- Brings the system to the state defined by the system target
- Executes `/etc/rc.local`

Part 4 : Run Levels

Run Level	Target Units	Description
0	<code>runlevel0.target</code> , <code>poweroff.target</code>	Shut down and power off
1	<code>runlevel1.target</code> , <code>rescue.target</code>	Set up a rescue shell
2,3,4	<code>runlevel[234].target</code> , <code>multi-user.target</code>	Set up a nongraphical multi-user shell
5	<code>runlevel5.target</code> , <code>graphical.target</code>	Set up a graphical multi-user shell
6	<code>runlevel6.target</code> , <code>reboot.target</code>	Shut down and reboot the system

- If systemctl command is not working , check if systemd is installed and if its installed re-install it

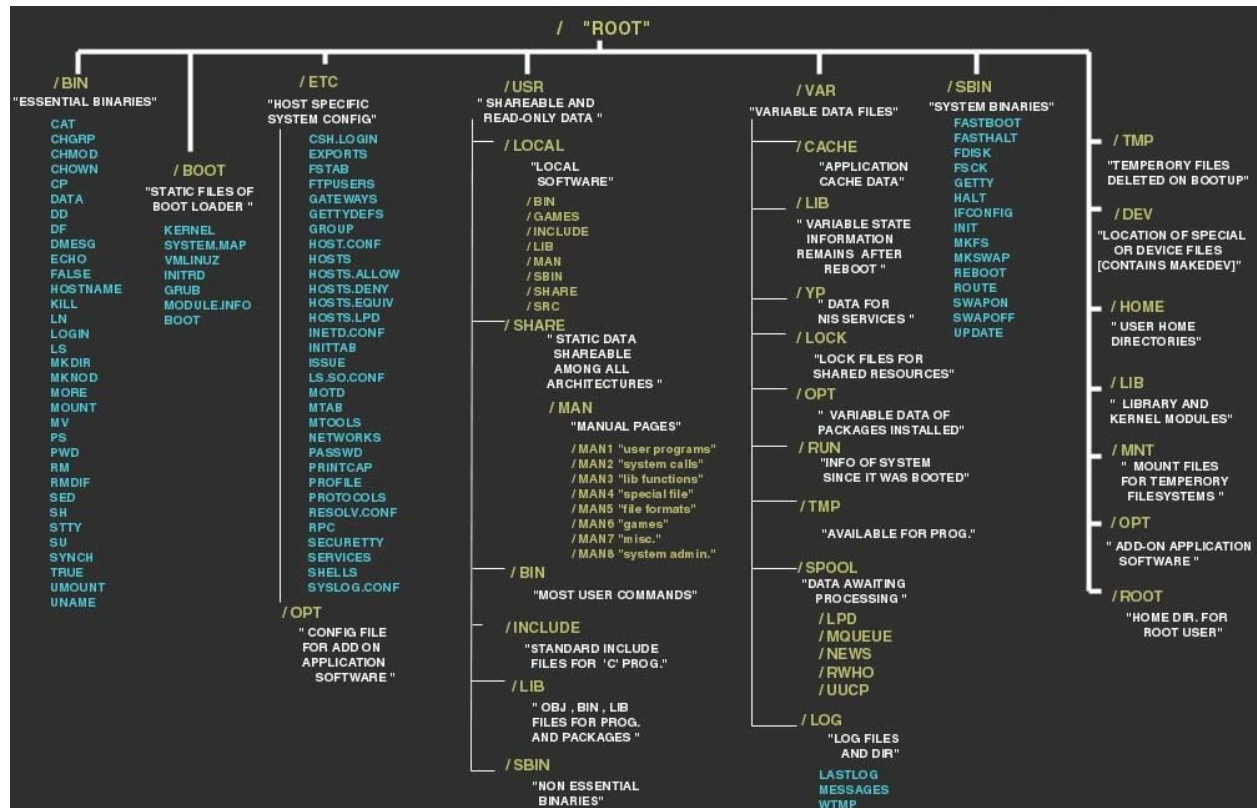
```
root@ceubuntu:/home/alem# dpkg -l | grep systemd
ii  libpam-systemd:amd64          204-5ubuntu20.29
amd64      system and service manager - PAM module
ii  libsystemd-daemon0:amd64     204-5ubuntu20.29
amd64      systemd utility library
ii  libsystemd-login0:amd64      204-5ubuntu20.29
amd64      systemd login utility library
ii  systemd-services             204-5ubuntu20.29
amd64      systemd runtime services
ii  systemd-shim                 6-2bzn1
amd64      shim for systemd
root@ceubuntu:/home/alem# apt-get install --reinstall systemd
```

- Check your Default run-level

```
root@mybuntu:/home/alem# systemctl get-default
graphical.target
root@mybuntu:/home/alem# runlevel
N 5
root@mybuntu:/home/alem#
```

Part 5 : The Linux File System Hierarchy Standard

READ: https://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard



- View the filesystem using the “tree” command
- You will need to install it first from apt

```
root@mybuntu:~# apt-get install tree
```

- Run “tree”

```
root@mybuntu:/# tree
.
├── bin
│   ├── bash
│   ├── btrfs
│   ├── btrfsck -> btrfs
│   ├── btrfs-debug-tree
│   ├── btrfs-find-root
│   ├── btrfs-image
│   ├── btrfs-map-logical
│   └── btrfs-select-super
(oops ... something crazy happened)
root@mybuntu:/#
```

Press : CTRL + C to stop the fast rolling output

- What just happened ?
- Lets try re-running the tree command with additional options (customize the output)

```
root@mybuntu:/# tree -L 1
.
├── bin
├── boot
├── dev
├── etc
├── home
├── initrd.img -> boot/initrd.img-4.15.0-54-generic
├── initrd.img.old -> boot/initrd.img-4.15.0-54-generic
├── lib
├── lib64
├── lost+found
├── media
├── mnt
├── opt
├── proc
├── root
├── run
└── sbin
```



```

├── snap
├── srv
├── swap.img
├── sys
├── tmp
├── usr
├── var
├── vmlinuz -> boot/vmlinuz-4.15.0-54-generic
└── vmlinuz.old -> boot/vmlinuz-4.15.0-54-generic

```

21 directories, 5 files

root@mybuntu:/#

- Another Command for listing directories under the “ROOT” / directory

```

root@mybuntu:/# ls /
bin boot dev etc home initrd.img initrd.img.old lib lib64
lost+found media mnt opt proc root run sbin snap srv swap.img
sys tmp usr var vmlinuz vmlinuz.old
root@mybuntu:/#

```

- Explore /dev - device files

```

root@mybuntu:/# ls /dev/
autofs          cuse          hugepages    loop2         memory_bandwidth  pts
shm             tty10         tty2         tty29         tty38         tty47         tty56         tty8           ttyS15
ttyS24          ttyS5         vboxuser     vcса2         zero
block           disk          hwrng        loop3         mqueue
random          snapshot      tty11        tty20         tty3          tty39         tty48         tty57         tty9
ttyS16          ttyS25        ttyS6        vcs           vcса3
bsg             dri           i2c-0        loop4         net
rfkill          snd           tty12        tty21         tty30         tty4          tty49         tty58         ttyprintk
ttyS17          ttyS26        ttyS7        vcs1          vcса4
btrfs-control   dvd           initctl      loop5         network_latency    rtc
sr0             tty13        tty22        tty31         tty40         tty5          tty59         ttyS0         ttyS18
ttyS27          ttyS8         vcs2         vcса5
bus             ecryptfs      input        loop6         network_throughput
rtc0            stderr        tty14        tty23         tty32         tty41         tty50         tty6           ttyS1
ttyS19          ttyS28        ttyS9        vcs3          vcса6
cdrom           fb0           kmsg         loop7         null          sda
stdin           tty15        tty24        tty33         tty42         tty51         tty60         ttyS10        ttyS2

