Linux System Administration for DevOps Engineers

By Ritesh Kumar Singh

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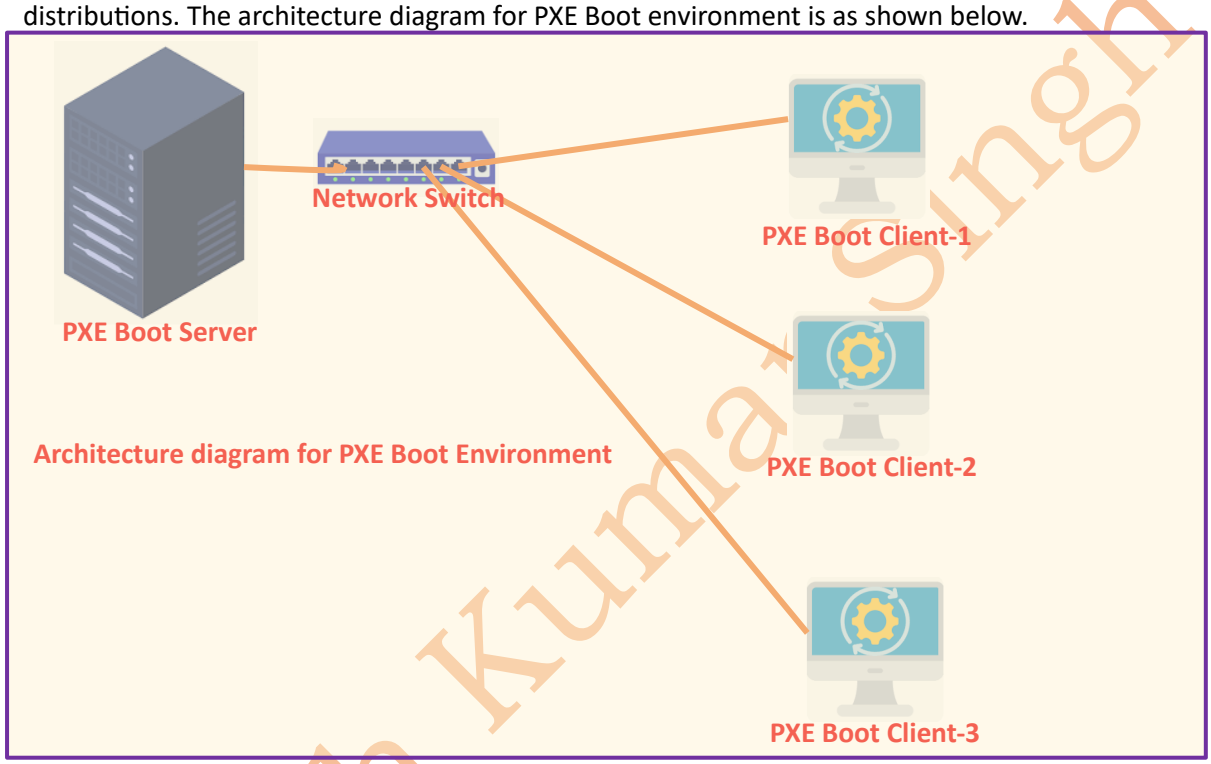
या कुन्देन्दुतुषारहारधवला या शुभ्रवस्त्रावृता
या वीणावरदण्डमण्डितकरा या श्वेतपद्मासना।
या ब्रह्माच्युत शंकरप्रभृतिभिर्देवैः सदा वन्दिता
सा मां पातु सरस्वती भगवती निःशेषजाड्यापहा ॥

Linux System Administration for DevOps Engineers

To natively install Linux on a machine in Organisations two methods usually followed **1. PXE (Preboot Execution Environment) Boot** or 2. Boot from a **USB Flash Drive (bootable/multi-boot pen drive)**.

1. PXE (Preboot Execution Environment) Boot

PXE Boot environment uses client-server model, there will be one PXE Boot Server (which assigns IP addresses using DHCP to the Client, TFTP Server transfer initial Boot Files bootloader and kernel and NFS Server to host the Linux Distribution Files). On PXE Client we need to Install the Linux distributions. The architecture diagram for PXE Boot environment is as shown below.



To configure PXE Boot Server I followed the steps as written below.

```
[root@pxe-boot-server ~]# 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: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether [redacted] brd [redacted]
    altname enp2s1
    inet 192.168.40.128/24 brd 192.168.40.255 scope global dynamic noprefixroute ens33
       valid_lft 1787sec preferred_lft 1787sec
    inet6 [redacted] scope link noprefixroute
       valid_lft forever preferred_lft forever
3: virbr0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN group default qlen 1000
    link/ether [redacted] brd [redacted]
    inet 192.168.122.1/24 brd 192.168.122.255 scope global virbr0
       valid_lft forever preferred_lft forever
```

```
[root@pxe-boot-server ~]# yum install -y dnsmasq syslinux tftp-server nfs-utils
```

```
Key imported successfully
Running transaction check
Transaction check succeeded.
Running transaction test
Transaction test succeeded.
Running transaction
  Preparing        :                                                                                                    1/1
  Running scriptlet: syslinux-nonlinux-6.04-6.el8.noarch                                                                1/1
  Installing       : syslinux-nonlinux-6.04-6.el8.noarch                                                                1/7
  Installing       : syslinux-6.04-6.el8.x86_64                                                                         2/7
  Running scriptlet: dnsmasq-2.79-35.el8_10.x86_64                                                                      3/7
  Upgrading        : dnsmasq-2.79-35.el8_10.x86_64                                                                      3/7
  Running scriptlet: dnsmasq-2.79-35.el8_10.x86_64                                                                      3/7
  Running scriptlet: nfs-utils-1:2.3.3-64.el8_10.x86_64                                                                 4/7
  Upgrading        : nfs-utils-1:2.3.3-64.el8_10.x86_64                                                                 4/7
  Running scriptlet: nfs-utils-1:2.3.3-64.el8_10.x86_64                                                                 4/7
  Installing       : tftp-server-5.2-27.el8.x86_64                                                                      5/7
  Running scriptlet: tftp-server-5.2-27.el8.x86_64                                                                      5/7
  Running scriptlet: dnsmasq-2.79-33.el8_10.x86_64                                                                      6/7
  Cleanup          : dnsmasq-2.79-33.el8_10.x86_64                                                                      6/7
  Running scriptlet: dnsmasq-2.79-33.el8_10.x86_64                                                                      6/7
  Running scriptlet: nfs-utils-1:2.3.3-59.el8.x86_64                                                                    7/7
  Cleanup          : nfs-utils-1:2.3.3-59.el8.x86_64                                                                    7/7
  Running scriptlet: nfs-utils-1:2.3.3-59.el8.x86_64                                                                    7/7
  Verifying        : syslinux-6.04-6.el8.x86_64                                                                         1/7
  Verifying        : syslinux-nonlinux-6.04-6.el8.noarch                                                                2/7
  Verifying        : tftp-server-5.2-27.el8.x86_64                                                                      3/7
  Verifying        : nfs-utils-1:2.3.3-64.el8_10.x86_64                                                                 4/7
  Verifying        : nfs-utils-1:2.3.3-59.el8.x86_64                                                                    5/7
  Verifying        : dnsmasq-2.79-35.el8_10.x86_64                                                                      6/7
  Verifying        : dnsmasq-2.79-33.el8_10.x86_64                                                                      7/7

Upgraded:
  dnsmasq-2.79-35.el8_10.x86_64                                  nfs-utils-1:2.3.3-64.el8_10.x86_64
Installed:
  syslinux-6.04-6.el8.x86_64          syslinux-nonlinux-6.04-6.el8.noarch          tftp-server-5.2-27.el8.x86_64

Complete!
```

```
[root@pxe-boot-server ~]# mv /etc/dnsmasq.conf /etc/dnsmasq.conf.bkp
```

```
[root@pxe-boot-server ~]# cat /etc/dnsmasq.conf
interface=ens33 # e.g., eth0, enp1s0
dhcp-range=192.168.40.150,192.168.40.250,12h
dhcp-option=3,192.168.40.1 # Gateway
dhcp-option=6,8.8.8.8,8.8.4.4 # DNS servers

# TFTP server configuration
enable-tftp
tftp-root=/var/lib/tftpboot

# PXE boot configuration
dhcp-boot=pxelinux.0
```

The **Syslinux PXE** bootloaders are installed under the path /usr/share/syslinux as shown in the screenshot attached below.

```
[root@pxe-boot-server ~]# ls /usr/share/syslinux/
altmbr.bin    cpu.c32       dmitest.c32   hdt.c32         isohdpfx_f.bin      lfs.c32       lua.c32       pcitest.c32   sanboot.c32     vesamenu.c32
altmbr_c.bin  cpuid.c32     dosutil       hexdump.c32     isohdppx.bin        libcom32.c32  mboot.c32     pmload.c32    sdi.c32         vpdtest.c32
altmbr_f.bin  cpuidtest.c32 elf.c32       host.c32        isohdppx_c.bin      libgpl.c32    mbr.bin       poweroff.c32  sysdump.c32     whichsys.c32
cat.c32       debug.c32     ethersel.c32  ifcpu.c32       isohdppx_f.bin      liblua.c32    mbr_c.bin     prdhcp.c32    syslinux.c32    zzjson.c32
chain.c32     dhcp.c32      gfxboot.c32   ifcpu64.c32     isolinux-debug.bin  libmenu.c32   mbr_f.bin     pwd.c32       syslinux.com
cmd.c32       diag          gptmbr.bin    ifmemdsk.c32    isolinux.bin        libutil.c32   memdisk       pxechn.c32    syslinux.exe
cmenu.c32     dir.c32       gptmbr_c.bin  ifplop.c32      kbdmap.c32          linux.c32     meminfo.c32   pxelinux.0    syslinux64.exe
config.c32    disk.c32      gptmbr_f.bin  isohdpfx.bin    kontron_wdt.c32     lpxelinux.0   menu.c32      reboot.c32    vesa.c32
cptime.c32    dmi.c32       gpxecmd.c32   isohdpfx_c.bin  ldlinux.c32         ls.c32        pci.c32       rosh.c32      vesainfo.c32
```

Copy all Syslinux bootloaders from /usr/share/syslinux/ to /var/lib/tftpboot as shown in the screenshot attached below.

```
[root@pxe-boot-server ~]# cp -r /usr/share/syslinux/* /var/lib/tftpboot/
```

The **PXE Server** reads its configuration from file pxelinux.cfg, which is found in the directory described in the tftp-root setting from the DNSMASQ configuration file above.

First, create a pxelinux.cfg directory and create a default file using the commands as written below

```
[root@pxe-boot-server ~]# mkdir /var/lib/tftpboot/pxelinux.cfg
[root@pxe-boot-server ~]# touch /var/lib/tftpboot/pxelinux.cfg/default
```

```
[root@pxe-boot-server ~]# cat /var/lib/tftpboot/pxelinux.cfg/default
default menu.c32
prompt 0
timeout 300
ONTIMEOUT local

menu title ########## PXE Boot Menu ##########

label 1
menu label ^1) Install Almalinux 8
kernel images/almalinux/vmlinuz
append initrd=images/almalinux/initrd.img inst.repo=nfs:nfsvers=4:192.168.40.128:/srv/nfs/almalinux/
```

```
[root@pxe-boot-server ~]# mkdir -p /srv/nfs/almalinux
```

```
[root@pxe-boot-server ~]# mount -o loop /root/AlmaLinux-8.10-x86_64-dvd.iso /mnt
mount: /mnt: WARNING: device write-protected, mounted read-only.
```

```
[root@pxe-boot-server ~]# rsync -avz /mnt/* /srv/nfs/almalinux/
```

```
[root@pxe-boot-server ~]# umount -l /mnt
```

```
[root@pxe-boot-server ~]# cat /etc/exports
/srv/nfs/almalinux 192.168.40.0/24(rw,sync,no_root_squash)
```

```
[root@pxe-boot-server ~]# exportfs -r
```

```
[root@pxe-boot-server ~]# systemctl restart nfs-server
[root@pxe-boot-server ~]# systemctl status nfs-server
● nfs-server.service - NFS server and services
   Loaded: loaded (/usr/lib/systemd/system/nfs-server.service; disabled; vendor preset: disabled)
   Active: active (exited) since Sun 2025-10-26 15:28:44 IST; 13s ago
  Process: 40080 ExecStart=/bin/sh -c if systemctl -q is-active gssproxy; then systemctl reload gssproxy ; fi (code=exited, status=0/SUCCESS)
  Process: 40066 ExecStart=/usr/sbin/rpc.nfsd (code=exited, status=0/SUCCESS)
  Process: 40064 ExecStartPre=/usr/sbin/exportfs -r (code=exited, status=0/SUCCESS)
 Main PID: 40080 (code=exited, status=0/SUCCESS)

Oct 26 15:28:44 pxe-boot-server systemd[1]: Starting NFS server and services...
Oct 26 15:28:44 pxe-boot-server systemd[1]: Started NFS server and services.
```

```
[root@pxe-boot-server ~]# umount -l /mnt
```

```
[root@pxe-boot-server ~]# mkdir -p /var/lib/tftpboot/images/almalinux
[root@pxe-boot-server ~]# cp /srv/nfs/almalinux/images/pxeboot/vmlinuz /var/lib/tftpboot/images/almalinux/
[root@pxe-boot-server ~]# cp /srv/nfs/almalinux/images/pxeboot/initrd.img /var/lib/tftpboot/images/almalinux/
[root@pxe-boot-server ~]# systemctl restart dnsmasq tftp
[root@pxe-boot-server ~]# systemctl enable dnsmasq tftp
```

```
[root@pxe-boot-server ~]# systemctl status dnsmasq tftp
● dnsmasq.service - DNS caching server.
   Loaded: loaded (/usr/lib/systemd/system/dnsmasq.service; enabled; vendor preset: disabled)
   Active: active (running) since Sun 2025-10-26 15:34:10 IST; 7s ago
 Main PID: 40199 (dnsmasq)
    Tasks: 1 (limit: 22873)
   Memory: 1.0M
   CGroup: /system.slice/dnsmasq.service
           └─40199 /usr/sbin/dnsmasq -k

Oct 26 15:34:10 pxe-boot-server systemd[1]: Started DNS caching server..
Oct 26 15:34:10 pxe-boot-server dnsmasq[40199]: started, version 2.79 cachesize 150
Oct 26 15:34:10 pxe-boot-server dnsmasq[40199]: compile time options: IPv6 GNU-getopt DBus no-i18n IDN2 DHCP DHCPv6 no-Lua TFTP no-conntrack ipset auth DNSSE>
Oct 26 15:34:10 pxe-boot-server dnsmasq-dhcp[40199]: DHCP, IP range 192.168.40.150 -- 192.168.40.250, lease time 12h
Oct 26 15:34:10 pxe-boot-server dnsmasq-tftp[40199]: TFTP root is /var/lib/tftpboot
Oct 26 15:34:10 pxe-boot-server dnsmasq[40199]: reading /etc/resolv.conf
Oct 26 15:34:10 pxe-boot-server dnsmasq[40199]: using nameserver 192.168.40.2#53
Oct 26 15:34:10 pxe-boot-server dnsmasq[40199]: read /etc/hosts - 2 addresses

● tftp.service - Tftp Server
   Loaded: loaded (/usr/lib/systemd/system/tftp.service; indirect; vendor preset: disabled)
   Active: active (running) since Sun 2025-10-26 15:34:10 IST; 7s ago
     Docs: man:in.tftpd
 Main PID: 40200 (in.tftpd)
    Tasks: 1 (limit: 22873)
   Memory: 184.0K
   CGroup: /system.slice/tftp.service
           └─40200 /usr/sbin/in.tftpd -s /var/lib/tftpboot

Oct 26 15:34:10 pxe-boot-server systemd[1]: Stopping Tftp Server...
Oct 26 15:34:10 pxe-boot-server systemd[1]: tftp.service: Succeeded.
Oct 26 15:34:10 pxe-boot-server systemd[1]: Stopped Tftp Server.
Oct 26 15:34:10 pxe-boot-server systemd[1]: Started Tftp Server.
```

```
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-service=dhcp
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-service=tftp
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-service=nfs
success
[root@pxe-boot-server ~]# firewall-cmd --reload
success
```

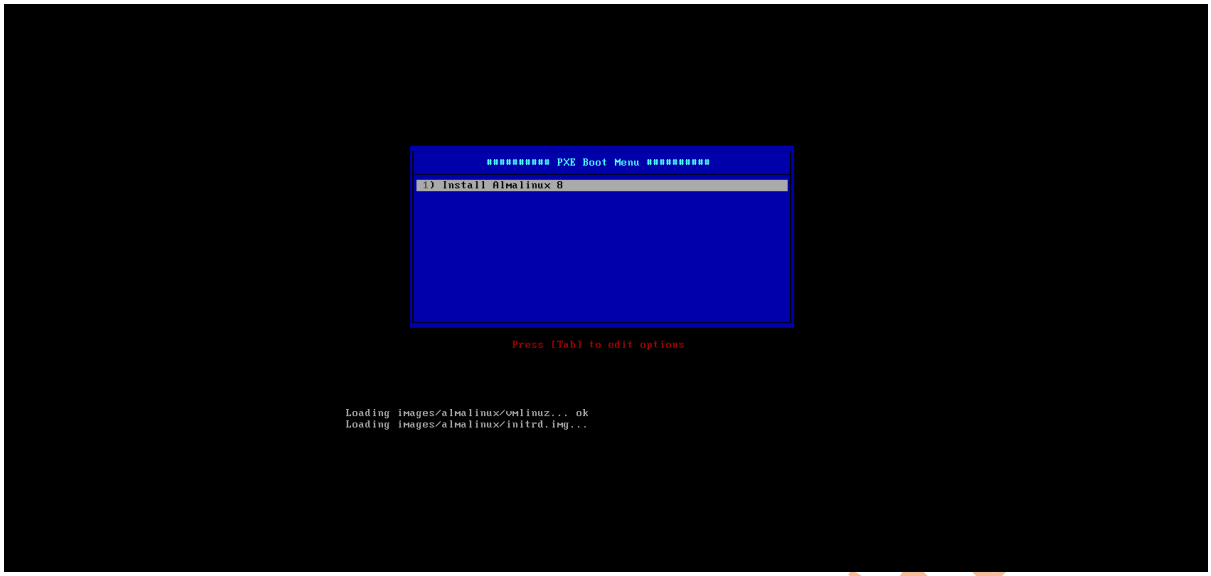
```
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-port=2049/tcp
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-port=2049/udp
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-port=111/tcp
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-port=111/udp
success
[root@pxe-boot-server ~]# firewall-cmd --reload
success
```

```
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-service=rpc-bind
success
[root@pxe-boot-server ~]# firewall-cmd --permanent --add-service=mountd
success
```