```

```

ttyS29  uhid      vcs4      vfio
char          fd      lightnvm  loop-control  port
sda1      stdout  tty16    tty25  tty34  tty43  tty52  tty61  ttyS11
ttyS20    ttyS3    uinput   vcs5    vga_arbiter
console    full      log      mapper    ppp
sda2      tty      tty17    tty26  tty35  tty44  tty53  tty62  ttyS12
ttyS21    ttyS30   urandom   vcs6    vhci
core      fuse      loop0     mcelog      psaux      sg0
tty0      tty18    tty27    tty36  tty45  tty54  tty63  ttyS13  ttyS22
ttyS31    userio    vcsa     vhost-net
cpu_dma_latency  hpet      loop1     mem      ptmx      sg1
tty1      tty19    tty28    tty37  tty46  tty55  tty7   ttyS14  ttyS23
ttyS4     vboxguest vcsa1    vhost-vsock
root@mybuntu:/#

```

- /sys - Contains information about devices, drivers, and some kernel features

```

root@mybuntu:/# cat /sys/block/sda/sda2/size
55195648
root@mybuntu:/#

```

```

root@mybuntu:/# cat /sys/kernel/boot_params/version
0x020d
root@mybuntu:/#

```

- What does that file represent ? Read :
https://www.kernel.org/doc/Documentation/ABI/testing/sysfs-kernel-boot_params

Part 6 : Managing Linux Environments

- Where are we in the filesystem heirarchy ?

```

root@mybuntu:~# pwd
/root
root@mybuntu:~#

```

- Change our present working directory to /etc/systemd

```
root@mybuntu:~# cd /etc/systemd/  
root@mybuntu:/etc/systemd# pwd  
/etc/systemd  
root@mybuntu:/etc/systemd#
```

- Where is this information coming from ? Environment Variables

```
root@mybuntu:/etc/systemd# env
```

- What other Environment Variable do we notice ?
 - PATH ? Also used on Windows

```
root@mybuntu:/etc/systemd# echo $PATH  
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr  
r/local/games  
root@mybuntu:/etc/systemd#  
root@mybuntu:/etc/systemd# echo Gebeya  
Gebeya  
root@mybuntu:/etc/systemd#
```

- How do we create a simple variable ?

```
root@mybuntu:~# city="Addis Ababa"  
root@mybuntu:~# echo $city  
Addis Ababa  
root@mybuntu:~#
```

- Timezone and Locale Settings

```
root@mybuntu:~# timedatectl  
Local time: Mon 2019-07-08 00:22:41 UTC  
Universal time: Mon 2019-07-08 00:22:41 UTC  
RTC time: Mon 2019-07-08 00:22:42  
Time zone: Etc/UTC (UTC, +0000)  
System clock synchronized: yes  
systemd-timesyncd.service active: yes  
RTC in local TZ: no  
root@mybuntu:~#
```

- List all timezones

```
root@mybuntu:~# timedatectl list-timezones | less
Africa/Abidjan
Africa/Accra
Africa/Addis_Ababa
Africa/Algiers
Africa/Asmara
Africa/Bamako
Africa/Bangui
Africa/Banjul
Africa/Bissau
```

- Change Timezone

```
root@mybuntu:/home/alem# timedatectl set-timezone Africa/Addis_Ababa
root@mybuntu:/home/alem# timedatectl
          Local time: Tue 2019-07-23 16:41:55 EAT
        Universal time: Tue 2019-07-23 13:41:55 UTC
           RTC time: Tue 2019-07-23 13:41:57
        Time zone: Africa/Addis_Ababa (EAT, +0300)
System clock synchronized: yes
systemd-timesyncd.service active: yes
          RTC in local TZ: no
root@mybuntu:/home/alem#
```

- Locale

```
root@mybuntu:~# localectl status
System Locale: LANG=en_US.UTF-8
   VC Keymap: n/a
   X11 Layout: us
   X11 Model: pc105
root@mybuntu:~#
```

Part 7 : Command Line Introduction

- GUI is pretty , but system administration is strongly tied to CLI
- TL;DR why CLI : Efficiency, Efficiency and Efficiency
 - Infrastructure automation
 - Example of inefficient UI : AWS site vs AWS CLI
- PSA : There are hundreds of commands and you can't remember each and every command by heart >> Linux comes with Help Resources

Help resources

- Internet
- “man” utility from CLI
- “info” utility from CLI
- README files that come with installation of a CLI utility
- --help option

- “man” from CLI

```
man <command>
```

- “man” is a software package that needs to be installed, to install man

```
sudo apt install man-db
```

- “info” lets us explore the usage manuals for all available commands
 - To install info

```
sudo apt install info
```

- Running “info” returns a directory of commands

```
info
```

- to see example usages of the “curl” command

```
info curl examples
```

- we can also get examples and README files that comes with the installation package by going to the /usr/share/doc/<command> directory. Here is an example for the wget command

```
alem@mybuntu:~$ cd /usr/share/doc/wget/  
alem@mybuntu:/usr/share/doc/wget$ ls  
AUTHORS changelog.Debian.gz copyright MAILING-LIST NEWS.gz README
```

```
alem@mybuntu:/usr/share/doc/wget$
```

- Using the --help option : most commands (not all) come with a usage help menu, here is an example for wget

```
alem@mybuntu:/usr/share/doc/wget$ wget --help | less
GNU Wget 1.19.4, a non-interactive network retriever.
Usage: wget [OPTION]... [URL]...

Mandatory arguments to long options are mandatory for short options too.

Startup:
-V, --version          display the version of Wget and exit
-h, --help             print this help
-b, --background       go to background after startup
-e, --execute=COMMAND  execute a '.wgetrc'-style command

Logging and input file:
-o, --output-file=FILE  log messages to FILE
-a, --append-output=FILE append messages to FILE
-d, --debug             print lots of debugging information
-q, --quiet             quiet (no output)
-v, --verbose           be verbose (this is the default)
-nv, --no-verbose       turn off verbosity, without being quiet
```

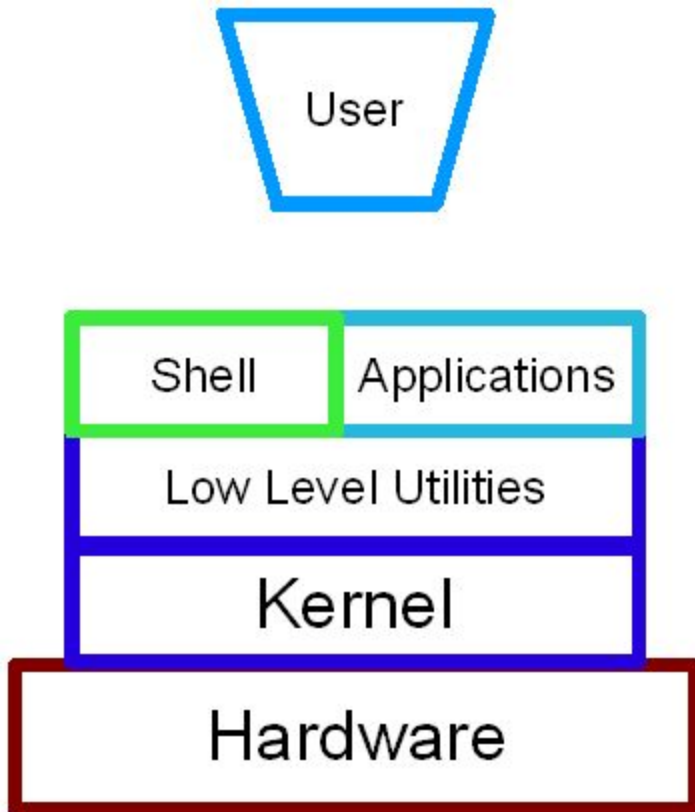
Locating Commands

- Sometimes you might need to locate where a command is in the filesystem

```
alem@mybuntu:/usr/share/doc/wget$ type wget
wget is hashed (/usr/bin/wget)
alem@mybuntu:/usr/share/doc/wget$ which wget
/usr/bin/wget
alem@mybuntu:/usr/share/doc/wget$
```

The Linux Terminal

- Everytime when you open a terminal, a new shell session is created.
- What is Shell ?
 - The shell accepts human readable commands and translates them into something the kernel can read and process.



- we are using BASH shell - what other shells are out there ?
- Our user account information is used to determine what kind of shell is started when we login (/etc/passwd)

```
messagebus:x:103:107::/nonexistent:/usr/sbin/nologin
_apt:x:104:65534::/nonexistent:/usr/sbin/nologin
lxd:x:105:65534:/var/lib/lxd:/bin/false
uuidd:x:106:110:/run/uuidd:/usr/sbin/nologin
dnsmasq:x:107:65534:dnsmasq,,,:/var/lib/misc:/usr/sbin/nologin
landscape:x:108:112:/var/lib/landscape:/usr/sbin/nologin
pollinate:x:109:1:/var/cache/pollinate:/bin/false
sshd:x:110:65534:/run/sshd:/usr/sbin/nologin
alem:x:1000:1000:Alem Abreha:/home/alem:/bin/bash
```

- `.bash_rc` and `.profile` in (user's home directory) files are used in setting up our terminal shell

```
alem@mybuntu:~$ ls -a
.  ..  .bash_history  .bash_logout  .bashrc  .cache  .config  .gnupg  .mozilla  .profile
.sudo_as_admin_successful  .viminfo  .Xauthority
alem@mybuntu:~$
```

- NOTE: Hidden files start with a “.”

Command syntax and shortcuts

- invoking a command name by itself usually returns an output

```
alem@mybuntu:~$ ls
file1
alem@mybuntu:~$
```

- adding combination of arguments customizes the command output

```
alem@mybuntu:~$ ls -a
.  ..  .bash_history  .bash_logout  .bashrc  .cache  .config  file1  .gnupg
.mozilla  .profile  .sudo_as_admin_successful  .viminfo  .Xauthority
alem@mybuntu:~$
```

- arguments usually have short and long (complete) form

```
alem@mybuntu:~$ ls --all
.  ..  .bash_history  .bash_logout  .bashrc  .cache  .config  file1  .gnupg
.mozilla  .profile  .sudo_as_admin_successful  .viminfo  .Xauthority
alem@mybuntu:~$
```

- check usage for available arguments and options

```
alem@mybuntu:~$ ls --help | less
Usage: ls [OPTION]... [FILE]...
List information about the FILES (the current directory by default).
Sort entries alphabetically if none of -cftuvSUX nor --sort is specified.

Mandatory arguments to long options are mandatory for short options too.
-a, --all                do not ignore entries starting with .
-A, --almost-all        do not list implied . and ..
--author                 with -l, print the author of each file
-b, --escape             print C-style escapes for nongraphic characters
--block-size=SIZE        scale sizes by SIZE before printing them; e.g.,
                          '--block-size=M' prints sizes in units of
```


	1,048,576 bytes; see SIZE format below
-B, --ignore-backups	do not list implied entries ending with ~
-c	with -lt: sort by, and show, ctime (time of
last	modification of file status information);

- Check the following 2 commands, this is also sometimes possible ... weird hmmm

```

alem@mybuntu:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
default qlen 1000
    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: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state
UP group default qlen 1000
    link/ether 08:00:27:70:92:6f brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic enp0s3
        valid_lft 83938sec preferred_lft 83938sec
    inet6 fe80::a00:27ff:fe70:926f/64 scope link
        valid_lft forever preferred_lft forever

```

```

alem@mybuntu:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
default qlen 1000
    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: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state
UP group default qlen 1000
    link/ether 08:00:27:70:92:6f brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic enp0s3
        valid_lft 83934sec preferred_lft 83934sec
    inet6 fe80::a00:27ff:fe70:926f/64 scope link
        valid_lft forever preferred_lft forever

```

- try the ls command with the following arguments/options and notice the differences in the outputs

```

alem@mybuntu:~$ ls -l
total 104
-rw-rw-r-- 1 alem alem    0 Jul 11 04:50 file1
-rw-rw-r-- 1 alem alem  7747 Jul 11 05:09 file2
-rw-rw-r-- 1 alem alem 96348 Jul 11 05:09 file3
alem@mybuntu:~$ ls -lh
total 104K
-rw-rw-r-- 1 alem alem    0 Jul 11 04:50 file1
-rw-rw-r-- 1 alem alem  7.6K Jul 11 05:09 file2
-rw-rw-r-- 1 alem alem  95K Jul 11 05:09 file3
alem@mybuntu:~$ ls -lht
total 104K
-rw-rw-r-- 1 alem alem  95K Jul 11 05:09 file3
-rw-rw-r-- 1 alem alem  7.6K Jul 11 05:09 file2
-rw-rw-r-- 1 alem alem    0 Jul 11 04:50 file1
alem@mybuntu:~$ ls -lht
total 104K
-rw-rw-r-- 1 alem alem    0 Jul 11 04:50 file1
-rw-rw-r-- 1 alem alem  7.6K Jul 11 05:09 file2
-rw-rw-r-- 1 alem alem  95K Jul 11 05:09 file3
alem@mybuntu:~$

```

- run the above commands against a different directory - this lets you see the contents of that particular directory from wherever you are in the filesystem.
- Where are you in the filesystem ?

```

alem@mybuntu:~$ pwd
/home/alem
alem@mybuntu:~$

```

- System Administrators are generally lazy, Lazy is Smart ?
 - autocomplete : you can start typing the initial few letters of the command and hit TAB on the keyboard for autocompletion
 - shortcut: type cd from anywhere in the filesystem, it will drop you back in your home directory
 - check history command
 - Run !<history#>

- up and down arrow keys
- What are special characters (regular expressions) in bash?
http://tldp.org/LDP/Bash-Beginners-Guide/html/sect_03_03.html

Part 8 : Navigating the Linux File System

- move around the directory tree : cd (change directory)
- present(current) working directory : pwd
- create a new directory : mkdir
- copy files : cp
- delete files : rm (rm -rf /)
- move files to a different directory: mv
- what is "." vs ".." files ?
- Remove directory : rmdir

Searching the Linux File System

- an average linux server has millions of files - searching file a single file visually is not doable ... how do we search for files ?
 - quickest method : use the locate command

```

alem@mybuntu:~$ locate dhclient
/etc/apparmor/init/network-interface-security/sbin.dhclient
/etc/apparmor.d/sbin.dhclient
/etc/apparmor.d/cache/sbin.dhclient
/etc/apparmor.d/local/sbin.dhclient
/etc/dhcp/dhclient-enter-hooks.d
/etc/dhcp/dhclient-exit-hooks.d
/etc/dhcp/dhclient.conf
/etc/dhcp/dhclient-enter-hooks.d/debug
/etc/dhcp/dhclient-enter-hooks.d/resolved
/etc/dhcp/dhclient-exit-hooks.d/debug

```

- A more sophisticated file search tool : find

```

alem@mybuntu:~$ sudo find /etc -name passwd*
/etc/passwd
/etc/pam.d/passwd
/etc/passwd-
/etc/cron.daily/passwd

```

```
alem@mybuntu:~$
```

Text manipulation and processing

- string content pattern matching - grep
- filtering outputs by chaining commands - pipe "|"
- directing the output of a command to be saved in a file rather than dumping on the screen (stdout) - redirecting ">" , "<"
- redirecting : overwrite ">" vs append ">>"

```
alem@mybuntu:~$ cat /etc/passwd | grep bash
root:x:0:0:root:/root:/bin/bash
alem:x:1000:1000:Alem Abreha:/home/alem:/bin/bash
alem@mybuntu:~$
```

```
alem@mybuntu:~$ cat /etc/passwd | grep bash > bash_users.txt
alem@mybuntu:~$ ls
bash_users.txt  file1  file2  file3  scripts
alem@mybuntu:~$ cat bash_users.txt
root:x:0:0:root:/root:/bin/bash
alem:x:1000:1000:Alem Abreha:/home/alem:/bin/bash
alem@mybuntu:~$
```