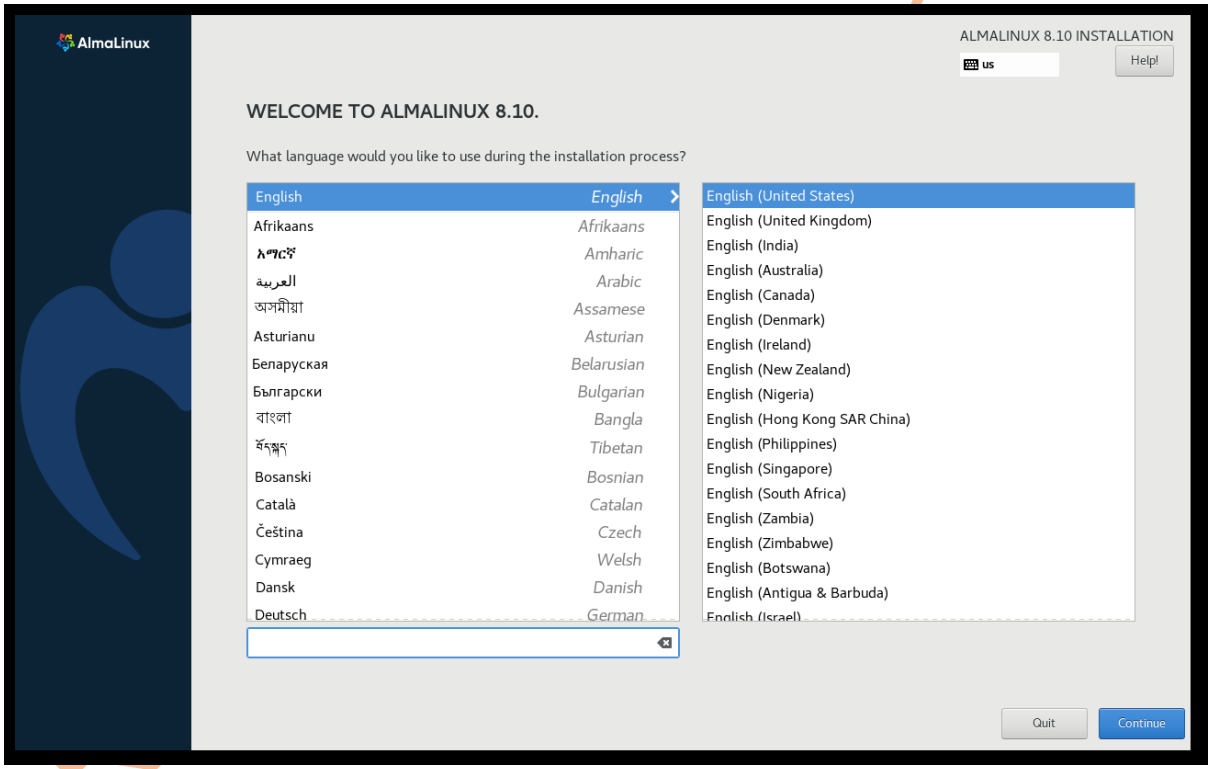
```
[root@pxe-boot-server ~]# firewall-cmd --reload
success
```

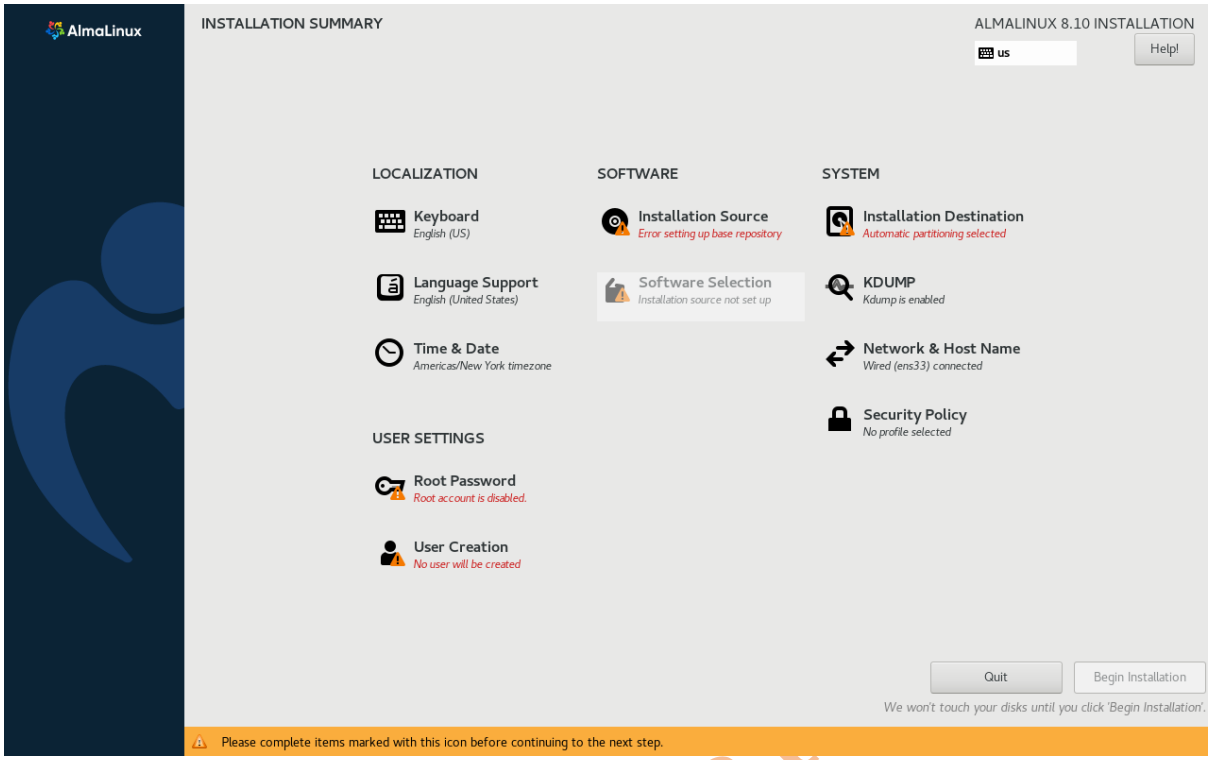
Here I considered the Linux Systems (PXE Boot Server and PXE Clients) are available in the network 192.168.40.0/24. Using below steps I shown how to install Linux Distros on PXE Client.

Power On the PXE Client (Systems where you want to install Linux OS) and press **esc** to bring the startup menu and repeatedly press the key **F12** (for Network Boot). If Network Boot Option is not showing in the startup menu, then you need to Enable it from the BIOS Option. Press F10 key for BIOS Option and enable the Network Boot. Then restart your system and press **F12** Key for Network Boot (PXE Boot).

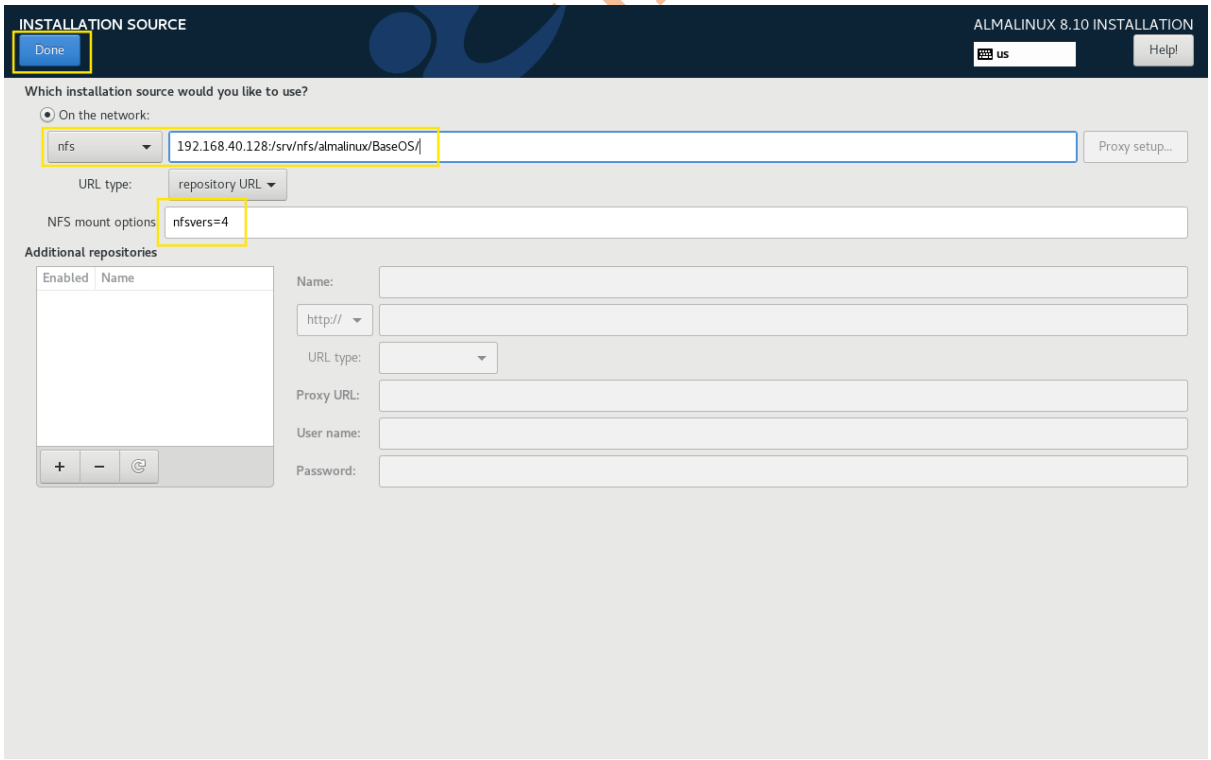


As shown in the screenshot attached below, installer had been started.

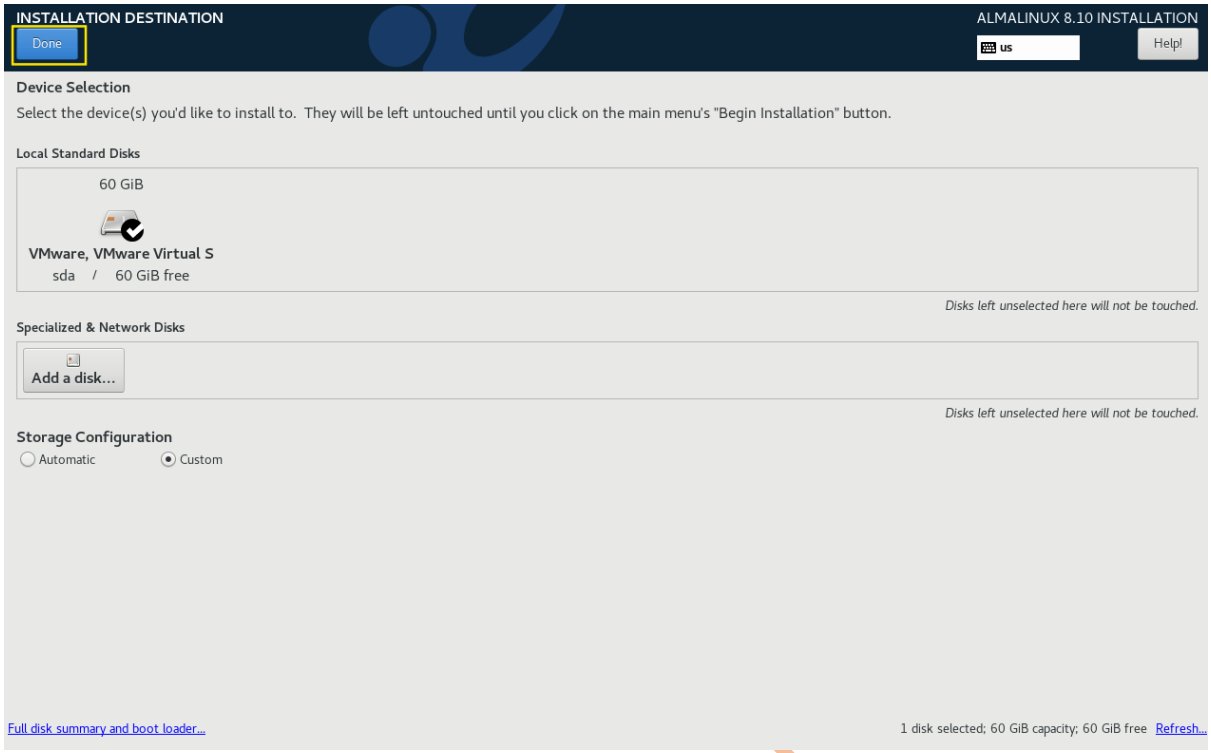


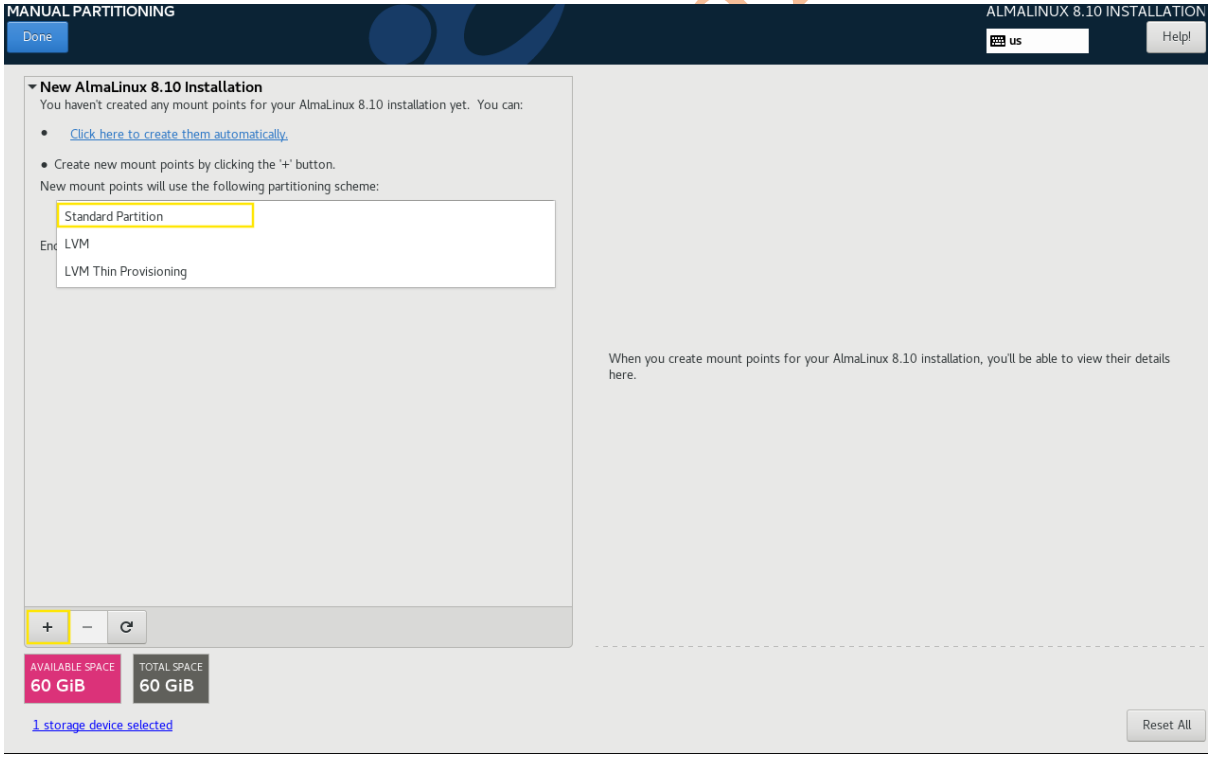


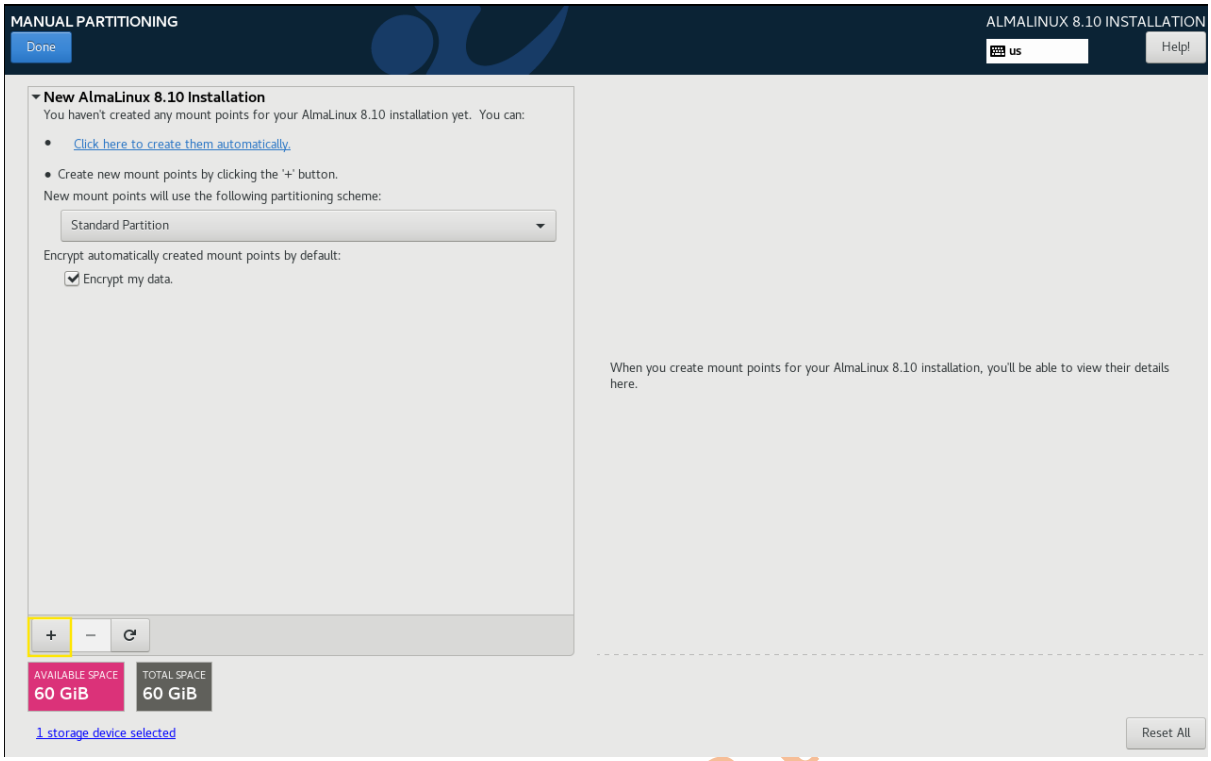
I had chosen the NFS URL as **192.168.40.128:/srv/nfs/almalinux/BaseOS/** as can be shown in the screenshot attached below. As I was interested to install Alma Linux 8 using NFS Share for Server Mode here.

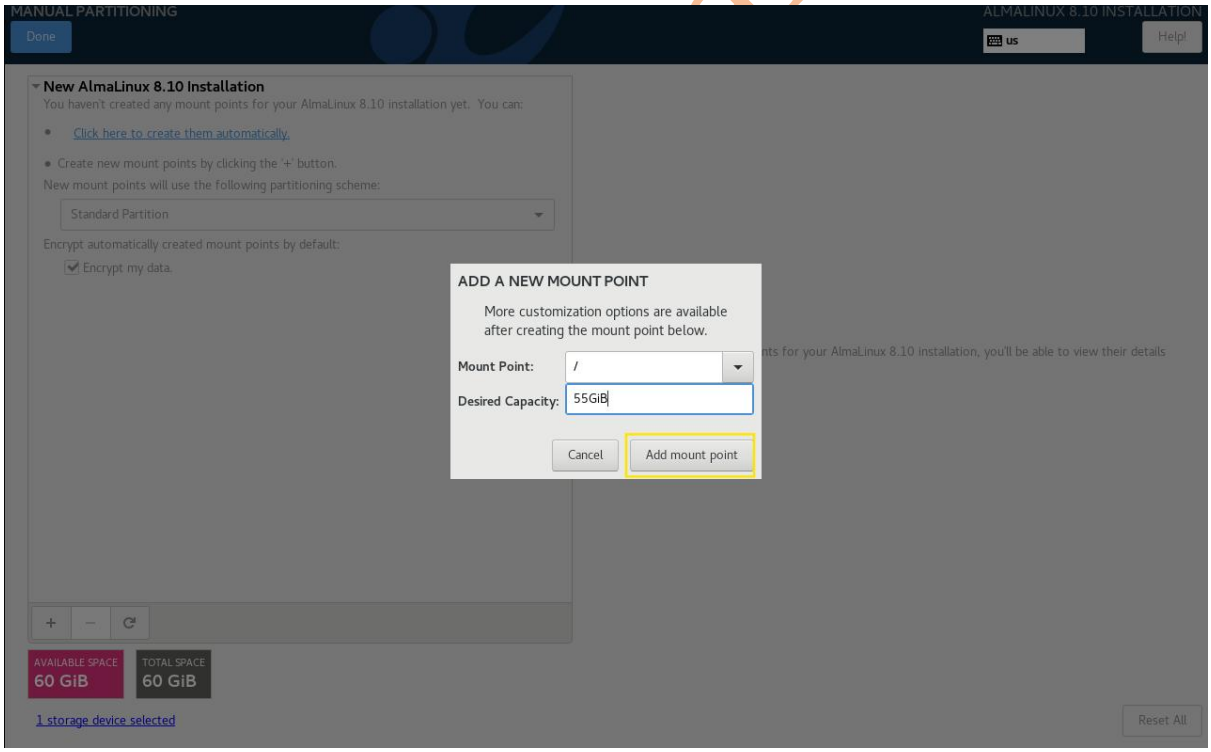


Ritesh Kumar Singh || Email Address: - riteshkumarsingh9559@gmail.com **|| LinkedIn: -** https://www.linkedin.com/in/ritesh-kumar-singh-41113128b/ **|| GitHub: -** https://github.com/singhritesh85


INSTALLATION DESTINATION
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
Device Selection
Select the device(s) you'd like to install to. They will be left untouched until you click on the main menu's "Begin Installation" button.
Local Standard Disks
60 GiB
VMware, VMware Virtual S
sda / 60 GiB free
Disks left unselected here will not be touched.
Specialized & Network Disks
Add a disk...
Disks left unselected here will not be touched.
Storage Configuration
Automatic
Custom
Full disk summary and boot loader...
1 disk selected; 60 GiB capacity; 60 GiB free
Refresh...


MANUAL PARTITIONING
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
New AlmaLinux 8.10 Installation
You haven't created any mount points for your AlmaLinux 8.10 installation yet. You can:
Click here to create them automatically.
Create new mount points by clicking the '+' button.
New mount points will use the following partitioning scheme:
Standard Partition
LVM
LVM Thin Provisioning
When you create mount points for your AlmaLinux 8.10 installation, you'll be able to view their details here.
AVAILABLE SPACE
60 GiB
TOTAL SPACE
60 GiB
1 storage device selected
Reset All





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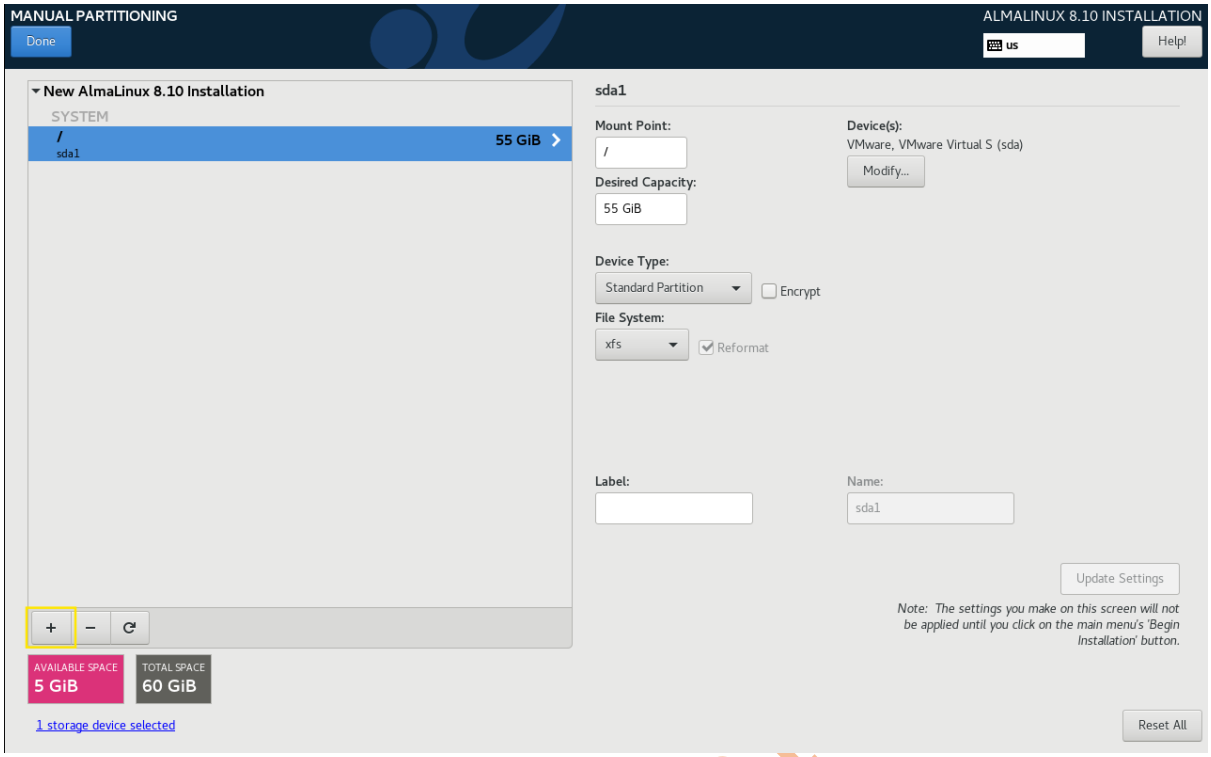
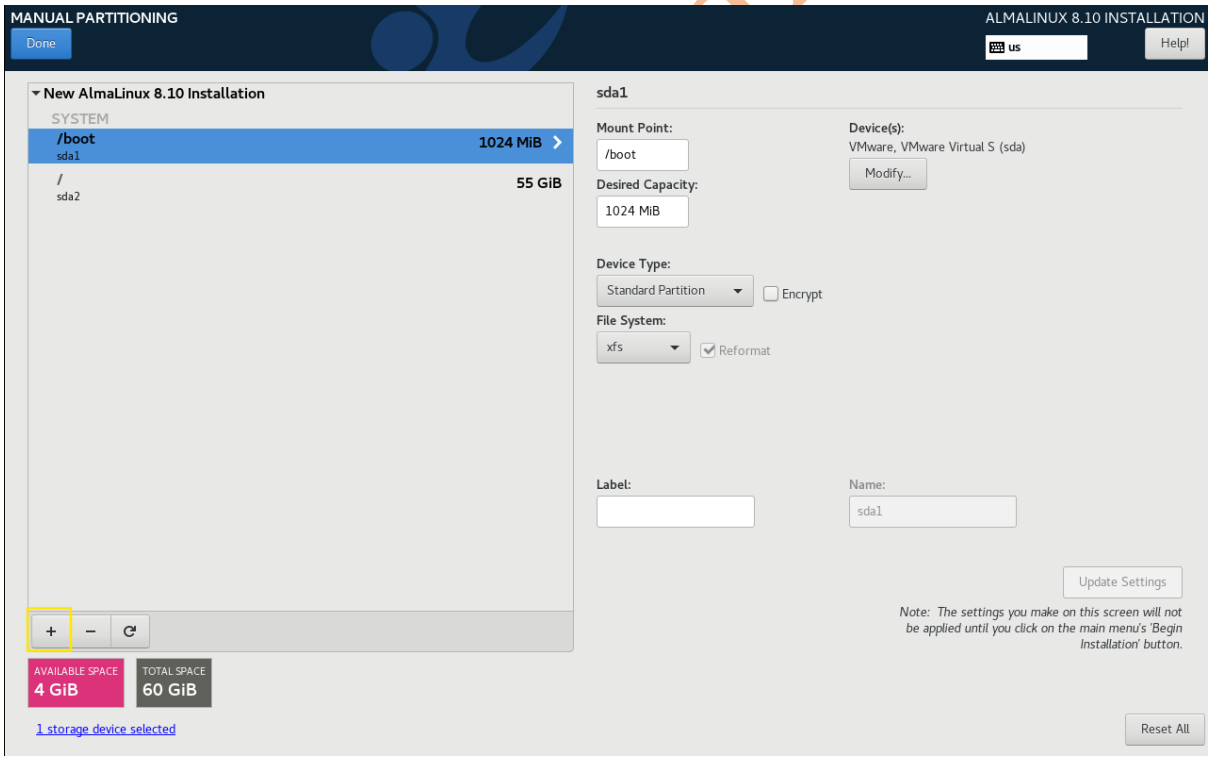
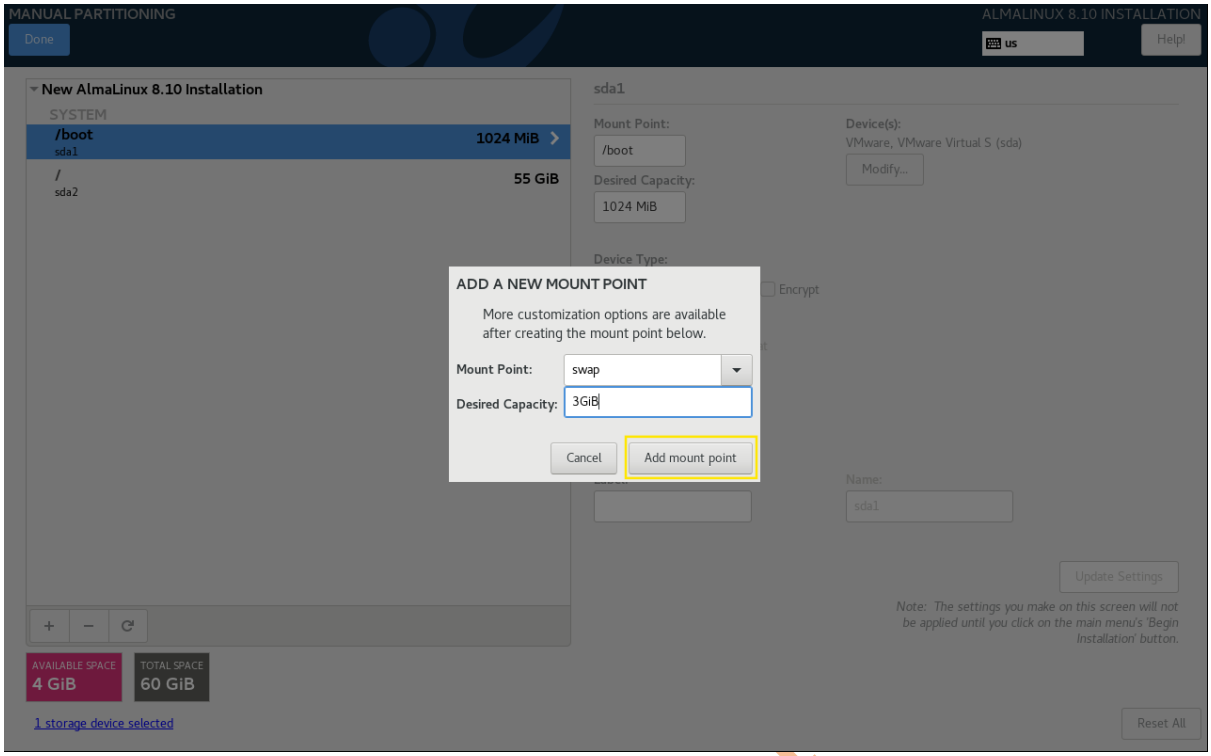
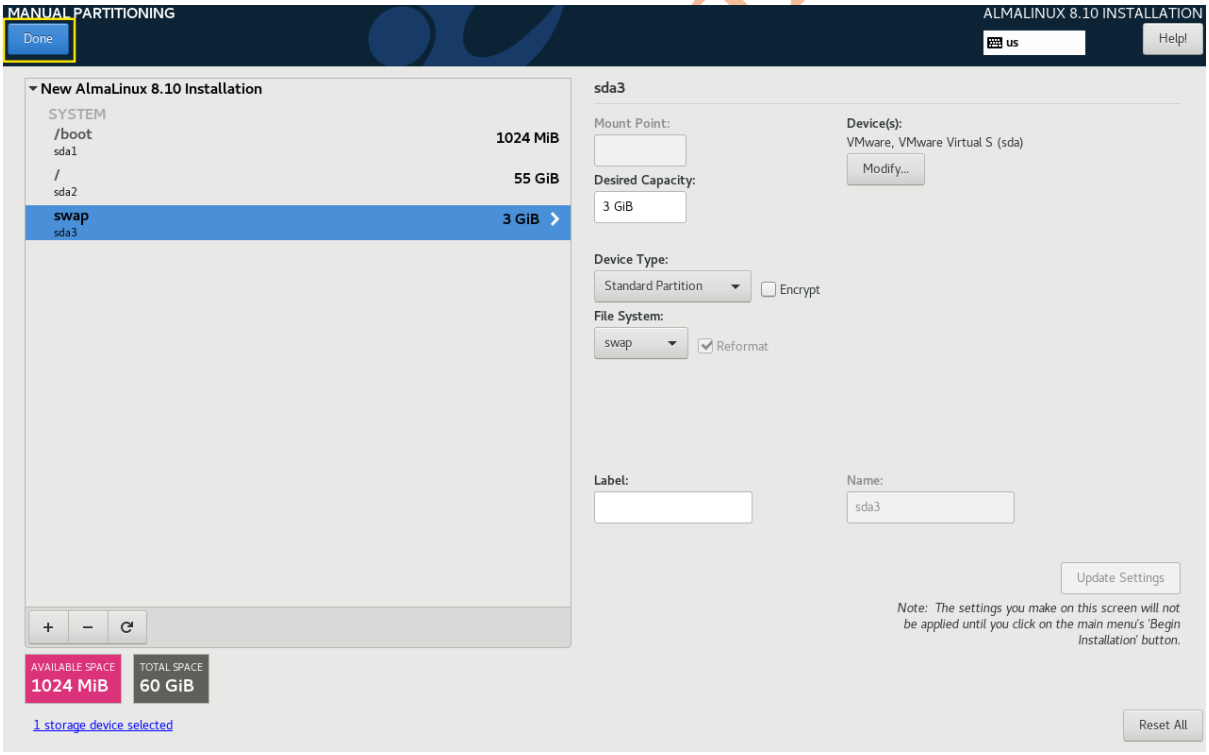
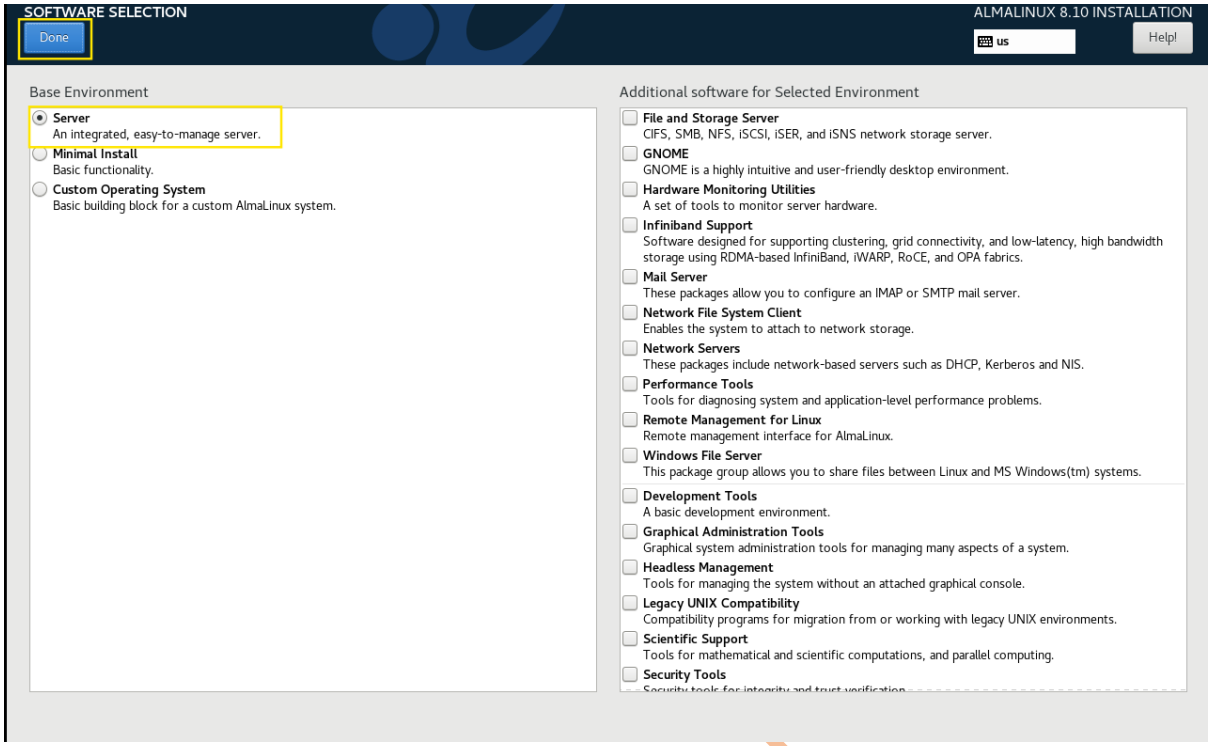
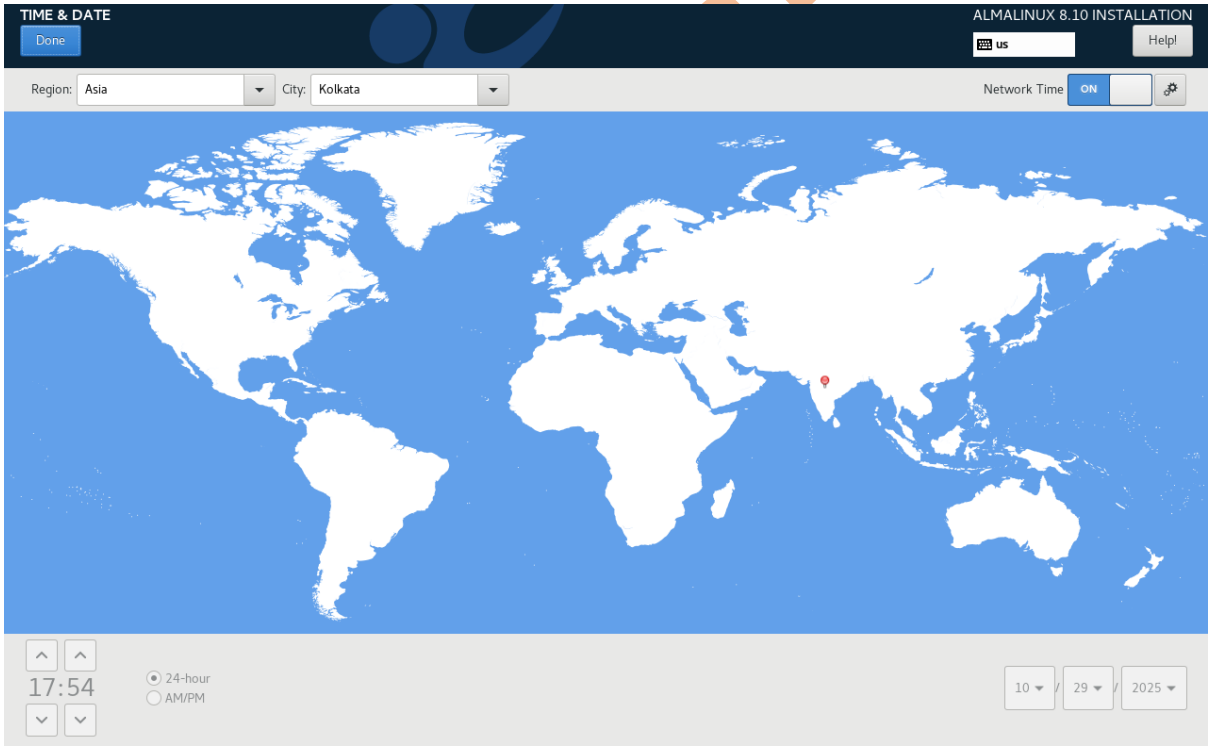

MANUAL PARTITIONING
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
New AlmaLinux 8.10 Installation
SYSTEM
/
sda1
55 GiB
sda1
Mount Point:
/
Desired Capacity:
55 GiB
Device(s):
VMware, VMware Virtual S (sda)
Modify...
Device Type:
Standard Partition
Encrypt
File System:
xfs
Reformat
Label:
Name:
sda1
Update Settings
Note: The settings you make on this screen will not be applied until you click on the main menu's 'Begin Installation' button.
AVAILABLE SPACE
5 GiB
TOTAL SPACE
60 GiB
1 storage device selected
Reset All