- what happens if we run the above command again?
- now we are requested for a list of users that are given bash shell access, how do we get only the list of usernames getting rid off the other information in the bash_users.txt file ?

```
alem@mybuntu:~$ cut -d: -f1 bash_users.txt
root
alem
alem@mybuntu:~$
```

- Practice : Do some text processing on a log file

Standard Streams

- What are standard streams?
 - They are input/output communication channels :
https://en.wikipedia.org/wiki/Standard_streams

- Standard Input , stdin, 0
- Standard Output, stdout, 1
- Standard Error, stderr, 2

```

alem@mybuntu:~$ curl http://gogolgg.comm
curl: (6) Could not resolve host: gogolgg.comm
alem@mybuntu:~$ curl http://gogolgg.comm 2>err
alem@mybuntu:~$ ls
bash_users.txt  err  file1  file2  file3  in  scripts
alem@mybuntu:~$ cat err
curl: (6) Could not resolve host: gogolgg.comm
alem@mybuntu:~$

```

File Archives

- archiving and compression makes data transport efficient
- archiving in linux is done using tar
- usually tar files are also compressed : *.tar.gz , *.tgz
- archiving syntax

```
tar czvf <somenewfile.tar.gz> <directory_to_be_archived>
```

- Un-archiving syntax

```
tar xzvf <some.tar.gz>
```

- gzip compresses the archive to save disk space ? Find out the compression factor by comparing a compressed vs non-compressed archive.
Read : https://en.wikipedia.org/wiki/Data_compression_ratio
<https://www.rootusers.com/gzip-vs-bzip2-vs-xz-performance-comparison/>
- another tool to archive and compress : zip

Part 9 : Managing System Hardware

- All mounted filesystems

```

root@mybuntu:~# df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            463M     0  463M   0% /dev
tmpfs           99M   952K   98M   1% /run

```

```

/dev/sda2      26G  3.9G   21G  16% /
tmpfs          493M    0  493M   0% /dev/shm
tmpfs          5.0M    0   5.0M   0% /run/lock
tmpfs          493M    0  493M   0% /sys/fs/cgroup
/dev/loop0     91M   91M    0 100% /snap/core/6350
/dev/loop1     98M   98M    0 100% /snap/docker/384
tmpfs          99M    0   99M   0% /run/user/1000
root@mybuntu:~#

```

- What filesystems (ext4 format) from what devices are currently mounted ?

```

root@mybuntu:~# df -ht ext4
Filesystem      Size  Used Avail Use% Mounted on
/dev/sda2       26G   3.9G   21G  16% /
root@mybuntu:~#

```

- If there is a drive attached to our system but we haven't created a filesystem on it and it's not mounted yet, we can list all block devices that are attached to our system

```

root@mybuntu:~# lsblk
NAME MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
loop0  7:0    0    91M  1 loop /snap/core/6350
loop1  7:1    0   97.4M  1 loop /snap/docker/384
sda     8:0    0  26.3G  0 disk
├─sda1   8:1    0    1M  0 part
└─sda2   8:2    0  26.3G  0 part /
sr0     11:0    1 1024M  0 rom
root@mybuntu:~# lsblk --help

```

NOTE: Most commands accept --help flag for usage information

- dmesg - display kernel ring buffer : important messages generated by the kernel
- Comprehensive review of hardware on the system

```

root@mybuntu:~# lshw | less
mybuntu
  description: Computer
  product: VirtualBox
  vendor: innotek GmbH
  version: 1.2
  serial: 0

```

```

width: 64 bits
capabilities: smbios-2.5 dmi-2.5 vsyscall32
configuration: family=Virtual Machine
uuid=8E55509A-F37E-4E76-9AD7-294216C60C96
*-core
  description: Motherboard
  product: VirtualBox
  vendor: Oracle Corporation
  physical id: 0
  version: 1.2
  serial: 0
*-firmware
  description: BIOS
  vendor: innotek GmbH
  physical id: 0
  version: VirtualBox
  date: 12/01/2006
  size: 128KiB
  capabilities: isa pci cdboot bootselect int9keyboard int10video
acpi
*-memory
  description: System memory
  physical id: 1
  size: 985MiB
*-cpu
  product: Intel(R) Core(TM) i7-4750HQ CPU @ 2.00GHz
  vendor: Intel Corp.
  physical id: 2
  bus info: cpu@0
  width: 64 bits
  capabilities: fpu fpu_exception wp vme de pse tsc msr pae mce cx8
apic sep mtrr pge mca cmov pat pse36 clflush mmx fxsr sse sse2 ht syscall
nx rdtscp x86-64 constant_tsc rep_good nopl xtopology nonstop_tsc cpuid
tsc_known_freq pni pclmulqdq monitor ssse3 cx16 pcid sse4_1
(... truncated ...)

```

Part 10 : Working with Linux Kernel Modules

- What are Kernel Modules ?
 - pieces of code that can be loaded and unloaded into the kernel upon demand.
- Why ?

- They extend the functionality of the kernel without the need to reboot the system.
- Scenario : Troubleshooting a peripheral if the device not recognized by the system
 - First thing to check : is the appropriate kernel module loaded ?
 - Connected usb devices: lsusb command

```
alem@mybuntu:~$ lsusb
Bus 001 Device 001: ID 1d6b:0001 Linux Foundation 1.1 root hub
alem@mybuntu:~$
```

- pci slot connected devices - lspci

```
alem@mybuntu:~$ lspci
00:00.0 Host bridge: Intel Corporation 440FX - 82441FX PMC [Natoma] (rev 02)
00:01.0 ISA bridge: Intel Corporation 82371SB PIIX3 ISA [Natoma/Triton II]
00:01.1 IDE interface: Intel Corporation 82371AB/EB/MB PIIX4 IDE (rev 01)
00:02.0 VGA compatible controller: VMware SVGA II Adapter
00:03.0 Ethernet controller: Intel Corporation 82540EM Gigabit Ethernet Controller (rev 02)
00:04.0 System peripheral: InnoTek Systemberatung GmbH VirtualBox Guest Service
00:05.0 Multimedia audio controller: Intel Corporation 82801AA AC'97 Audio Controller (rev 01)
00:06.0 USB controller: Apple Inc. KeyLargo/Intrepid USB
00:07.0 Bridge: Intel Corporation 82371AB/EB/MB PIIX4 ACPI (rev 08)
00:0d.0 SATA controller: Intel Corporation 82801HM/HEM (ICH8M/ICH8M-E) SATA Controller [AHCI mode] (rev 02)
alem@mybuntu:~$
```

- every hardware : lshw
- If the hardware you are expecting to see is missing from the list of hw/peripherals , chances are you are missing a suitable kernel module
- kernel modules are located on disk :/lib/modules
- For example sound kernel module is under :

```
alem@mybuntu:~$ ls /lib/modules/4.15.0-54-generic/kernel/sound
ac97_bus.ko  core  drivers  firewire  hda  i2c  isa  pci  pcmcia  soc
soundcore.ko  synth  usb  x86
alem@mybuntu:~$
```


- To check if the sound kernel module is loaded currently

```
alem@mybuntu:~$ lsmod | grep sound
soundcore                16384  1 snd
alem@mybuntu:~$
```

- In this case the kernel module for sound "soundcore" is loaded into kernel, but if it were not , here is how you load the module into kernel

```
alem@mybuntu:~$ sudo modprobe soundcore
```

Part 11 : Linux Software Repositories

- Convenient way to download software
- Managing Dependencies
- Software Update and Security (Somewhat Trusted Source)
- Based on Distribution families

DISTRIBUTION	LOW-LEVEL TOOL	HIGH-LEVEL TOOL
Debian and derivatives	dpkg	apt-get / aptitude
CentOS	rpm	yum
openSUSE	rpm	zypper

Source: <https://www.tecmint.com/linux-package-management/>

Debian

- APT (.dpkg packages)
- <https://help.ubuntu.com/lts/serverguide/apt.htm>

RedHat(CentOS)

- YUM (.rpm packages), future plan is DNF
- <https://www.tecmint.com/20-linux-yum-yellowdog-updater-modified-commands-for-package-management/>

SUSE

- ZYpp
- <https://www.tecmint.com/linux-package-management/>

Arch Linux

- Pacman
- <https://wiki.archlinux.org/index.php/Pacman>

- How does your Linux know where to download software from ?