MANUAL PARTITIONING
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
New AlmaLinux 8.10 Installation
SYSTEM
/boot
sda1
1024 MiB
/
sda2
55 GiB
sda1
Mount Point:
/boot
Desired Capacity:
1024 MiB
Device(s):
VMware, VMware Virtual S (sda)
Modify...
Device Type:
Standard Partition
Encrypt
File System:
xfs
Reformat
Label:
Name:
sda1
Update Settings
Note: The settings you make on this screen will not be applied until you click on the main menu's 'Begin Installation' button.
AVAILABLE SPACE
4 GiB
TOTAL SPACE
60 GiB
1 storage device selected
Reset All

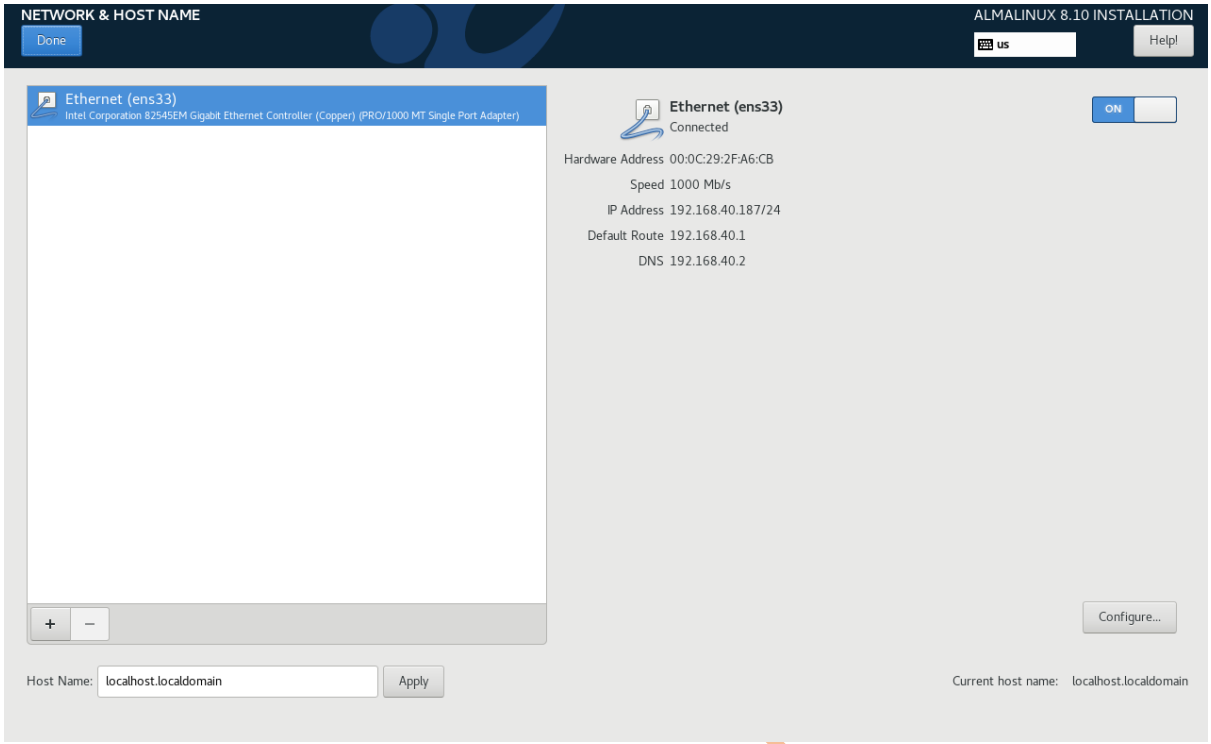

MANUAL PARTITIONING
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
New AlmaLinux 8.10 Installation
SYSTEM
/boot
sda1
1024 MiB
/
sda2
55 GiB
sda1
Mount Point:
/boot
Desired Capacity:
1024 MiB
Device(s):
VMware, VMware Virtual S (sda)
Modify...
Device Type:
Encrypt
ADD A NEW MOUNT POINT
More customization options are available after creating the mount point below.
Mount Point:
swap
Desired Capacity:
3GiB
Cancel
Add mount point
Name:
sda1
Update Settings
Note: The settings you make on this screen will not be applied until you click on the main menu's 'Begin Installation' button.
AVAILABLE SPACE
4 GiB
TOTAL SPACE
60 GiB
1 storage device selected
Reset All

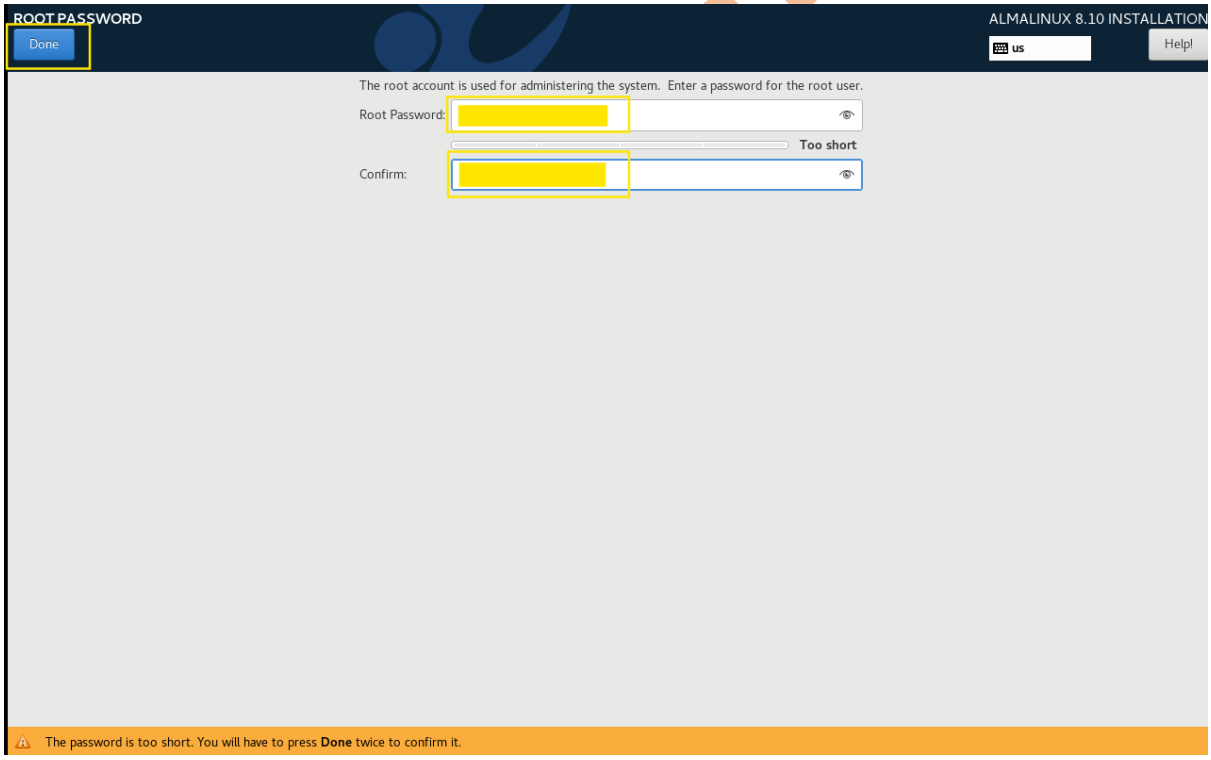

MANUAL PARTITIONING
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
New AlmaLinux 8.10 Installation
SYSTEM
/boot
sda1
1024 MiB
/
sda2
55 GiB
swap
sda3
3 GiB
sda3
Mount Point:
Desired Capacity:
3 GiB
Device(s):
VMware, VMware Virtual S (sda)
Modify...
Device Type:
Standard Partition
Encrypt
File System:
swap
Reformat
Label:
Name:
sda3
Update Settings
Note: The settings you make on this screen will not be applied until you click on the main menu's 'Begin Installation' button.
AVAILABLE SPACE
1024 MiB
TOTAL SPACE
60 GiB
1 storage device selected
Reset All

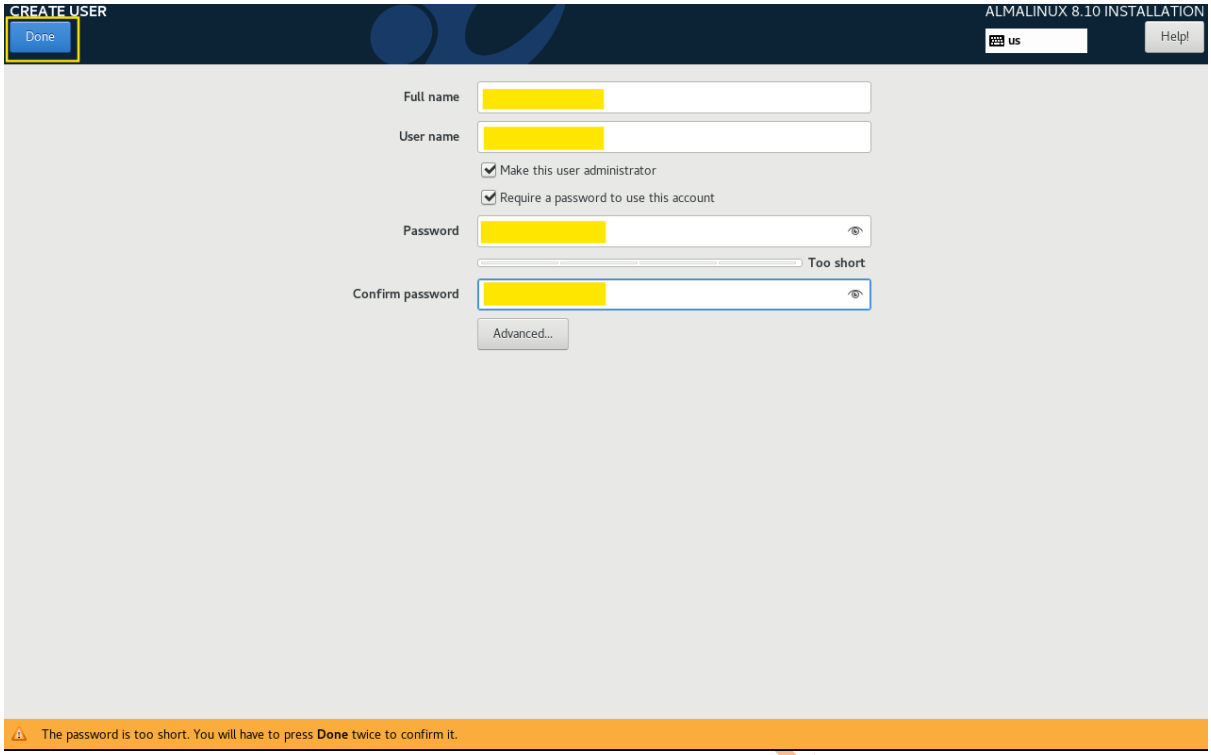


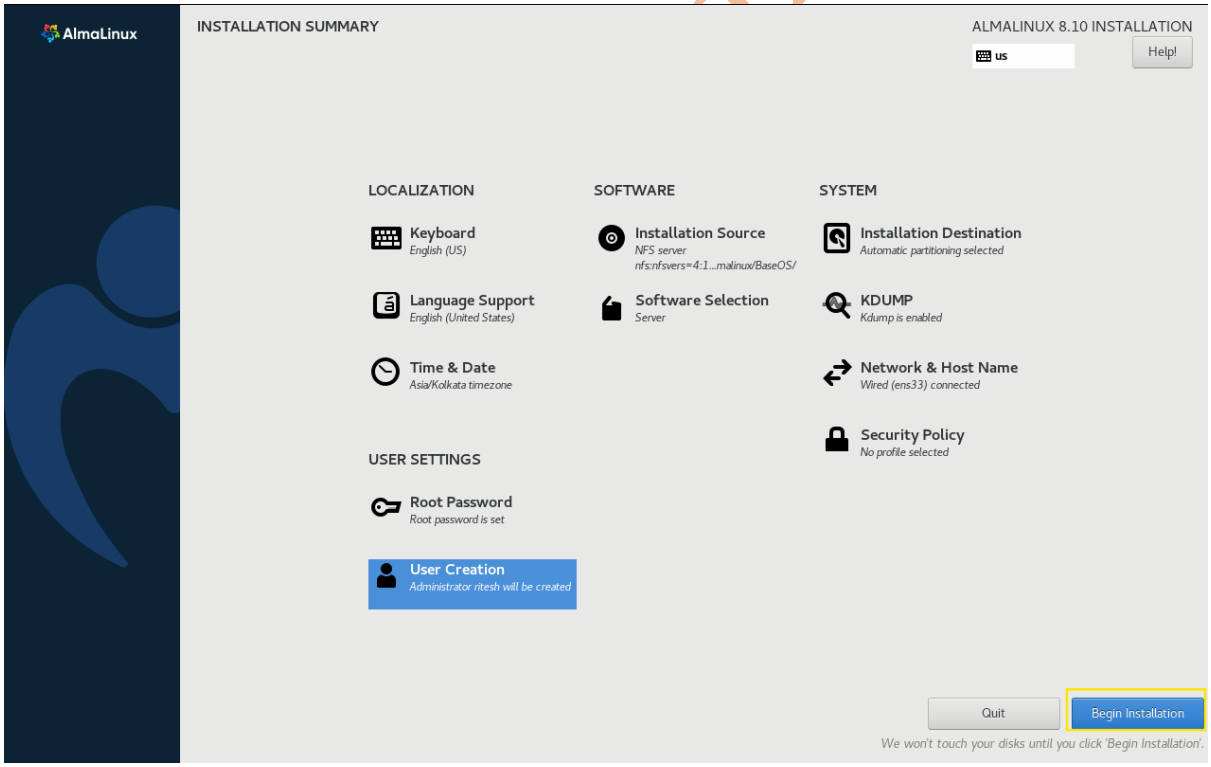


Ritesh Kumar Singh || Email Address: - riteshkumarsingh9559@gmail.com **|| LinkedIn: -** https://www.linkedin.com/in/ritesh-kumar-singh-41113128b/ **|| GitHub: -** https://github.com/singhritesh85

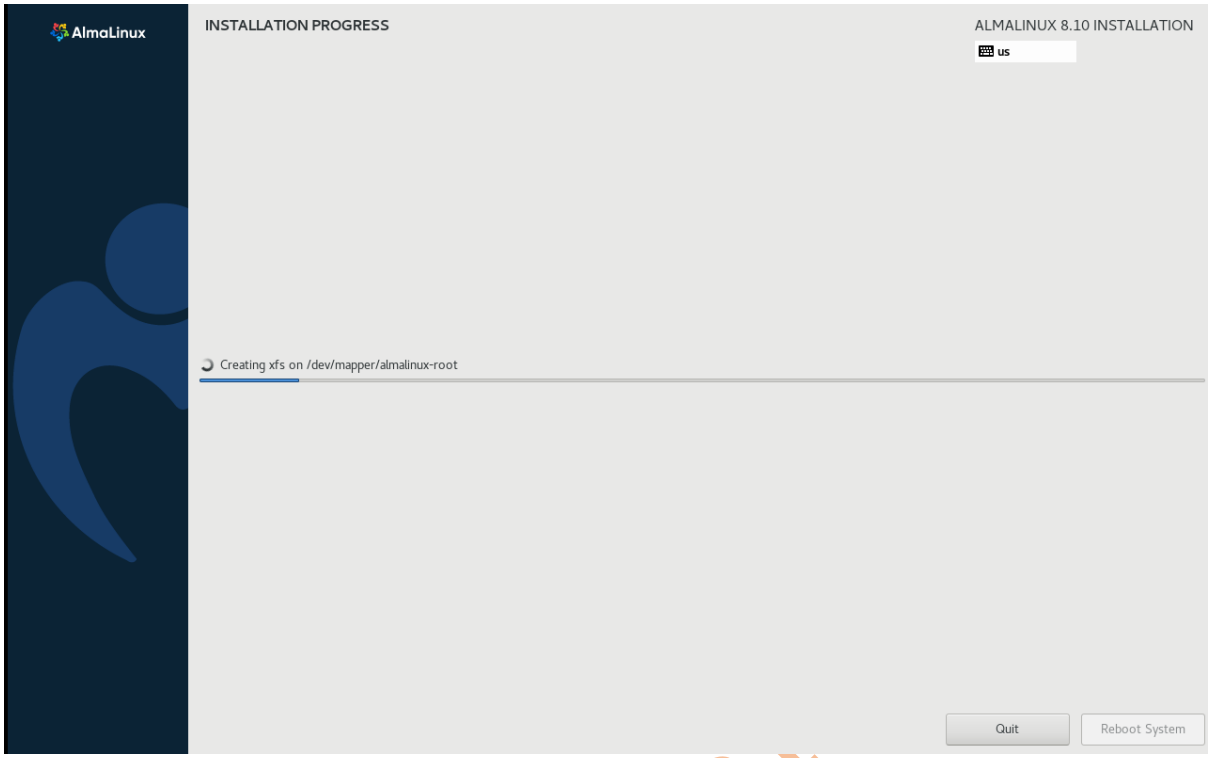

NETWORK & HOST NAME
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
Ethernet (ens33)
Intel Corporation 82545EM Gigabit Ethernet Controller (Copper) (PRO/1000 MT Single Port Adapter)
Ethernet (ens33)
Connected
ON
Hardware Address 00:0C:29:2F:A6:CB
Speed 1000 Mb/s
IP Address 192.168.40.187/24
Default Route 192.168.40.1
DNS 192.168.40.2
Configure...
Host Name: localhost.localdomain
Apply
Current host name: localhost.localdomain


ROOT PASSWORD
Done
ALMALINUX 8.10 INSTALLATION
us
Help!
The root account is used for administering the system. Enter a password for the root user.
Root Password:
Too short
Confirm:
The password is too short. You will have to press Done twice to confirm it.

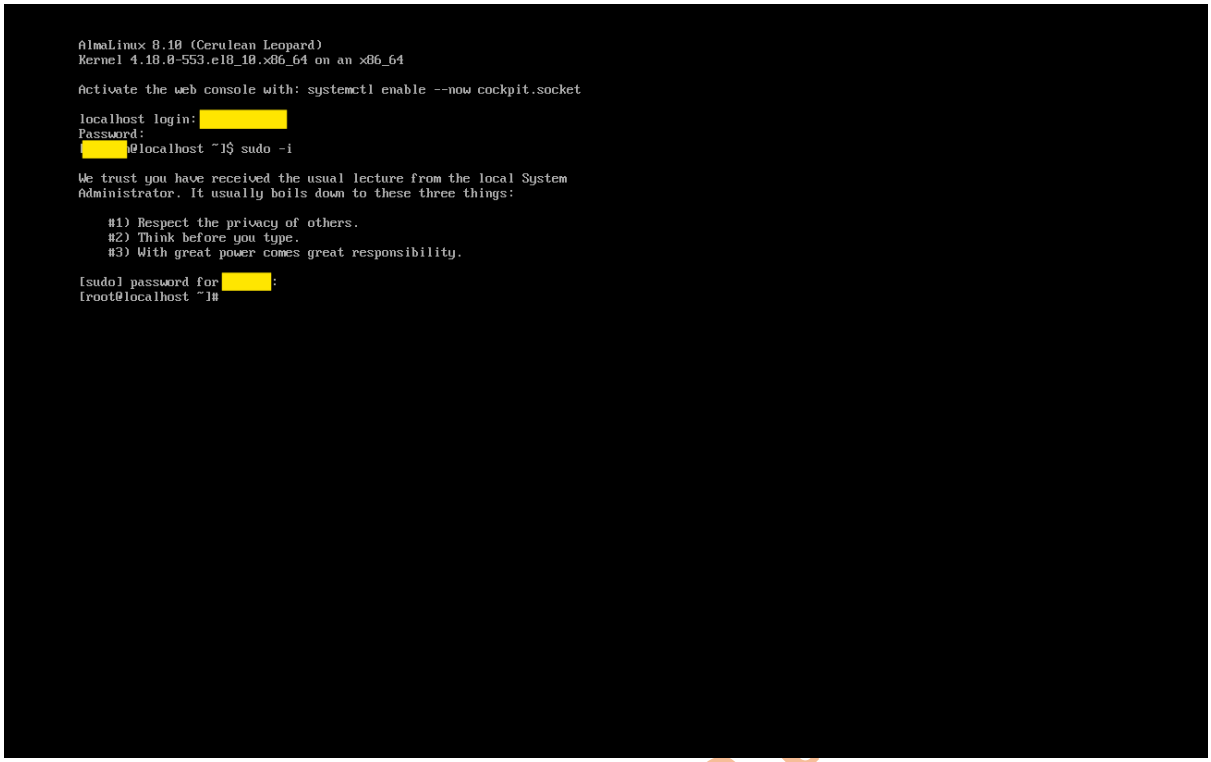




As shown in the screenshot attached below, installation had been started.