Let's look under the hood ...

- APT configuration lives under /etc/apt

```
root@mybuntu:/home/alem# cd /etc/apt/  
root@mybuntu:/etc/apt#
```

```
root@mybuntu:/etc/apt# less sources.list | grep -v ^#  
deb http://archive.ubuntu.com/ubuntu bionic main restricted  
  
deb http://archive.ubuntu.com/ubuntu bionic-updates main restricted  
  
deb http://archive.ubuntu.com/ubuntu bionic universe  
deb http://archive.ubuntu.com/ubuntu bionic-updates universe  
  
deb http://archive.ubuntu.com/ubuntu bionic multiverse  
deb http://archive.ubuntu.com/ubuntu bionic-updates multiverse  
  
deb http://archive.ubuntu.com/ubuntu bionic-backports main restricted  
universe multiverse  
  
deb http://archive.ubuntu.com/ubuntu bionic-security main restricted  
deb http://archive.ubuntu.com/ubuntu bionic-security universe  
deb http://archive.ubuntu.com/ubuntu bionic-security multiverse  
root@mybuntu:/etc/apt#
```

NOTE: Apt combines most commonly used functionalities from apt-get and apt-cache (unify)
<https://itsfoss.com/apt-vs-apt-get-difference/>

- Recommended : update local software index before you start installing packages

```
alem@mybuntu:~$ sudo apt update  
[sudo] password for alem:  
Hit:1 http://archive.ubuntu.com/ubuntu bionic InRelease  
Get:2 http://archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]  
Get:3 http://archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]  
Get:4 http://archive.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]  
Get:5 http://archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages  
[681 kB]  
Get:6 http://archive.ubuntu.com/ubuntu bionic-updates/main Translation-en
```

```

[251 kB]
Get:7 http://archive.ubuntu.com/ubuntu bionic-updates/universe amd64
Packages [969 kB]
Get:8 http://archive.ubuntu.com/ubuntu bionic-updates/universe
Translation-en [293 kB]
Get:9 http://archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64
Packages [6,640 B]
Get:10 http://archive.ubuntu.com/ubuntu bionic-security/main amd64 Packages
[450 kB]
Get:11 http://archive.ubuntu.com/ubuntu bionic-security/main Translation-en
[156 kB]
Get:12 http://archive.ubuntu.com/ubuntu bionic-security/multiverse amd64
Packages [4,008 B]
Fetched 3,062 kB in 2s (1,616 kB/s)
Reading package lists... Done
Building dependency tree
Reading state information... Done
89 packages can be upgraded. Run 'apt list --upgradable' to see them.
alem@mybuntu:~$

```

- Search for a software package

```

alem@mybuntu:~$ apt search video editing | less

WARNING: apt does not have a stable CLI interface. Use with caution in
scripts.

Sorting...
Full Text Search...
flowblade/bionic 1.12-1 all
  non-linear video editor

games-content-dev/bionic 2.2ubuntu2 all
  development of game content

gopchop/bionic 1.1.8-6 amd64
  fast, lossless cuts-only editor for MPEG2 video files

kdenlive/bionic 4:17.12.3-0ubuntu1 amd64
  non-linear video editor

```

```
kdenlive-data/bionic 4:17.12.3-0ubuntu1 all  
non-linear video editor (data files)
```

- Detailed information about a package

```
alem@mybuntu:~$ apt show kdenlive  
Package: kdenlive  
Version: 4:17.12.3-0ubuntu1  
Priority: optional  
Section: universe/graphics  
Origin: Ubuntu  
Maintainer: Debian/Kubuntu Qt/KDE Maintainers  
<debian-qt-kde@lists.debian.org>  
Original-Maintainer: Patrick Matthäi <pmatthaei@debian.org>  
Bugs: https://bugs.launchpad.net/ubuntu/+filebug  
Installed-Size: 6,759 kB  
Depends: breeze-icon-theme, ffmpeg, kded5, kdenlive-data (= 4:17.12.3-0ubuntu1), kinit, kio, melt, oxygen-icon-theme, qml-module-qtquick-controls, qml-module-qtquick2, libc6 (>= 2.15), libkf5archive5 (>= 4.96.0), libkf5bookmarks5 (>= 4.96.0), libkf5completion5 (>= 4.97.0), libkf5configcore5 (>= 4.98.0), libkf5configgui5 (>= 4.97.0), libkf5configwidgets5 (>= 5.26.0), libkf5coreaddons5 (>= 5.16.0), libkf5crash5 (>= 5.15.0), libkf5dbusaddons5 (>= 4.97.0), libkf5filemetadata3 (>= 5.0.2+git20140925), libkf5guiaddons5 (>= 4.96.0), libkf5i18n5 (>= 4.97.0), libkf5iconthemes5 (>= 5.25.0), libkf5itemviews5 (>= 4.96.0), libkf5jobwidgets5 (>= 4.96.0), libkf5kiocore5 (>= 4.96.0), libkf5kiofilewidgets5 (>= 4.96.0), libkf5kiowidgets5 (>= 5.33.0), libkf5newstuff5 (>= 4.95.0), libkf5notifications5 (>= 5.30.0), libkf5notifyconfig5 (>= 4.96.0), libkf5service-bin, libkf5service5 (>= 4.96.0), libkf5textwidgets5 (>= 5.0.0), libkf5widgetsaddons5 (>= 4.96.0), libkf5xmlgui-bin, libkf5xmlgui5 (>= 4.98.0), libmlt++3 (>= 6.6.0), libmlt6 (>= 6.6.0), libqt5core5a (>= 5.9.0~beta), libqt5dbus5 (>= 5.0.2), libqt5gui5 (>= 5.8.0), libqt5network5 (>= 5.0.2), libqt5qml5 (>= 5.0.2), libqt5quick5 (>= 5.6.1), libqt5svg5 (>= 5.6.0~beta), libqt5webkit5 (>= 5.6.0~rc), libqt5widgets5 (>= 5.7.0), libqt5xml5 (>= 5.0.2), libstdc++6 (>= 5.2)  
Recommends: dvdauthor, dvgrab, frei0r-plugins, genisoimage, recordmydesktop, swf-plugins  
Suggests: khelpcenter  
Homepage: http://www.kdenlive.org/  
Task: ubuntustudio-video  
Supported: 3y
```

```
Download-Size: 1,776 kB
APT-Sources: http://archive.ubuntu.com/ubuntu bionic/universe amd64
Packages
Description: non-linear video editor
Kdenlive is a non-linear video editing suite, which supports DV, HDV and
many
more formats.
Its main features are:
* Guides and marker for organizing timelines
* Copy and paste support for clips, effects and transitions
* Real time changes
* FireWire and Video4Linux capture
* Screen grabbing
* Exporting to any by FFmpeg supported format

alem@mybuntu:~$
```

- Installing the software

```
alem@mybuntu:~$ sudo apt install kdenlive
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  adwaita-icon-theme aspell aspell-en at-spi2-core avahi-daemon
  breeze-icon-theme catdoc cpp cpp-7 dconf-gsettings-backend dconf-service
  dictionaries-common dvdauthor dvgrab emacs-common ffmpeg
  (...truncated ...)
```

- Practice installing software packages. Example: Libreoffice - free office suite, Linux desktop options : Cinnamon/Mate , Gnome, KDE, xfce (But hey ... we are not interested in GUI for this bootcamp ...)