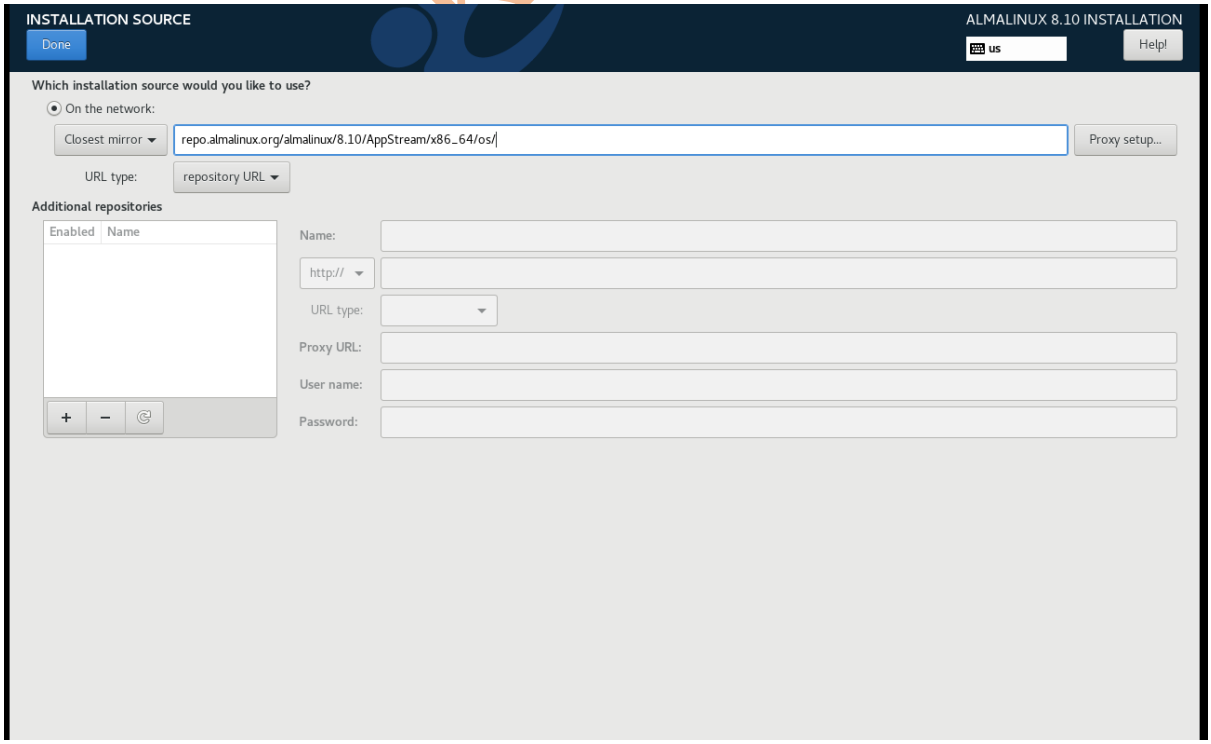


Now you need to reboot the system as shown in the screenshot attached below.

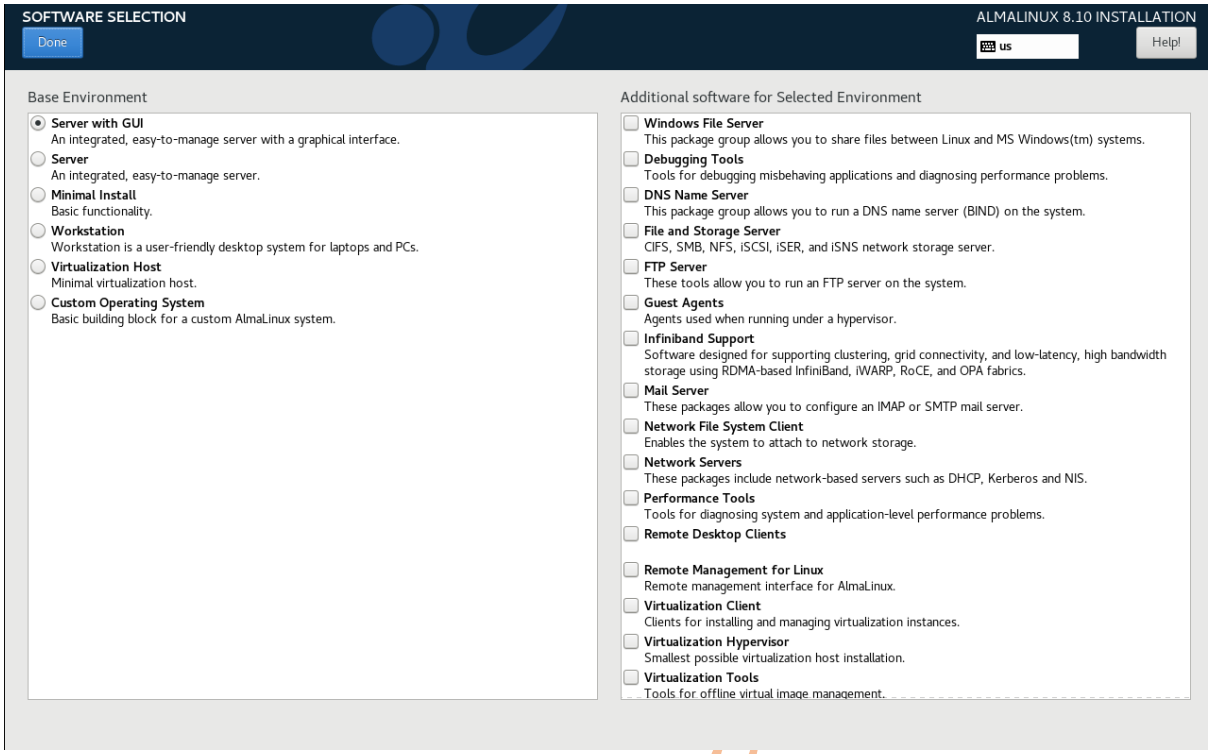


Finally, you can also login into this server using PuTTY/MobaXterm or from your Linux Machine using the IP Address of this Linux Server.

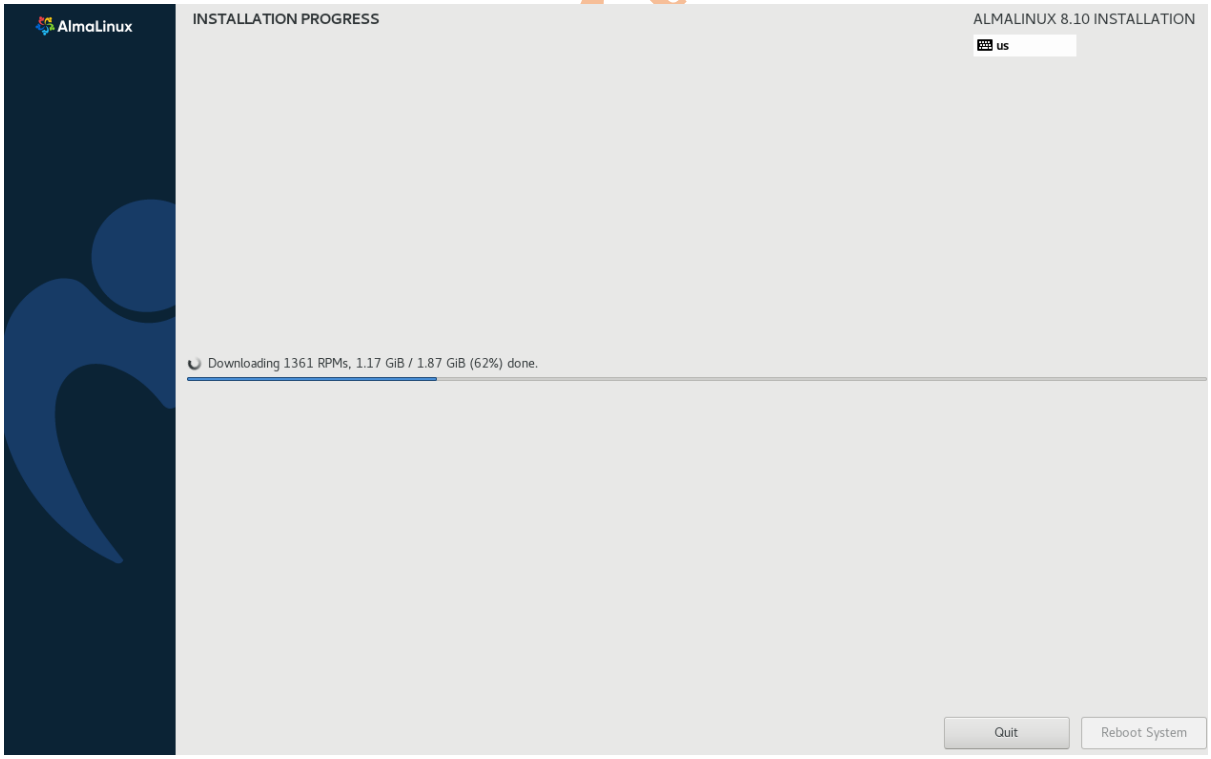
You can use Closest Mirror https://repo.almalinux.org/almalinux/8.10/AppStream/x86_64/os/ while booting a Linux machine as shown in the screenshot attached below. The URL provided here to boot the Almalinux machine is safe to use as it is the official repository for Almalinux. However, it is safe to use Closest Mirror https://repo.almalinux.org but it completely depends on your organisation to use it or not.



Before using Closest Mirror make sure Network & Host Ethernet should be in connected mode.



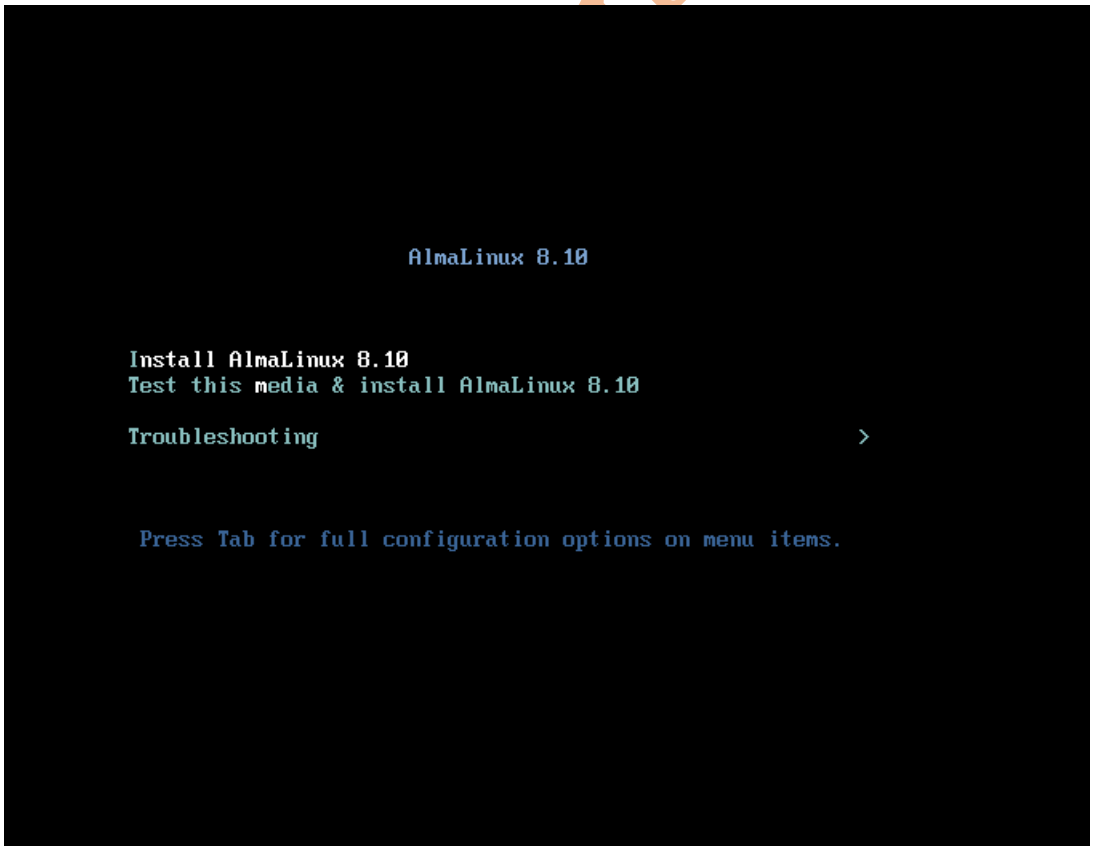
Further steps you can follow as I explained earlier.



2. Boot from a USB Flash Drive (bootable/multi-boot pen drive)

To boot a Linux machine using a USB Flash Drive (multi boot pen drive). You need first a multi boot pen drive (or bootable pen drive) then plugin-in the pen drive into the slot of your machine then power on your machine and start pressing the **esc** button and a start up menu will come on the screen here it will be mentioned which key to press for Boot Menu or BIOS Menu. To bring the Boot Menu usually F9 Key will be pressed but it varies with different company computers. For present case I consider by pressing F9 key Boot Menu will come and then select the USB Flash Drive Option and the Operating System (Alma Linux 8).


Ventoy
Boot in normal mode
Boot in grub2 mode
File checksum
Return to previous menu


AlmaLinux 8.10
Install AlmaLinux 8.10
Test this media & install AlmaLinux 8.10
Troubleshooting
Press Tab for full configuration options on menu items.

Now Installer will come then follow the procedure as I mentioned above to proceed further with Almalinux OS installation (While installation make sure you select the correct disk and not the Flash Drive). After Installation make sure to enable the Secure Boot Option from BIOS.

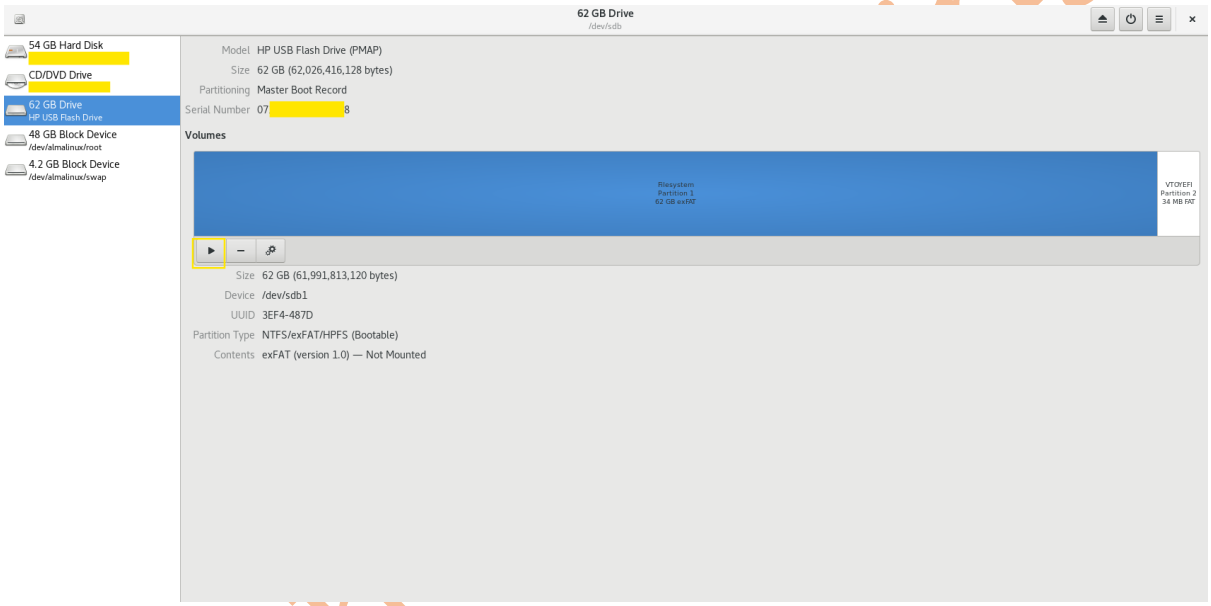
I used Ventoy to make the USB Flash Drive (Pen drive) multi boot as shown in the screenshot attached below. You can the link https://www.ventoy.net/en/download.html to download Ventoy.