Snapcraft

- A snap is a bundle of your app and its dependencies that works without modification across many different Linux distributions.
- <https://snapcraft.io/docs/getting-started>

Part 12 : Linux Networking

- the whole purpose of learning linux is to connect your machine to the internet and do some magic ... today if a machine is not connected to the internet it's useless ... what good will it do ?
- your machine needs to connect reliably with a unique IP address

Let's take a close look how Networking in Linux works ...

Network Route

- How does your linux know how to connect to the network ?
 - network route

```
alem@mybuntu:~$ ip route show
default via 10.0.2.2 dev enp0s3 proto dhcp src 10.0.2.15 metric 100
10.0.2.0/24 dev enp0s3 proto kernel scope link src 10.0.2.15
10.0.2.2 dev enp0s3 proto dhcp scope link src 10.0.2.15 metric 100
10.220.124.0/24 dev lxdbr0 proto kernel scope link src 10.220.124.1
172.17.0.0/16 dev docker0 proto kernel scope link src 172.17.0.1 linkdown
alem@mybuntu:~$
```

- Is there a DHCP server on the network that is leasing our network connection setup ?

```
alem@mybuntu:~$ sudo dhclient
RTNETLINK answers: File exists
alem@mybuntu:~$
```

- What is your machine's IP address ?

```
alem@mybuntu:~$ ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
default qlen 1000
    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: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state
UP group default qlen 1000
    link/ether 08:00:27:70:92:6f brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic enp0s3
        valid_lft 83737sec preferred_lft 83737sec
    inet6 fe80::a00:27ff:fe70:926f/64 scope link
        valid_lft forever preferred_lft forever
3: docker0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue
state DOWN group default
    link/ether 02:42:7e:f7:f1:71 brd ff:ff:ff:ff:ff:ff
    inet 172.17.0.1/16 brd 172.17.255.255 scope global docker0
        valid_lft forever preferred_lft forever
4: lxdbr0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
UP group default qlen 1000
    link/ether fe:72:93:2e:90:a3 brd ff:ff:ff:ff:ff:ff
    inet 10.220.124.1/24 scope global lxdbr0
        valid_lft forever preferred_lft forever
    inet6 fd42:6b02:b6f3:d5d9::1/64 scope global
        valid_lft forever preferred_lft forever
    inet6 fe80::d8f0:c4ff:fe4e:c043/64 scope link
        valid_lft forever preferred_lft forever
6: vethGDQIAA@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
master lxdbr0 state UP group default qlen 1000
    link/ether fe:72:93:2e:90:a3 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet6 fe80::fc72:93ff:fe2e:90a3/64 scope link
        valid_lft forever preferred_lft forever
alem@mybuntu:~$

```

IP Address

- What is loopback interface ? What is it used for ?
 - Virtual (logical) interface
 - To test if a host can talk to itself
 - To check TCP/IP network stack health
- IPV4 vs IPV6 ? 32bit -> 128bits
 - Read more : https://www.tutorialspoint.com/ipv4/ipv4_addressing
- older versions of "ip route show" and "ip addr" commands are still available

```

alem@mybuntu:~$ route

```


Kernel IP routing table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use
Iface						
default	_gateway	0.0.0.0	UG	0	0	0
enp0s3						
default	_gateway	0.0.0.0	UG	100	0	0
enp0s3						
10.0.2.0	0.0.0.0	255.255.255.0	U	0	0	0
enp0s3						
_gateway	0.0.0.0	255.255.255.255	UH	100	0	0
enp0s3						
10.220.124.0	0.0.0.0	255.255.255.0	U	0	0	0
lxdbr0						
172.17.0.0	0.0.0.0	255.255.0.0	U	0	0	0
docker0						

alem@mybuntu:~\$ ifconfig

```
docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
    ether 02:42:7e:f7:f1:71 txqueuelen 0 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

```
enp0s3: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 10.0.2.15 netmask 255.255.255.0 broadcast 10.0.2.255
    inet6 fe80::a00:27ff:fe70:926f prefixlen 64 scopeid 0x20<link>
    ether 08:00:27:70:92:6f txqueuelen 1000 (Ethernet)
    RX packets 259498 bytes 264612018 (264.6 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 174059 bytes 319902671 (319.9 MB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

```
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 20494 bytes 183427720 (183.4 MB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 20494 bytes 183427720 (183.4 MB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```

- Network connection information : netstat
 - View network interface along with usage statistics

```

alem@mybuntu:~$ netstat -i
Kernel Interface table
Iface      MTU      RX-OK RX-ERR RX-DRP RX-OVR      TX-OK TX-ERR TX-DRP TX-OVR
Flg
docker0    1500      0      0      0 0          0      0      0      0
BMU
enp0s3     1500    259570      0      0 0    174116      0      0      0
BMRU
lo         65536    20498      0      0 0    20498      0      0      0
LRU
lxdbr0     1500     3373      0      0 0     5178      0      0      0
BMRU
vethGDQI   1500     3373      0      0 0     5225      0      0      0
BMRU
alem@mybuntu:~$

```

- list all open and listening ports

```

alem@mybuntu:~$ netstat -l
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp      0      0 localhost:domain        0.0.0.0:*               LISTEN
tcp      0      0 mybuntu:domain          0.0.0.0:*               LISTEN
tcp      0      0 0.0.0.0:ssh             0.0.0.0:*               LISTEN
tcp6     0      0 mybuntu:domain          [::]:*                  LISTEN
tcp6     0      0 mybuntu:domain          [::]:*                  LISTEN
tcp6     0      0 [::]:ssh                [::]:*                  LISTEN
udp      0      0 localhost:domain        0.0.0.0:*               LISTEN
udp      0      0 mybuntu:domain          0.0.0.0:*               LISTEN
udp      0      0 0.0.0.0:bootps          0.0.0.0:*               LISTEN
udp      0      0 0.0.0.0:bootpc          0.0.0.0:*               LISTEN
udp      0      0 mybuntu:bootpc          0.0.0.0:*               LISTEN
udp6     0      0 [::]:dhcpv6-server      [::]:*                  LISTEN
udp6     0      0 mybuntu:domain          [::]:*                  LISTEN
udp6     0      0 mybuntu:domain          [::]:*                  LISTEN
raw6     0      0 [::]:ipv6-icmp          [::]:*                  7
raw6     0      0 [::]:ipv6-icmp          [::]:*                  7

Active UNIX domain sockets (only servers)
Proto RefCnt Flags               Type               State             I-Node   Path
unix    2      [ ACC ]               STREAM             LISTENING         25872    /

```

```

/var/lib/lxd/devlxd/sock
unix 2      [ ACC ]     SEQPACKET  LISTENING     13585
/run/udev/control
unix 2      [ ACC ]     STREAM     LISTENING     21773
/run/user/1000/systemd/private
unix 2      [ ACC ]     STREAM     LISTENING     21777
/run/user/1000/gnupg/S.gpg-agent.browser
unix 2      [ ACC ]     STREAM     LISTENING     21778
/run/user/1000/gnupg/S.gpg-agent.ssh
unix 2      [ ACC ]     STREAM     LISTENING     21779
/run/user/1000/gnupg/S.gpg-agent.extra
unix 2      [ ACC ]     STREAM     LISTENING     21780
/run/user/1000/gnupg/S.gpg-agent
unix 2      [ ACC ]     STREAM     LISTENING     21781
/run/user/1000/gnupg/S.dirmngr

```

- TIP: Also check "ss -i" command - another utility to investigate sockets
- what are sockets ?
 - IP Address + Port Number
- TCP Vs UDP
 - TCP : is for connection oriented applications. It has built in error checking and will re-transmit missing packets. What TCP applications do you know?
 - UDP : is for connection less applications. It has no built in error checking and will not re transmit missing packets. What UDP applications do you know?
- Check Network Services and Ports
 - /etc/services
 - <http://www.iana.org/assignments/port-numbers>

Domain Name System (DNS) Configuration

- Computers are just fine identifying one another by IP over the network, but humans can't keep up with numbers like computers ? How many phone numbers do you know by heart ?
- Have you ever memorized a single IPv6 address ? :)
- DNS service maps numeric IP addresses to human readable names
- IP address to hostname mapping records are kept in databases
- Servers running these databases are performing the task of translating human readable names to IP address that computers understand are called DNS servers.
- Root DNS servers : <https://www.iana.org/domains/root/servers>
- Find out if you have a DNS server configured and have access ?
 - Just open a browser and go to www.google.com ? How did your computer figure out where the google servers are ?

- Run a DNS record lookup from the command line and find IP addresses for `www.google.com`