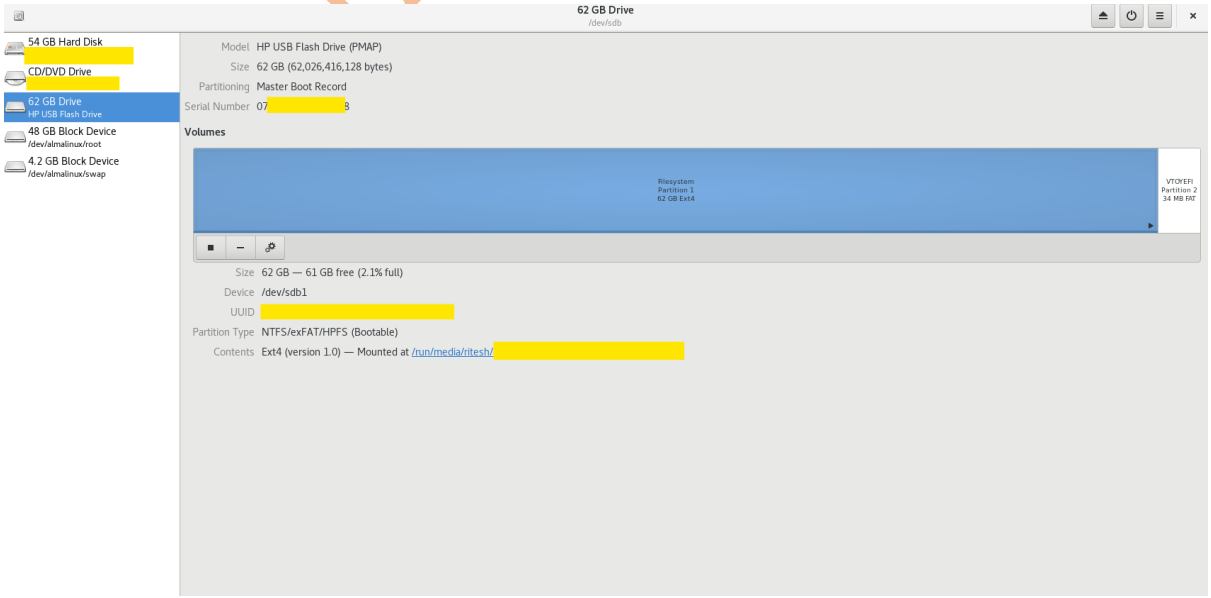
```
[root@localhost ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                   8:0    0   50G  0 disk
├─sda1                8:1    0    1G  0 part /boot
└─sda2                8:2    0   49G  0 part
  ├─almalinux-root 253:0    0 45.1G  0 lvm  /
  └─almalinux-swap 253:1    0  3.9G  0 lvm  [SWAP]
sdb                   8:16   1 57.8G  0 disk
sr0                  11:0    1 1024M  0 rom
```

```
[root@localhost ventoy-1.1.07]# ./Ventoy2Disk.sh -i /dev/sdb

**********************************************
      Ventoy: 1.1.07  x86_64
      longpanda admin@ventoy.net
      https://www.ventoy.net
**********************************************

Disk : /dev/sdb
Model: HP USB Flash Drive (scsi)
Size : 57 GB
Style: MBR


Attention:
You will install Ventoy to /dev/sdb.
All the data on the disk /dev/sdb will be lost!!!

Continue? (y/n) y

All the data on the disk /dev/sdb will be lost!!!
Double-check. Continue? (y/n) y

Create partitions on /dev/sdb by parted in MBR style ...
Done
Wait for partitions ...
partition exist OK
create efi fat fs /dev/sdb2 ...
mkfs.fat 4.1 (2017-01-24)
success
Wait for partitions $vPART1 and $vPART2 ...
/dev/sdb1 exist OK
/dev/sdb2 exist OK
/dev/sdb1 NOT exist
writing data to disk ...
sync data ...
esp partition processing ...

Install Ventoy to /dev/sdb successfully finished.

[root@localhost ventoy-1.1.07]# pwd
/home/ritesh/Downloads/ventoy-1.1.07-linux/ventoy-1.1.07
```

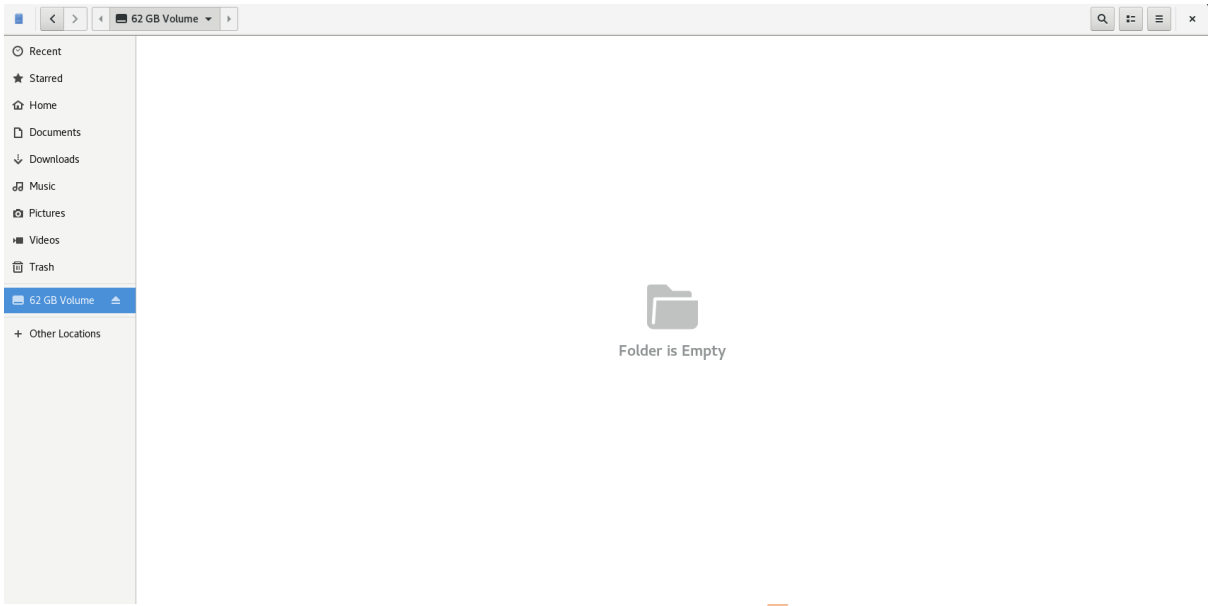
Then mount the USB Flash Drive as shown in the screenshot attached below.

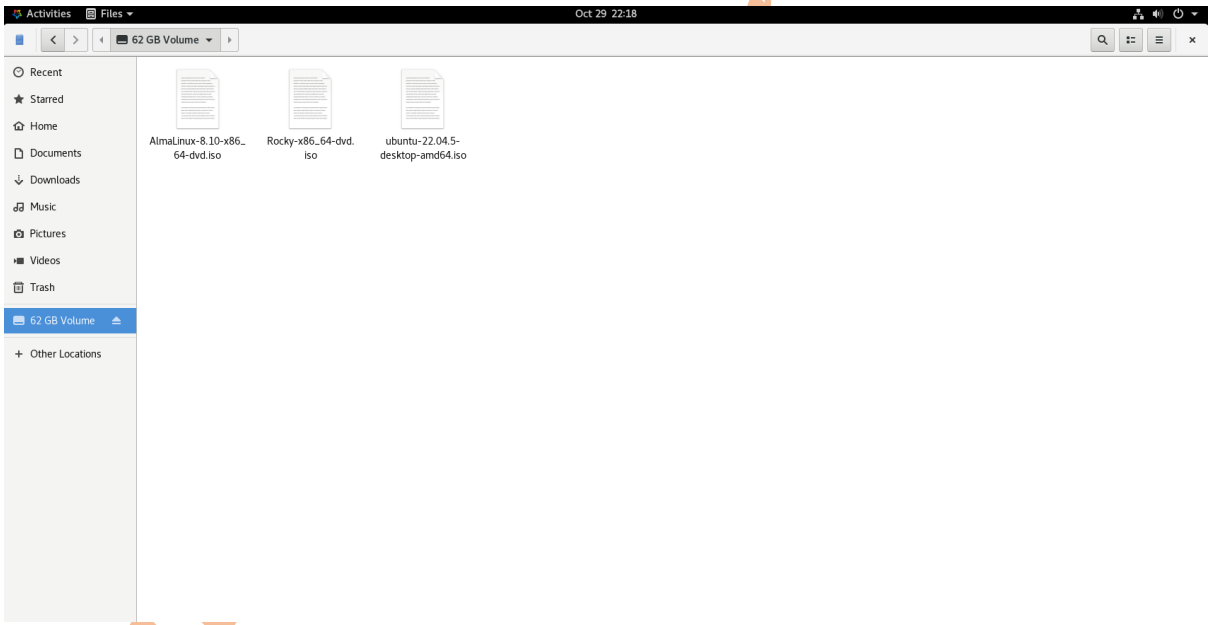
```
[root@localhost ~]# mkfs.ext4 /dev/sdb1
mke2fs 1.45.6 (20-Mar-2020)
/dev/sdb1 contains a exfat file system
Proceed anyway? (y,N) y
Creating filesystem with 15134720 4k blocks and 3784704 inodes
Filesystem UUID: 4d1c78b4-c609-4bbc-9f66-60fc99f57782
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000, 7962624, 11239424

Allocating group tables: done
Writing inode tables: done
Creating journal (65536 blocks):

done
Writing superblocks and filesystem accounting information: done
```



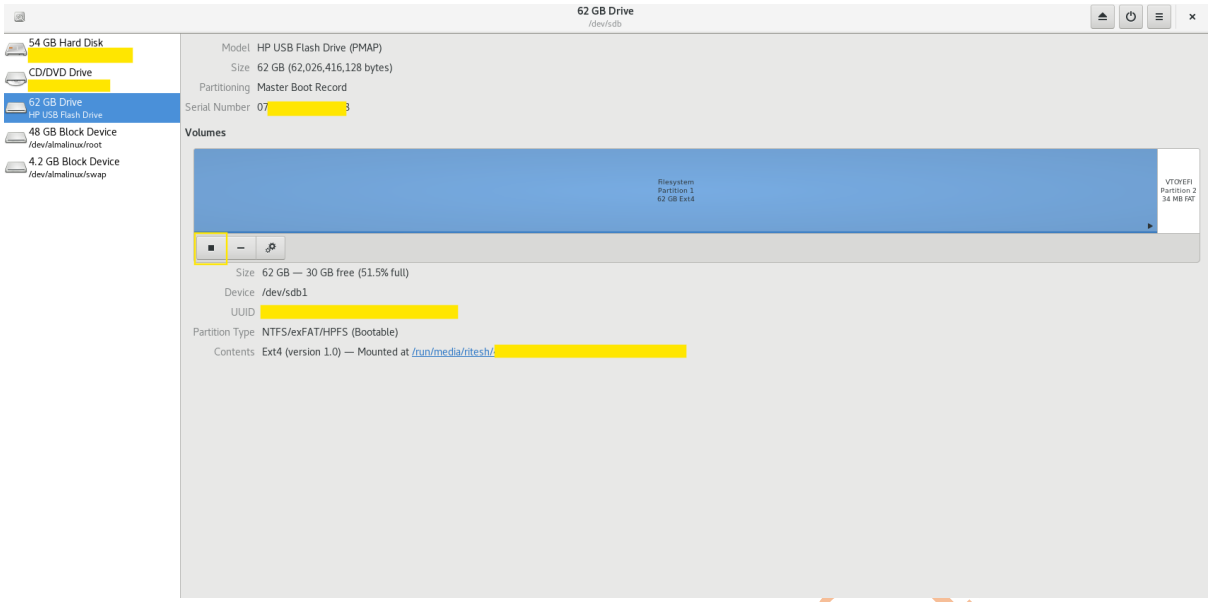


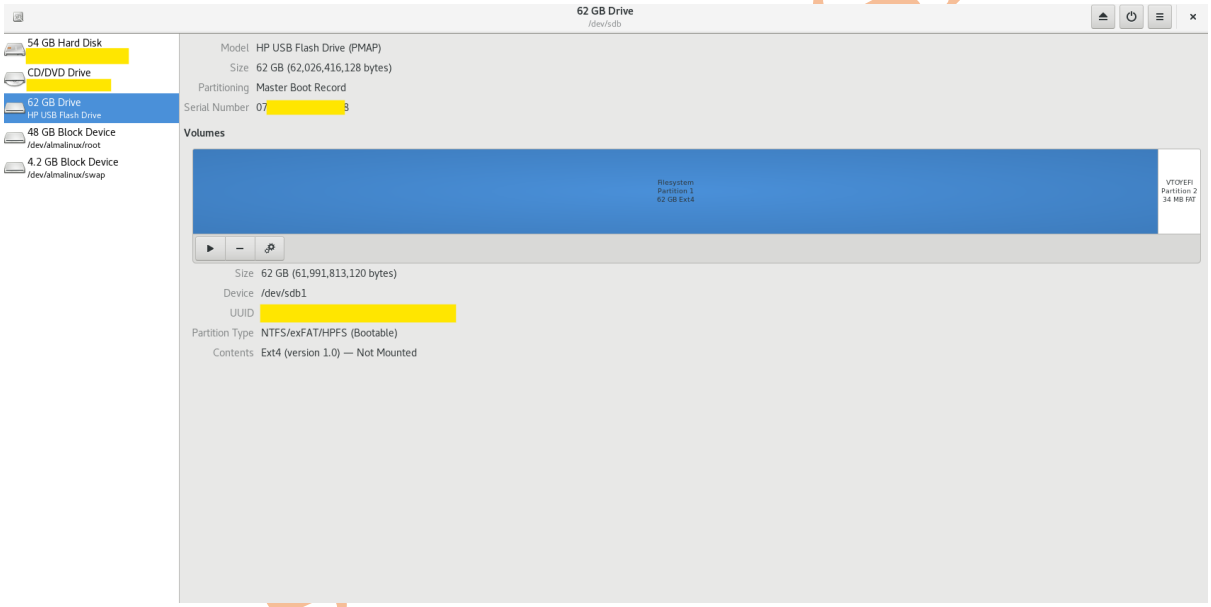
Then drag and drop the Operating system ISO files in the USB Flash Directory as shown in the screenshot attached below.





Unmount the /dev/sdb1 partition of the USB Flash Drive

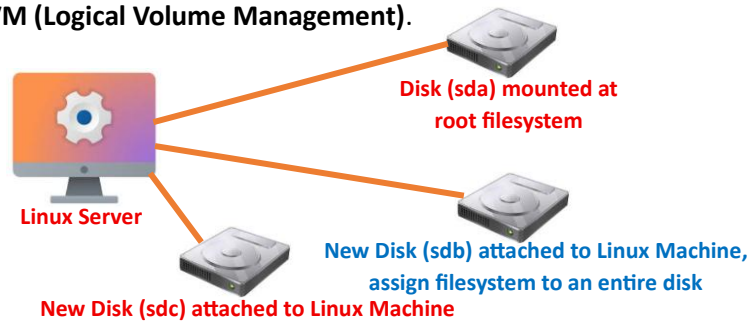




Your multi-boot USB Flash Drive (multi-boot pen drive) is ready; you can use it to boot the Linux System as discussed above.

Disk Partition in Linux

In Linux **disk partition** is a logical section of a physical storage drive (like an HDD or SSD) which is treated as a separate disk. Under this topic I will explain you how to do the disk partition and how to create the **LVM (Logical Volume Management)**.



As shown in the diagram above in this example there are three disks sda, sdb and sdc attached to the Linux machine. Disk **sda** (50GB) contain the Almalinux 9 Operating System and for disk **sdb** (10GB) I will assign ext4 filesystem to this disk and mount it to a directory. For disk **sdc** (10GB) I will create the partition and then LVM, finally mount them to a directory.

```
[root@therema-server ~]# lsblk
NAME                  MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS
sda                     8:0    0   50G  0 disk
├─sda1                  8:1    0    1G  0 part /boot
└─sda2                  8:2    0   49G  0 part
  ├─almalinux-root    253:0    0   44G  0 lvm  /
  └─almalinux-swap    253:1    0    5G  0 lvm  [SWAP]
sdb                     8:16   0   10G  0 disk
sdc                     8:32   0   10G  0 disk
sr0                    11:0    1 11.4G  0 rom
```

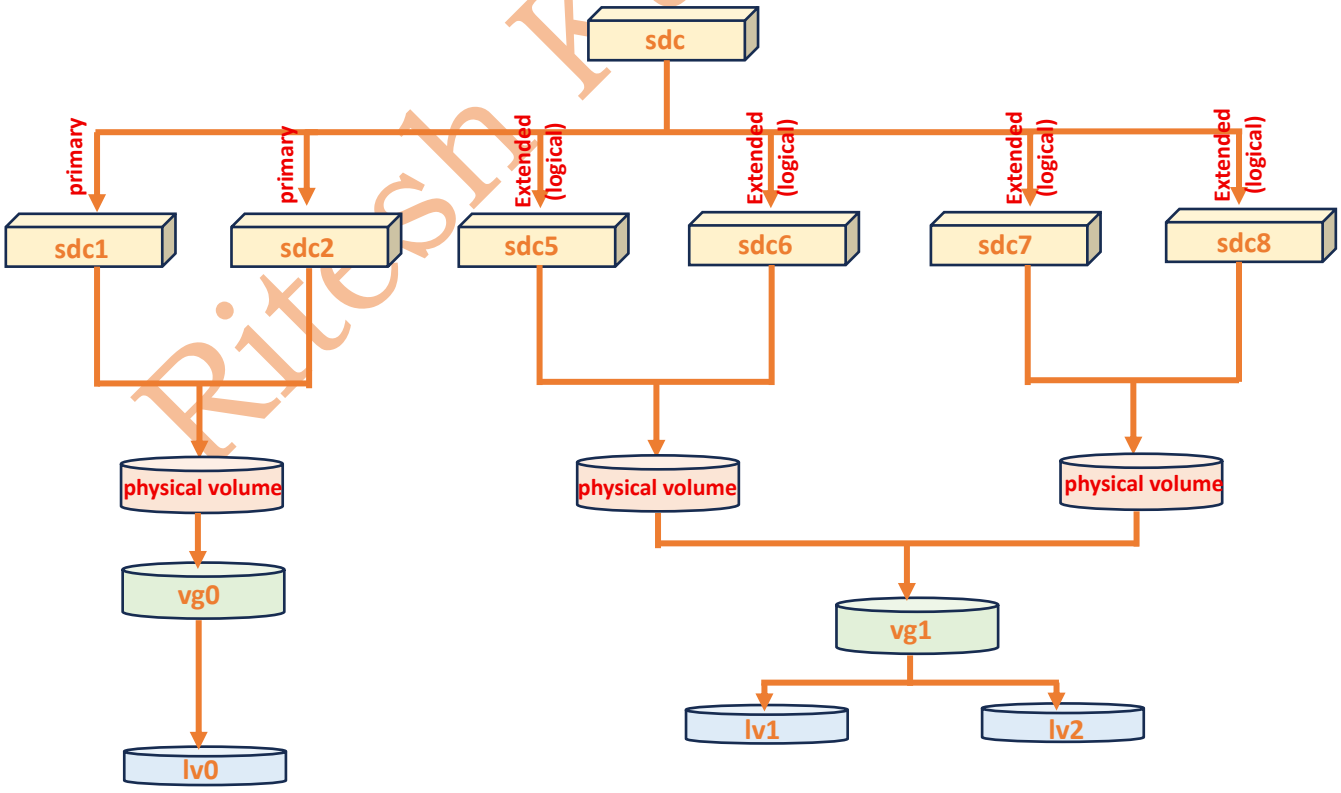
```
[root@therema-server ~]# mkfs.ext4 /dev/sdb
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 2621440 4k blocks and 655360 inodes
Filesystem UUID: [redacted]
Superblock backups stored on blocks:
        [redacted]

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done

[root@therema-server ~]# mkdir /dexter
[root@therema-server ~]# vim /etc/fstab
[root@therema-server ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Thu Oct 30 10:11:07 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
/dev/mapper/almalinux-root /                       xfs     defaults        0 0
UUID=[redacted] /boot                   xfs     defaults        0 0
/dev/mapper/almalinux-swap none                    swap    defaults        0 0

/dev/sdb /dexter ext4 defaults 0 0
[root@therema-server ~]# mount -a
```

```
[root@therema-server ~]# df -hT
Filesystem                Type      Size  Used Avail Use% Mounted on
devtmpfs                  devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs                     tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs                     tmpfs     725M  9.6M  716M   2% /run
/dev/mapper/almalinux-root xfs       44G  4.7G   40G  11% /
/dev/sda1                 xfs       960M  366M  595M  39% /boot
tmpfs                     tmpfs     363M   52K  363M   1% /run/user/42
tmpfs                     tmpfs     363M   36K  363M   1% /run/user/1000
/dev/sdb                  ext4      9.8G   24K  9.3G   1% /dexter
```

Here disk portioning scheme was used as MBR (Master Boot Record), and hence you can create **four primary partitions** or **three primary and one extended partition** (extended partition further can contain several logical partitions).

```
[root@therema-server ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINTS
sda                   8:0    0   50G  0 disk
├─sda1                8:1    0    1G  0 part /boot
└─sda2                8:2    0   49G  0 part
  ├─almalinux-root 253:0    0   44G  0 lvm  /
  └─almalinux-swap 253:1    0    5G  0 lvm  [SWAP]
sdb                   8:16   0   10G  0 disk /dexter
sdc                   8:32   0   10G  0 disk
sr0                  11:0    1 11.4G  0 rom
[root@therema-server ~]# fdisk -l /dev/sdc
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: VMware Virtual S
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
```

Here for **sdc** I will create two primary and one extended partition, under extended partition I had created four logical partitions and finally the two LVM (using two logical partitions each in one LVM). Its details are as shown in the architecture diagram drawn below. With two primary partitions I will create one LVM.



```
[root@therema-server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.37.4).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Device does not contain a recognized partition table.
Created a new DOS disklabel with disk identifier 0x1ccad1ba.

Command (m for help): n
Partition type
   p   primary (0 primary, 0 extended, 4 free)
   e   extended (container for logical partitions)
Select (default p): p
Partition number (1-4, default 1):
First sector (2048-20971519, default 2048):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (2048-20971519, default 20971519): +2G

Created a new partition 1 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Selected partition 1
Hex code or alias (type L to list all): L

00 Empty            24 NEC DOS          81 Minix / old Lin  bf Solaris
01 FAT12            27 Hidden NTFS Win  82 Linux swap / So  c1 DRDOS/sec (FAT-
02 XENIX root       39 Plan 9           83 Linux            c4 DRDOS/sec (FAT-
03 XENIX usr        3c PartitionMagic   84 OS/2 hidden or   c6 DRDOS/sec (FAT-
04 FAT16 <32M       40 Venix 80286      85 Linux extended   c7 Syrinx
05 Extended         41 PPC PReP Boot    86 NTFS volume set  da Non-FS data
06 FAT16            42 SFS              87 NTFS volume set  db CP/M / CTOS / .
07 HPFS/NTFS/exFAT  4d QNX4.x           88 Linux plaintext  de Dell Utility
08 AIX              4e QNX4.x 2nd part  8e Linux LVM        df BootIt
09 AIX bootable     4f QNX4.x 3rd part  93 Amoeba           e1 DOS access
0a OS/2 Boot Manag  50 OnTrack DM       94 Amoeba BBT       e3 DOS R/O
0b W95 FAT32        51 OnTrack DM6 Aux  9f BSD/OS           e4 SpeedStor
0c W95 FAT32 (LBA)  52 CP/M             a0 IBM Thinkpad hi  ea Linux extended
0e W95 FAT16 (LBA)  53 OnTrack DM6 Aux  a5 FreeBSD          eb BeOS fs
0f W95 Ext'd (LBA)  54 OnTrackDM6       a6 OpenBSD          ee GPT

Hex code or alias (type L to list all): 8e
Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.

[root@therema-server ~]# fdisk -l /dev/sdc
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: VMware Virtual S
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x1ccad1ba

Device     Boot Start     End Sectors Size Id Type
/dev/sdc1        2048 4196351 4194304   2G 8e Linux LVM
```

```
[root@therema-server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.37.4).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p): p
Partition number (2-4, default 2):
First sector (4196352-20971519, default 4196352):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (4196352-20971519, default 20971519): +2G

Created a new partition 2 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Partition number (1,2, default 2):
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@therema-server ~]# fdisk -l /dev/sdc
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: VMware Virtual S
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x1ccad1ba

Device     Boot   Start     End Sectors Size Id Type
/dev/sdc1          2048 4196351 4194304   2G 8e Linux LVM
/dev/sdc2       4196352 8390655 4194304   2G 8e Linux LVM
```

```
[root@therema-server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.37.4).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): n
Partition type
   p   primary (2 primary, 0 extended, 2 free)
   e   extended (container for logical partitions)
Select (default p): e
Partition number (3,4, default 3):
First sector (8390656-20971519, default 8390656):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (8390656-20971519, default 20971519): +5G

Created a new partition 3 of type 'Extended' and of size 5 GiB.

Command (m for help): n
Partition type
   p   primary (2 primary, 1 extended, 1 free)
   l   logical (numbered from 5)
Select (default p): l

Adding logical partition 5
First sector (8392704-18876415, default 8392704):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (8392704-18876415, default 18876415): +1G

Created a new partition 5 of type 'Linux' and of size 1 GiB.

Command (m for help): n
Partition type
   p   primary (2 primary, 1 extended, 1 free)
   l   logical (numbered from 5)
Select (default p): l

Adding logical partition 6
First sector (10491904-18876415, default 10491904):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (10491904-18876415, default 18876415): +1G

Created a new partition 6 of type 'Linux' and of size 1 GiB.

Command (m for help): n
Partition type
   p   primary (2 primary, 1 extended, 1 free)
   l   logical (numbered from 5)
Select (default p): l

Adding logical partition 7
First sector (12591104-18876415, default 12591104):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (12591104-18876415, default 18876415): +1G

Created a new partition 7 of type 'Linux' and of size 1 GiB.

Command (m for help): n
Partition type
   p   primary (2 primary, 1 extended, 1 free)
   l   logical (numbered from 5)
Select (default p): l

Adding logical partition 8
First sector (14690304-18876415, default 14690304):
```

```
Last sector, +/-sectors or +/-size{K,M,G,T,P} (14690304-18876415, default 18876415): +1.5G

Created a new partition 8 of type 'Linux' and of size 1.5 GiB.

Command (m for help): t
Partition number (1-3,5-8, default 8): 5
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): t
Partition number (1-3,5-8, default 8): 6
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): t
Partition number (1-3,5-8, default 8): 7
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): t
Partition number (1-3,5-8, default 8):
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@therema-server ~]# fdisk -l /dev/sdc
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: VMware Virtual S
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x1ccad1ba

Device     Boot    Start      End  Sectors  Size Id Type
/dev/sdc1           2048  4196351  4194304    2G 8e Linux LVM
/dev/sdc2        4196352  8390655  4194304    2G 8e Linux LVM
/dev/sdc3        8390656 18876415 10485760    5G  5 Extended
/dev/sdc5        8392704 10489855  2097152    1G 8e Linux LVM
/dev/sdc6       10491904 12589055  2097152    1G 8e Linux LVM
/dev/sdc7       12591104 14688255  2097152    1G 8e Linux LVM
/dev/sdc8       14690304 17836031  3145728  1.5G 8e Linux LVM
```

```
[root@therema-server ~]# partprobe /dev/sdc
```

```
[root@therema-server ~]# pvcreate /dev/sdc1 /dev/sdc2
  Physical volume "/dev/sdc1" successfully created.
  Physical volume "/dev/sdc2" successfully created.
[root@therema-server ~]# pvs
  PV         VG        Fmt  Attr PSize   PFree
  /dev/sda2  almalinux lvm2 a--  <49.00g    0
  /dev/sdc1            lvm2 ---    2.00g 2.00g
  /dev/sdc2            lvm2 ---    2.00g 2.00g
```

```
[root@therema-server ~]# vgcreate vg0 /dev/sdc1 /dev/sdc2
  Volume group "vg0" successfully created
```

```
[root@therema-server ~]# vgdisplay
  --- Volume group ---
  VG Name               vg0
  System ID
  Format                lvm2
  Metadata Areas        2
  Metadata Sequence No  1
  VG Access             read/write
  VG Status             resizable
  MAX LV                0
  Cur LV                0
  Open LV               0
  Max PV                0
  Cur PV                2
  Act PV                2
  VG Size               3.99 GiB
  PE Size               4.00 MiB
  Total PE              1022
  Alloc PE / Size       0 / 0
  Free  PE / Size       1022 / 3.99 GiB
  VG UUID               [redacted]
```

```
[root@therema-server ~]# lvcreate -L 1.5G -n lv0 vg0
  Logical volume "lv0" created.
```

```
[root@therema-server ~]# lvdisplay
  --- Logical volume ---
  LV Path                /dev/vg0/lv0
  LV Name                lv0
  VG Name                vg0
  LV UUID                ZN0J7y-FLvs-bt5X-fNLb-f7bg-O9A0-Iit0gR
  LV Write Access        read/write
  LV Creation host, time therema-server, 2025-10-30 21:47:09 +0530
  LV Status              available
  # open                 0
  LV Size                1.50 GiB
  Current LE             384
  Segments               1
  Allocation             inherit
  Read ahead sectors     auto
  - currently set to     256
  Block device           253:2
```

```
[root@therema-server ~]# mkswap /dev/vg0/lv0
Setting up swapspace version 1, size = 1.5 GiB (1610608640 bytes)
no label, UUID=4fb61356-68e1-4c18-a42a-4634006c0a02
```

```
[root@therema-server ~]# mkswap /dev/vg0/lv0
Setting up swapspace version 1, size = 1.5 GiB (1610608640 bytes)
no label, UUID=[redacted]
[root@therema-server ~]# vim /etc/fstab
[root@therema-server ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Thu [redacted] 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
/dev/mapper/almalinux-root /                       xfs     defaults        0 0
UUID=[redacted] /boot                   xfs     defaults        0 0
/dev/mapper/almalinux-swap none                    swap    defaults        0 0

/dev/sdb /dexter ext4 defaults 0 0

/dev/vg0/lv0 swap swap defaults 0 0
[root@therema-server ~]# swapon -a
```

```
[root@therema-server ~]# pvcreate /dev/sdc5 /dev/sdc6
  Physical volume "/dev/sdc5" successfully created.
  Physical volume "/dev/sdc6" successfully created.
[root@therema-server ~]# pvcreate /dev/sdc7 /dev/sdc8
  Physical volume "/dev/sdc7" successfully created.
  Physical volume "/dev/sdc8" successfully created.
```

```
[root@therema-server ~]# pvdisplay
```

```
[root@therema-server ~]# pvs
  PV         VG        Fmt  Attr PSize   PFree
  /dev/sda2  almalinux lvm2 a--  <49.00g      0
  /dev/sdc1  vg0       lvm2 a--   <2.00g 508.00m
  /dev/sdc2  vg0       lvm2 a--   <2.00g  <2.00g
  /dev/sdc5            lvm2 ---    1.00g   1.00g
  /dev/sdc6            lvm2 ---    1.00g   1.00g
  /dev/sdc7            lvm2 ---    1.00g   1.00g
  /dev/sdc8            lvm2 ---    1.50g   1.50g
```

```
[root@therema-server ~]# vgcreate vg1 /dev/sdc5 /dev/sdc6 /dev/sdc7 /dev/sdc8
  Volume group "vg1" successfully created
```

```
[root@therema-server ~]# vgs
  VG        #PV #LV #SN Attr   VSize   VFree
  almalinux   1   2   0 wz--n- <49.00g    0
  vg0         2   1   0 wz--n-   3.99g 2.49g
  vg1         4   0   0 wz--n-   4.48g 4.48g
```

```
[root@therema-server ~]# lvcreate -L 1.5G -n lv1 vg1
  Logical volume "lv1" created.
[root@therema-server ~]# lvs
  LV   VG        Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  root almalinux -wi-ao---- <44.00g
  swap almalinux -wi-ao----   5.00g
  lv0  vg0       -wi-ao----   1.50g
  lv1  vg1       -wi-a-----   1.50g
[root@therema-server ~]# lvcreate -L 1.5G -n lv2 vg1
  Logical volume "lv2" created.
[root@therema-server ~]# lvs
  LV   VG        Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  root almalinux -wi-ao---- <44.00g
  swap almalinux -wi-ao----   5.00g
  lv0  vg0       -wi-ao----   1.50g
  lv1  vg1       -wi-a-----   1.50g
  lv2  vg1       -wi-a-----   1.50g
```

```
[root@therema-server ~]# mkfs.ext4 /dev/vg1/lv1
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 393216 4k blocks and 98304 inodes
Filesystem UUID: 669f0ece-7933-4a74-ae4f-2dea12d886de
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (8192 blocks): done
Writing superblocks and filesystem accounting information: done

[root@therema-server ~]# mkfs.ext4 /dev/vg1/lv2
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 393216 4k blocks and 98304 inodes
Filesystem UUID: 09914630-fd42-4f5a-a7ea-299666625de9
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (8192 blocks): done
Writing superblocks and filesystem accounting information: done
```

```
[root@therema-server ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Thu Oct 30 10:11:07 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
/dev/mapper/almalinux-root /                       xfs     defaults        0 0
UUID=[redacted]/boot                   xfs     defaults        0 0
/dev/mapper/almalinux-swap none                    swap    defaults        0 0

/dev/sdb /dexter ext4 defaults 0 0

/dev/vg0/lv0 swap swap defaults 0 0

/dev/vg1/lv1 /pablo/therema ext4 defaults 0 0

/dev/vg1/lv2 /pablo/mederma ext4 defaults 0 0
[root@therema-server ~]# mount -a
```

```
[root@therema-server ~]# df -hT
Filesystem                Type      Size  Used Avail Use% Mounted on
devtmpfs                  devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs                     tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs                     tmpfs     725M  9.8M  715M   2% /run
/dev/mapper/almalinux-root xfs       44G  4.7G   40G  11% /
/dev/sda1                 xfs       960M  366M  595M  39% /boot
tmpfs                     tmpfs     363M   96K  363M   1% /run/user/1000
/dev/sdb                  ext4      9.8G   24K  9.3G   1% /dexter
/dev/sr0                  iso9660    12G   12G     0 100% /run/media/ritesh/AlmaLinux-9-6-x86_64-dvd
/dev/mapper/vg1-lv1       ext4      1.5G   24K  1.4G   1% /pablo/therema
/dev/mapper/vg1-lv2       ext4      1.5G   24K  1.4G   1% /pablo/mederma
```

Till now I had created three partitions in the disk **sdc**, two primary and one extended. Now I will create a new partition named as **/dev/sdc4** and will create physical volume then extend vg1 and finally lv1. After that I will extend the LVM lv0 and will shrink the LVM lv2.

Before creating a new partition in the disk **sdc**, unmount and swapoff all the existed partitions of the disk.

```
[root@therema-server ~]# swapoff /dev/vg0/lv0
[root@therema-server ~]# umount -l /dev/vg1/lv1
[root@therema-server ~]# umount -l /dev/vg1/lv2
```

```
[root@therema-server ~]# fdisk /dev/sdc
```

```
Command (m for help): n
Partition type
   p   primary (2 primary, 1 extended, 1 free)
   l   logical (numbered from 5)
Select (default p):

Using default response p.
Selected partition 4
First sector (18876416-20971519, default 18876416):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (18876416-20971519, default 20971519): +512M

Created a new partition 4 of type 'Linux' and of size 512 MiB.

Command (m for help): t
Partition number (1-8, default 8): 4
Hex code or alias (type L to list all): 8e

Changed type of partition 'Linux' to 'Linux LVM'.

Command (m for help): w
The partition table has been altered.
Syncing disks.
```

```
[root@therema-server ~]# fdisk -l /dev/sdc
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: VMware Virtual S
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x18eed553

Device     Boot    Start      End  Sectors  Size Id Type
/dev/sdc1           2048  4196351  4194304    2G 8e Linux LVM
/dev/sdc2        4196352  8390655  4194304    2G 8e Linux LVM
/dev/sdc3        8390656 18876415 10485760    5G  5 Extended
/dev/sdc4       18876416 19924991  1048576  512M 8e Linux LVM
/dev/sdc5        8392704 10489855  2097152    1G 8e Linux LVM
/dev/sdc6       10491904 12589055  2097152    1G 8e Linux LVM
/dev/sdc7       12591104 14688255  2097152    1G 8e Linux LVM
/dev/sdc8       14690304 17836031  3145728  1.5G 8e Linux LVM

Partition table entries are not in disk order.
```

```
[root@therema-server ~]# partprobe /dev/sdc
```

```
[root@therema-server ~]# pvcreate /dev/sdc4
  Physical volume "/dev/sdc4" successfully created.
[root@therema-server ~]# pvdisplay
```

```
  "/dev/sdc4" is a new physical volume of "512.00 MiB"
  --- NEW Physical volume ---
  PV Name               /dev/sdc4
  VG Name
  PV Size               512.00 MiB
  Allocatable           NO
  PE Size               0
  Total PE              0
  Free PE               0
  Allocated PE          0
  PV UUID               [redacted]
```

```
[root@therema-server ~]# vgextend vg1 /dev/sdc4
  Volume group "vg1" successfully extended
[root@therema-server ~]# vgdisplay
  --- Volume group ---
  VG Name               vg1
  System ID
  Format                lvm2
  Metadata Areas        5
  Metadata Sequence No  4
  VG Access             read/write
  VG Status             resizable
  MAX LV                0
  Cur LV                2
  Open LV               0
  Max PV                0
  Cur PV                5
  Act PV                5
  VG Size               4.98 GiB
  PE Size               4.00 MiB
  Total PE              1275
  Alloc PE / Size       768 / 3.00 GiB
  Free  PE / Size       507 / 1.98 GiB
  VG UUID               [redacted]
```

```
[root@therema-server ~]# lvextend -L +512M /dev/vg1/lv1
  Size of logical volume vg1/lv1 changed from 1.50 GiB (384 extents) to 2.00 GiB (512 extents).
  Logical volume vg1/lv1 successfully resized.
```

```
[root@therema-server ~]# e2fsck -f /dev/vg1/lv1
e2fsck 1.46.5 (30-Dec-2021)
Pass 1: Checking inodes, blocks, and sizes
Pass 2: Checking directory structure
Pass 3: Checking directory connectivity
Pass 4: Checking reference counts
Pass 5: Checking group summary information
/dev/vg1/lv1: 11/98304 files (0.0% non-contiguous), 15524/393216 blocks
[root@therema-server ~]# resize2fs /dev/vg1/lv1
resize2fs 1.46.5 (30-Dec-2021)
Resizing the filesystem on /dev/vg1/lv1 to 524288 (4k) blocks.
The filesystem on /dev/vg1/lv1 is now 524288 (4k) blocks long.
```

```
[root@therema-server ~]# lvextend -L +512M /dev/vg0/lv0
  Size of logical volume vg0/lv0 changed from 1.50 GiB (384 extents) to 2.00 GiB (512 extents).
  Logical volume vg0/lv0 successfully resized.
[root@therema-server ~]# mkswap /dev/vg0/lv0
mkswap: /dev/vg0/lv0: warning: wiping old swap signature.
Setting up swapspace version 1, size = 2 GiB (2147479552 bytes)
no label, UUID=[redacted]
```

```
[root@therema-server ~]# lvextend -L +512M /dev/vg0/lv0
  Size of logical volume vg0/lv0 changed from 1.50 GiB (384 extents) to 2.00 GiB (512 extents).
  Logical volume vg0/lv0 successfully resized.
[root@therema-server ~]# mkswap /dev/vg0/lv0
mkswap: /dev/vg0/lv0: warning: wiping old swap signature.
Setting up swapspace version 1, size = 2 GiB (2147479552 bytes)
no label, UUID=
```

```
[root@therema-server ~]# fsck -f /dev/vg1/lv2
fsck from util-linux 2.37.4
e2fsck 1.46.5 (30-Dec-2021)
Pass 1: Checking inodes, blocks, and sizes
Pass 2: Checking directory structure
Pass 3: Checking directory connectivity
Pass 4: Checking reference counts
Pass 5: Checking group summary information
/dev/mapper/vg1-lv2: 11/65536 files (0.0% non-contiguous), 13275/262144 blocks
[root@therema-server ~]# resize2fs /dev/vg1/lv2 512M
resize2fs 1.46.5 (30-Dec-2021)
Resizing the filesystem on /dev/vg1/lv2 to 131072 (4k) blocks.
The filesystem on /dev/vg1/lv2 is now 131072 (4k) blocks long.

[root@therema-server ~]# lvreduce -L 1G /dev/vg1/lv2
  File system ext4 found on vg1/lv2.
  File system size (512.00 MiB) is smaller than the requested size (1.00 GiB).
  File system reduce is not needed, skipping.
  Size of logical volume vg1/lv2 changed from 1.50 GiB (384 extents) to 1.00 GiB (256 extents).
  Logical volume vg1/lv2 successfully resized.
```

```
[root@therema-server ~]# lvdisplay
  --- Logical volume ---
  LV Path                /dev/vg1/lv1
  LV Name                lv1
  VG Name                vg1
  LV UUID                TS3ara-29TR-Hsoe-r4uv-ZHc3-bODT-DDtRrO
  LV Write Access        read/write
  LV Creation host, time therema-server, 2025-10-30 22:13:37 +0530
  LV Status              available
  # open                 1
  LV Size                2.00 GiB
  Current LE             512
  Segments               3
  Allocation             inherit
  Read ahead sectors     auto
  - currently set to     256
  Block device           253:3

  --- Logical volume ---
  LV Path                /dev/vg1/lv2
  LV Name                lv2
  VG Name                vg1
  LV UUID                gHXDF4-ejUo-ZRww-bZQx-Am5S-WXeH-M6423c
  LV Write Access        read/write
  LV Creation host, time therema-server, 2025-10-30 22:14:43 +0530
  LV Status              available
  # open                 1
  LV Size                1.00 GiB
  Current LE             256
  Segments               2
  Allocation             inherit
  Read ahead sectors     auto
  - currently set to     256
  Block device           253:4
```