```
alem@mybuntu:~$ host www.google.com
www.google.com has address 172.217.12.4
www.google.com has IPv6 address 2607:f8b0:400f:801::2004
alem@mybuntu:~$
```

- Check network connectivity to an IP address - ping - send small data continuously and expect and echo back

```
alem@mybuntu:~$ ping 172.27.2.10
PING 172.27.2.10 (172.27.2.10) 56(84) bytes of data.
64 bytes from 172.27.2.10: icmp_seq=1 ttl=63 time=1.88 ms
64 bytes from 172.27.2.10: icmp_seq=2 ttl=63 time=1.94 ms
64 bytes from 172.27.2.10: icmp_seq=3 ttl=63 time=2.64 ms
64 bytes from 172.27.2.10: icmp_seq=4 ttl=63 time=2.06 ms
^C
--- 172.27.2.10 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3006ms
rtt min/avg/max/mdev = 1.888/2.136/2.644/0.301 ms
alem@mybuntu:~$
```

- If you are able to ping an IP address but not the hostname, its an indication of DNS configuration issue ?
- Some Linux distributions manage DNS server configuration in `/etc/resolv.conf` file
- In our case DNS configuration is managed by systemd as commented in `/etc/resolv.conf`

```
systemd-resolve --status
```

- You can also create your local record entry that will work along with DNS
 - `/etc/hosts`

```
alem@mybuntu:~$ cat /etc/hosts
127.0.0.1 localhost.localdomain localhost
::1 localhost6.localdomain6 localhost6

# The following lines are desirable for IPv6 capable hosts
::1 localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
ff02::3 ip6-allhosts
alem@mybuntu:~$
```

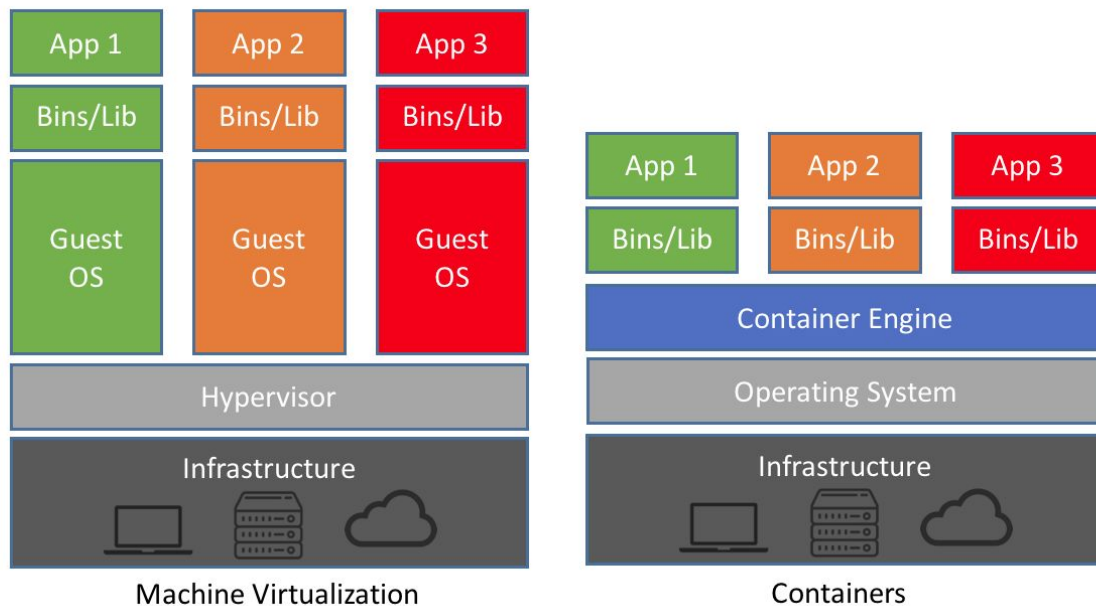
Remote Connections and SSH (Secure Shell)

- In my career as a systems engineer I have worked with thousands of linux servers at a time , these servers have always been geographically scattered across continents. As a matter of fact I have never physically seen any of them physically(in person), Remote access is vital to systems administration.
- why is remote access important ?
 - most servers are headless (like the VM you are using)
 - accessing VMs in the cloud: no physical ports available
 - accessing physically inaccessible (remote) servers or VMs in the cloud
- SSH provides encrypted communication
 - symmetric vs asymmetric encryption
 - public key <-> private key exchange
- Explain ssh session setup process ... ??
 - Read more :
<https://www.digitalocean.com/community/tutorials/understanding-the-ssh-encryption-on-and-connection-process>
- Installing ssh : Package is OpenSSH
 - Server : openssh-server
 - Client : openssh-client
- Configuration files
 - Server : /etc/ssh/sshd_config
 - Client : /etc/ssh/ssh_config
- Default Port : TCP 22 , you can of course use another port number (but remember to specify the port with -p option on the commandline when trying to connect)
- None default keypair
 - Key Generation : ssh-keygen
 - using private key : ssh -i
 - and ssh key exchange
- scp : transferring files between servers through SSH protocol

Part 13 : Linux Containers (LXC)

- Containers vs Virtual Machines
- containers provide a way to virtualize an OS, so that multiple workloads can run on a single OS instance.
- With VMs, the hardware is being virtualized to run multiple OS instances.

Article : <https://blog.netapp.com/blogs/containers-vs-vm/>



Source: <https://blog.netapp.com/blogs/containers-vs-vm/>

TL;DR VMs vs Containers

VMs => Share hardware

Containers => Share OS

Creating Containers

Everything you need to know : <https://linuxcontainers.org/>

- First install lxc via lxd

```
alem@mybuntu:~$ sudo apt-get install lxd
[sudo] password for alem:
Reading package lists... Done
Building dependency tree
Reading state information... Done
lxd is already the newest version (3.0.3-0ubuntu1~18.04.1).
0 upgraded, 0 newly installed
```

- Build and launch a centos 7 container

```
alem@mybuntu:~$ sudo lxc launch images:centos/7/amd64 centos7
If this is your first time running LXD on this machine, you should also
run: lxd init
To start your first container, try: lxc launch ubuntu:18.04

Creating centos7
Error: Failed container creation: No storage pool found. Please create a
new storage pool
alem@mybuntu:~$ lxd init
Would you like to use LXD clustering? (yes/no) [default=no]:
Do you want to configure a new storage pool? (yes/no) [default=yes]:
Name of the new storage pool [default=default]:
Name of the storage backend to use (btrfs, dir, lvm) [default=btrfs]:
Create a new BTRFS pool? (yes/no) [default=yes]:
Would you like to use an existing block device? (yes/no) [default=no]:
Size in GB of the new loop device (1GB minimum) [default=15GB]: 1GB
Would you like to connect to a MAAS server? (yes/no) [default=no]:
Would you like to create a new local network bridge? (yes/no)
[default=yes]:
What should the new bridge be called? [default=lxdbr0]:
What IPv4 address should be used? (CIDR subnet notation, "auto" or "none")
```

```
[default=auto]:
What IPv6 address should be used? (CIDR subnet notation, "auto" or "none")
[default=auto]:
Would you like LXD to be available over the network? (yes/no) [default=no]:
Would you like stale cached images to be updated automatically? (yes/no)
[default=yes]
Would you like a YAML "lxd init" preseed to be printed? (yes/no)
[default=no]: yes
config: {}
networks:
- config:
    ipv4.address: auto
    ipv6.address: auto
    description: ""
    managed: false
    name: lxdbr0
    type: ""
storage_pools:
- config:
    size: 1GB
    description: ""
    name: default
    driver: btrfs
profiles:
- config: {}
  description: ""
  devices:
    eth0:
      name: eth0
      nictype: bridged
      parent: lxdbr0
      type: nic
    root:
      path: /
      pool: default
      type: disk
  name: default
cluster: null
```

```
alem@mybuntu:~$ sudo lxc launch images:centos/7/amd64 centos7
```

```
Creating centos7
```

```
Starting centos7
```



```
alem@mybuntu:~$
```

- List of available container images : <https://us.images.linuxcontainers.org/>
- List containers

```
alem@mybuntu:~$ sudo lxc list
```

```
+-----+-----+-----+-----+
+-----+-----+-----+
|  NAME  |  STATE  |          IPV4          |          IPV6          |
|  TYPE  | SNAPSHOTS |                        |                        |
+-----+-----+-----+-----+
+-----+-----+-----+
| centos7 | RUNNING | 10.220.124.152 (eth0) | fd42:6b02:b6f3:d5d9:216:3eff:fe10:5be9 (eth0) | PERSISTENT | 0 |
+-----+-----+-----+-----+
+-----+-----+-----+
alem@mybuntu:~$
```

- To open a terminal session in a running container ...

```
alem@mybuntu:~$ sudo lxc exec centos7 /bin/bash
[root@centos7 ~]#
[root@centos7 ~]# hostname
centos7
[root@centos7 ~]#
```

Practice

- Install and configure apache web server on the centos7 container
- Install apache software package httpd

```
[root@centos7 ~]# yum install httpd
Failed to set locale, defaulting to C
Loaded plugins: fastestmirror
Loading mirror speeds from cached hostfile
* base: mirror.vcu.edu
* extras: mirror.vcu.edu
* updates: mirror.vcu.edu
Resolving Dependencies
```

```
--> Running transaction check
---> Package httpd.x86_64 0:2.4.6-89.el7.centos will be installed
--> Processing Dependency: httpd-tools = 2.4.6-89.el7.centos for package:
httpd-2.4.6-89.el7.centos.x86_64
--> Processing Dependency: system-logos >= 7.92.1-1 for package:
httpd-2.4.6-89.el7.centos.x86_64
--> Processing Dependency: /etc/mime.types for package:
httpd-2.4.6-89.el7.centos.x86_64
--> Processing Dependency: libaprutil-1.so.0()(64bit) for package:
httpd-2.4.6-89.el7.centos.x86_64
--> Processing Dependency: libapr-1.so.0()(64bit) for package:
httpd-2.4.6-89.el7.centos.x86_64
--> Running transaction check
```

- Start? and enable? the service via systemctl

```
[root@centos7 ~]# systemctl start httpd
[root@centos7 ~]#
```

```
[root@centos7 ~]# systemctl enable httpd
Created symlink from
/etc/systemd/system/multi-user.target.wants/httpd.service to
/usr/lib/systemd/system/httpd.service.
[root@centos7 ~]#
```

- What's our container's IP address ?

```
[root@centos7 ~]# ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
default qlen 1000
    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
5: eth0@if6: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
UP group default qlen 1000
    link/ether 00:16:3e:10:5b:e9 brd ff:ff:ff:ff:ff:ff link-netnsid 0
```

```

    inet 10.220.124.152/24 brd 10.220.124.255 scope global dynamic eth0
        valid_lft 3090sec preferred_lft 3090sec
    inet6 fd42:6b02:b6f3:d5d9:216:3eff:fe10:5be9/64 scope global mngtmpaddr
dynamic
        valid_lft 3151sec preferred_lft 3151sec
    inet6 fe80::216:3eff:fe10:5be9/64 scope link
        valid_lft forever preferred_lft forever
[root@centos7 ~]#

```

- Verify the web page is up by using a web browser
- First we need to install firefox on our VM

```

alem@mybuntu:~$ sudo apt install firefox -y
[sudo] password for alem:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  adwaita-icon-theme at-spi2-core dconf-gsettings-backend dconf-service
fontconfig fontconfig-config fonts-dejavu-core glib-networking
glib-networking-common glib-networking-services
gsettings-desktop-schemas gtk-update-icon-cache hicolor-icon-theme
humanity-icon-theme libasound2 libasound2-data libatk-bridge2.0-0
libatk1.0-0 libatk1.0-data libatspi2.0-0 libavahi-client3
libavahi-common-data libavahi-common3 libcairo-gobject2 libcairo2

```

- Enable X11 (graphics) forwarding to the host machine (the host computer you are working on), by opening another ssh session to the VM with -X flag

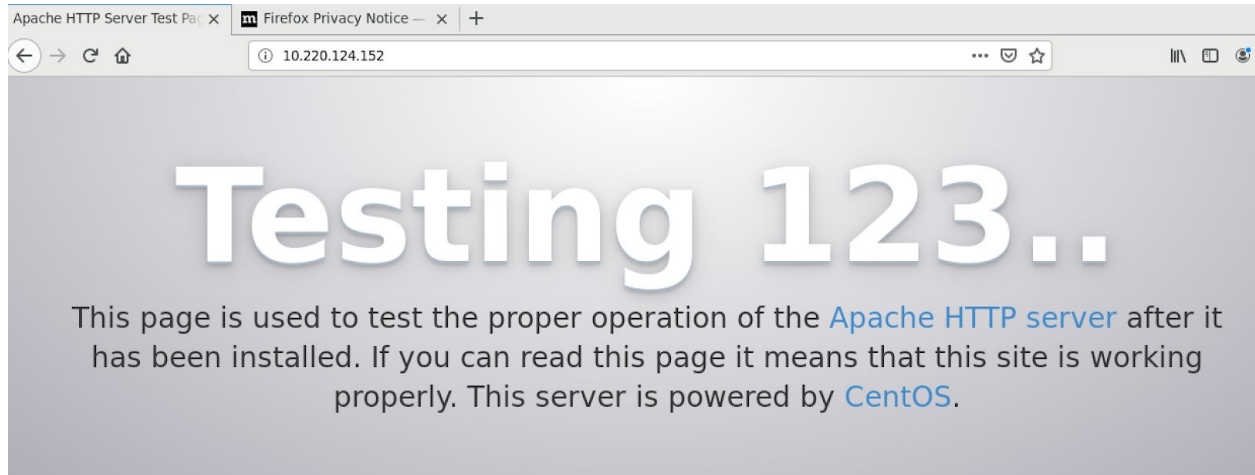
```

Alems-MacBook-Pro:~ alemabreha$ ssh -X alem@192.168.1.22
alem@mybuntu:~$ firefox

(firefox:4586): LIBDBUSMENU-GLIB-WARNING **: 03:53:37.860: Unable to get
session bus: Failed to execute child process "dbus-launch" (No such file or
directory)

```

- Start firefox and verify the apache server installed on the container



Just visiting?

The website you just visited is either experiencing problems or is undergoing routine maintenance.

If you would like to let the administrators of this website know that

Are you the Administrator?

You should add your website content to the directory `/var/www/html/`.

To prevent this page from ever being used, follow the instructions in the file `/etc/httpd/conf.d/welcome.conf`.

- What if we don't want to install firefox ? how do we check a web url from the command line ?

```
alem@mybuntu:~$ curl http://10.220.124.152
```

Part 14 : Linux Performance Monitoring and Troubleshooting

Part 15 : Bash Scripting Basics

References

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