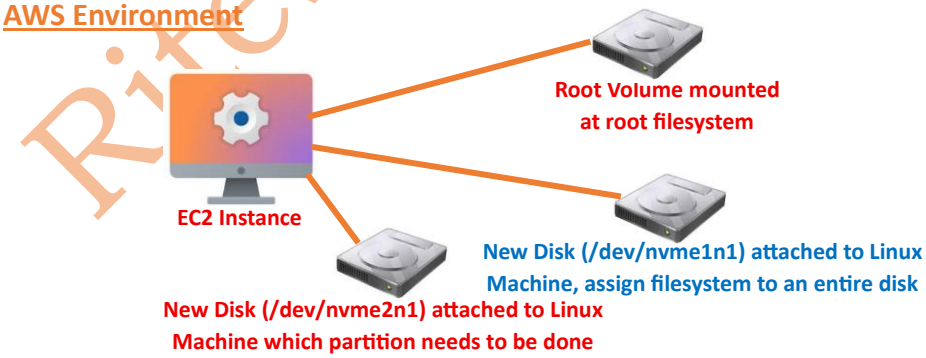
```
  --- Logical volume ---
  LV Path                /dev/vg0/lv0
  LV Name                lv0
  VG Name                vg0
  LV UUID                ZN0J7y-FLvs-bt5X-fNLb-f7bg-O9A0-Iit0gR
  LV Write Access        read/write
  LV Creation host, time therema-server, 2025-10-30 21:47:09 +0530
  LV Status              available
  # open                 2
  LV Size                2.00 GiB
  Current LE             512
  Segments               2
  Allocation             inherit
  Read ahead sectors     auto
  - currently set to     256
  Block device           253:2
```

```
[root@therema-server ~]# swapon -a
[root@therema-server ~]# mount -a
[root@therema-server ~]# df -hT
Filesystem                Type      Size  Used Avail Use% Mounted on
devtmpfs                  devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs                     tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs                     tmpfs     725M  9.9M  715M   2% /run
/dev/mapper/almalinux-root xfs       44G  5.8G   39G  14% /
/dev/sda1                 xfs       960M  366M  595M  39% /boot
/dev/mapper/vg1-lv1       ext4      2.0G   24K  1.9G   1% /pablo/therema
/dev/sdb                  ext4      9.8G   24K  9.3G   1% /dexter
tmpfs                     tmpfs     363M   52K  363M   1% /run/user/42
tmpfs                     tmpfs     363M   92K  363M   1% /run/user/1000
/dev/sr0                  iso9660    12G   12G     0 100% /run/media/ritesh/AlmaLinux-9-6-x86_64-dvd
/dev/mapper/vg1-lv2       ext4      974M   24K  907M   1% /pablo/mederma
[root@therema-server ~]# free -mh
               total        used        free      shared  buff/cache   available
Mem:           3.5Gi       1.3Gi       838Mi        19Mi       1.7Gi       2.2Gi
Swap:          7.0Gi          0B       7.0Gi
```

The disk portioning as shown above had been performed on **Almalinux 9.6**.

```
[root@therema-server ~]# cat /etc/os-release
NAME="AlmaLinux"
VERSION="9.6 (Sage Margay)"
ID="almalinux"
ID_LIKE="rhel centos fedora"
VERSION_ID="9.6"
PLATFORM_ID="platform:el9"
PRETTY_NAME="AlmaLinux 9.6 (Sage Margay)"
ANSI_COLOR="0;34"
LOGO="fedora-logo-icon"
CPE_NAME="cpe:/o:almalinux:almalinux:9::baseos"
HOME_URL="https://almalinux.org/"
DOCUMENTATION_URL="https://wiki.almalinux.org/"
BUG_REPORT_URL="https://bugs.almalinux.org/"

ALMALINUX_MANTISBT_PROJECT="AlmaLinux-9"
ALMALINUX_MANTISBT_PROJECT_VERSION="9.6"
REDHAT_SUPPORT_PRODUCT="AlmaLinux"
REDHAT_SUPPORT_PRODUCT_VERSION="9.6"
SUPPORT_END=2032-06-01
```

AWS Environment



In industry you may face the problem that on a Running EC2 Instance the attached volume may full, in that case you need to increase the size of attached EBS Volume. As per the project requirement you may need to create a new EBS volume and attach it to the Running EC2 Instance. I had used Amazon Linux 2023 as the Operating System.

```
[root@ip-172-31-18-218 ~]# df -hT
Filesystem       Type      Size  Used Avail Use% Mounted on
devtmpfs         devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs            tmpfs     453M     0  453M   0% /dev/shm
tmpfs            tmpfs     181M  424K  181M   1% /run
/dev/nvme0n1p1   xfs       8.0G  1.6G  6.4G  20% /
tmpfs            tmpfs     453M     0  453M   0% /tmp
/dev/nvme0n1p128 vfat       10M  1.3M  8.7M  13% /boot/efi
tmpfs            tmpfs      91M     0   91M   0% /run/user/1001
```

Let us consider that the attached EBS Volume had been full and we need to increase the size of EBS Volume. First in the terraform script for EC2 Instance provide the increased size for parameter **volume_size** to the desired new size in GB then run **terraform plan** proceed by **terraform apply**. For this project earlier the root volume size was 8GB and later it was increase by 7GB (targeted size=15GB). Which has started reflecting in the AWS Console as well after running the terraform apply command. Now check using the command **lsblk**, you find that volume size had been increase but not reflected in the mounted partition size.

```
[root@ip-172-31-18-218 ~]# lsblk
NAME          MAJ:MIN RM SIZE RO TYPE MOUNTPOINTS
nvme0n1       259:0    0  15G  0 disk
├─nvme0n1p1   259:1    0   8G  0 part /
├─nvme0n1p127 259:2    0   1M  0 part
└─nvme0n1p128 259:3    0  10M  0 part /boot/efi
[root@ip-172-31-18-218 ~]# df -hT
Filesystem       Type      Size  Used Avail Use% Mounted on
devtmpfs         devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs            tmpfs     453M     0  453M   0% /dev/shm
tmpfs            tmpfs     181M  424K  181M   1% /run
/dev/nvme0n1p1   xfs       8.0G  1.6G  6.4G  20% /
tmpfs            tmpfs     453M     0  453M   0% /tmp
/dev/nvme0n1p128 vfat       10M  1.3M  8.7M  13% /boot/efi
tmpfs            tmpfs      91M     0   91M   0% /run/user/1001
```

Run the below command and then check you will find that mounted partition size will be increased.

```
[root@ip-172-31-18-218 ~]# growpart /dev/nvme0n1 1
CHANGED: partition=1 start=24576 old: size=16752607 end=16777183 new: size=31432671 end=31457247
[root@ip-172-31-18-218 ~]# xfs_growfs /dev/nvme0n1p1
meta-data=/dev/nvme0n1p1         isize=512    agcount=2, agsize=1047040 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=1 inobtcount=1 nrext64=0
         =                       exchange=0
data     =                       bsize=4096   blocks=2094075, imaxpct=25
         =                       sunit=128    swidth=128 blks
naming   =version 2              bsize=16384  ascii-ci=0, ftype=1, parent=0
log      =internal log           bsize=4096   blocks=16384, version=2
         =                       sectsz=4096  sunit=4 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
data blocks changed from 2094075 to 3929083
[root@ip-172-31-18-218 ~]# df -hT
Filesystem       Type      Size  Used Avail Use% Mounted on
devtmpfs         devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs            tmpfs     453M     0  453M   0% /dev/shm
tmpfs            tmpfs     181M  424K  181M   1% /run
/dev/nvme0n1p1   xfs        15G  1.6G   14G  11% /
tmpfs            tmpfs     453M     0  453M   0% /tmp
/dev/nvme0n1p128 vfat       10M  1.3M  8.7M  13% /boot/efi
tmpfs            tmpfs      91M     0   91M   0% /run/user/1001
```

Using Terraform script I created two EBS volumes and attached it to the same Running EC2 Instance. Then I checked using the command **lsblk** my findings are as shown in the screenshot attached below.

```
[root@ip-172-31-18-218 ~]# lsblk
NAME          MAJ:MIN RM SIZE RO TYPE MOUNTPOINTS
nvme0n1       259:0    0  15G  0 disk
├─nvme0n1p1   259:1    0  15G  0 part /
├─nvme0n1p127 259:2    0   1M  0 part
└─nvme0n1p128 259:3    0  10M  0 part /boot/efi
nvme1n1       259:4    0   5G  0 disk
nvme2n1       259:5    0  10G  0 disk
```

```
[root@ip-172-31-18-218 ~]# mkfs.xfs /dev/nvme1n1
meta-data=/dev/nvme1n1           isize=512    agcount=8, agsize=163840 blks
         =                       sectsz=512   attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=1 inobtcount=1 nrext64=0
         =                       exchange=0
data     =                       bsize=4096   blocks=1310720, imaxpct=25
         =                       sunit=1      swidth=1 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1, parent=0
log      =internal log           bsize=4096   blocks=16384, version=2
         =                       sectsz=512   sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
[root@ip-172-31-18-218 ~]# mkdir -p /thaplex/zikomo
```

```
[root@ip-172-31-18-218 ~]# cat /etc/fstab
#
UUID=                                  /           xfs    defaults,noatime  1   1
UUID=161A-5EA2        /boot/efi       vfat    defaults,noatime,uid=0,gid=0,umask=0077,shortname=winnt,x-systemd.automount 0 2

/dev/nvme1n1 /thaplex/zikomo xfs defaults 0 0
[root@ip-172-31-18-218 ~]# mount -a
[root@ip-172-31-18-218 ~]# df -hT
Filesystem       Type      Size  Used Avail Use% Mounted on
devtmpfs         devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs            tmpfs     453M     0  453M   0% /dev/shm
tmpfs            tmpfs     181M  440K  181M   1% /run
/dev/nvme0n1p1   xfs        15G  1.6G   14G  11% /
tmpfs            tmpfs     453M     0  453M   0% /tmp
/dev/nvme0n1p128 vfat       10M  1.3M  8.7M  13% /boot/efi
tmpfs            tmpfs      91M     0   91M   0% /run/user/1001
/dev/nvme1n1     xfs       5.0G   68M  4.9G   2% /thaplex/zikomo
```

```
[root@ip-172-31-18-218 ~]# fdisk /dev/nvme2n1

Welcome to fdisk (util-linux 2.37.4).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Device does not contain a recognized partition table.
Created a new DOS disklabel with disk identifier 0x8fd10c7b.

Command (m for help): n
Partition type
   p   primary (0 primary, 0 extended, 4 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (1-4, default 1):
First sector (2048-20971519, default 2048):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (2048-20971519, default 20971519): +2G

Created a new partition 1 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Selected partition 1
Hex code or alias (type L to list all): L

00 Empty            24 NEC DOS          81 Minix / old Lin  bf Solaris
01 FAT12            27 Hidden NTFS Win  82 Linux swap / So  c1 DRDOS/sec (FAT-
02 XENIX root       39 Plan 9           83 Linux            c4 DRDOS/sec (FAT-
03 XENIX usr        3c PartitionMagic   84 OS/2 hidden or   c6 DRDOS/sec (FAT-
04 FAT16 <32M       40 Venix 80286      85 Linux extended   c7 Syrinx
05 Extended         41 PPC PReP Boot    86 NTFS volume set  da Non-FS data
06 FAT16            42 SFS              87 NTFS volume set  db CP/M / CTOS / .
07 HPFS/NTFS/exFAT  4d QNX4.x           88 Linux plaintext  de Dell Utility
08 AIX              4e QNX4.x 2nd part  8e Linux LVM        df BootIt
09 AIX bootable     4f QNX4.x 3rd part  93 Amoeba           e1 DOS access
0a OS/2 Boot Manag  50 OnTrack DM       94 Amoeba BBT       e3 DOS R/O
0b W95 FAT32        51 OnTrack DM6 Aux  9f BSD/OS           e4 SpeedStor
0c W95 FAT32 (LBA)  52 CP/M             a0 IBM Thinkpad hi  ea Linux extended
```

```
Aliases:
   linux           - 83
   swap            - 82
   extended        - 05
   uefi            - EF
   raid            - FD
   lvm             - 8E
   linuxex         - 85
Hex code or alias (type L to list all): 83
Changed type of partition 'Linux' to 'Linux'.

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```



```
[root@ip-172-31-18-218 ~]# fdisk /dev/nvme2n1

Welcome to fdisk (util-linux 2.37.4).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (2-4, default 2):
First sector (4196352-20971519, default 4196352):
Last sector, +/-sectors or +/-size{K,M,G,T,P} (4196352-20971519, default 20971519): +2G

Created a new partition 2 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Partition number (1,2, default 2):
Hex code or alias (type L to list all): 83

Changed type of partition 'Linux' to 'Linux'.

Command (m for help): p
Disk /dev/nvme2n1: 10 GiB, 10737418240 bytes, 20971520 sectors
Disk model: Amazon Elastic Block Store
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0x8fd10c7b

Device         Boot   Start     End Sectors Size Id Type
/dev/nvme2n1p1         2048 4196351 4194304   2G 83 Linux
/dev/nvme2n1p2      4196352 8390655 4194304   2G 83 Linux
```

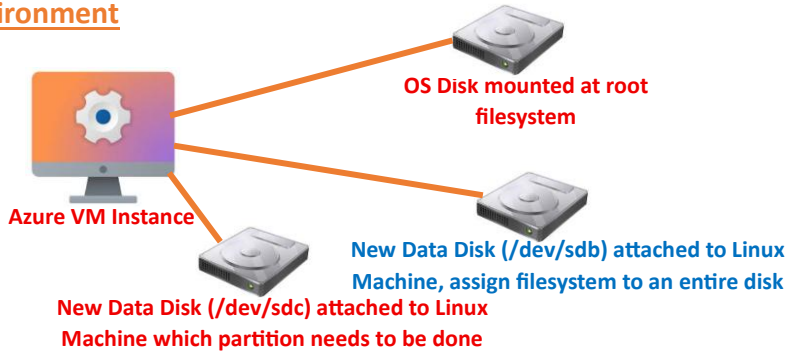
```
Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@ip-172-31-18-218 ~]# mkdir /thaplex/jonghou
[root@ip-172-31-18-218 ~]# mkdir /thaplex/dexter
```

```
[root@ip-172-31-18-218 ~]# partprobe /dev/nvme2n1
[root@ip-172-31-18-218 ~]# mkfs.ext4 /dev/nvme2n1p1
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 524288 4k blocks and 131072 inodes
Filesystem UUID: dd5dd21e-5e2f-4788-a07a-7b53bffc0d07
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done

[root@ip-172-31-18-218 ~]# mkfs.ext4 /dev/nvme2n1p2
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 524288 4k blocks and 131072 inodes
Filesystem UUID: 3043ccb2-b479-4d94-a149-f1a0555332ba
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done
```

```
[root@ip-172-31-18-218 ~]# cat /etc/fstab
#
UUID=[redacted]     /           xfs    defaults,noatime  1   1
UUID=[redacted]     /boot/efi       vfat    defaults,noatime,uid=0,gid=0,umask=0077,shortname=winnt,x-systemd.automount 0 2

/dev/nvme1n1 /thaplex/zikomo xfs defaults 0 0

/dev/nvme2n1p1 /thaplex/jonghou ext4 defaults 0 0

/dev/nvme2n1p2 /thaplex/dexter ext4 defaults 0 0
[root@ip-172-31-18-218 ~]# mount -a
[root@ip-172-31-18-218 ~]# df -hT
Filesystem       Type      Size  Used Avail Use% Mounted on
devtmpfs         devtmpfs  4.0M     0  4.0M   0% /dev
tmpfs            tmpfs     453M     0  453M   0% /dev/shm
tmpfs            tmpfs     181M  448K  181M   1% /run
/dev/nvme0n1p1   xfs        15G  1.6G   14G  11% /
tmpfs            tmpfs     453M     0  453M   0% /tmp
/dev/nvme0n1p128 vfat       10M  1.3M  8.7M  13% /boot/efi
tmpfs            tmpfs      91M     0   91M   0% /run/user/1001
/dev/nvme1n1     xfs       5.0G   68M  4.9G   2% /thaplex/zikomo
/dev/nvme2n1p1   ext4      2.0G   24K  1.8G   1% /thaplex/jonghou
/dev/nvme2n1p2   ext4      2.0G   24K  1.8G   1% /thaplex/dexter
```

Azure Environment



In industry you may face the problem that on a Running Azure VM the attached OS Disk may full, in that case you need to increase the size of attached OS Disk. For this project I had created the Azure VM using terraform script and as per the project requirement I need to increase the size of OS Disk from 30GB to 35GB. In terraform script of azure vm I increased the size using the parameter **os_disk = 35** (targeted size in GB), increasing the size of Azure VM OS Disk will restart the Azure VM So plan this activity during non-production hours. As per the project requirement you may need to create new Data Disks and attach it to the Running Azure VM. I created two data disks of size 5 and 10GB and attached to the running Azure VM using the terraform script. I had used Almalinux 8.10 as the Operating System.

```
[root@Dexter-Server ~]# cat /etc/os-release
NAME="AlmaLinux"
VERSION="8.10 (Cerulean Leopard)"
ID="almalinux"
ID_LIKE="rhel centos fedora"
VERSION_ID="8.10"
PLATFORM_ID="platform:el8"
PRETTY_NAME="AlmaLinux 8.10 (Cerulean Leopard)"
ANSI_COLOR="0;34"
LOGO="fedora-logo-icon"
CPE_NAME="cpe:/o:almalinux:almalinux:8::baseos"
HOME_URL="https://almalinux.org/"
DOCUMENTATION_URL="https://wiki.almalinux.org/"
BUG_REPORT_URL="https://bugs.almalinux.org/"

ALMALINUX_MANTISBT_PROJECT="AlmaLinux-8"
ALMALINUX_MANTISBT_PROJECT_VERSION="8.10"
REDHAT_SUPPORT_PRODUCT="AlmaLinux"
REDHAT_SUPPORT_PRODUCT_VERSION="8.10"
SUPPORT_END=2029-06-01
```

```
[root@Dexter-Server ~]# lsblk
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda      8:0    0   30G  0 disk
├─sda1   8:1    0    1M  0 part
├─sda2   8:2    0  200M  0 part /boot/efi
├─sda3   8:3    0    1G  0 part /boot
└─sda4   8:4    0 28.8G  0 part /
sdb      8:16   0    4G  0 disk
└─sdb1   8:17   0    4G  0 part /mnt
sdc      8:32   0   10G  0 disk
sdd      8:48   0    5G  0 disk
sr0     11:0    1  634K  0 rom
```

The screenshot after increasing the size is as shown below.

```
[root@Dexter-Server ~]# lsblk
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda      8:0    0   35G  0 disk
├─sda1   8:1    0    1M  0 part
├─sda2   8:2    0  200M  0 part /boot/efi
├─sda3   8:3    0    1G  0 part /boot
└─sda4   8:4    0 33.8G  0 part /
sdb      8:16   0    4G  0 disk
└─sdb1   8:17   0    4G  0 part /mnt
sdc      8:32   0   10G  0 disk
sdd      8:48   0    5G  0 disk
```

After increasing the size of OS Disk, it will be automatically reflected in the partition as shown in the screenshot attached below.

```
[root@Dexter-Server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  406M     0  406M   0% /dev
tmpfs          tmpfs     449M     0  449M   0% /dev/shm
tmpfs          tmpfs     449M   12M  438M   3% /run
tmpfs          tmpfs     449M     0  449M   0% /sys/fs/cgroup
/dev/sda4      xfs        34G  2.7G   32G   8% /
/dev/sda3      xfs      1014M  225M  790M  23% /boot
/dev/sda2      vfat      200M  5.9M  194M   3% /boot/efi
/dev/sdb1      ext4      3.9G   28K  3.7G   1% /mnt
tmpfs          tmpfs      90M     0   90M   0% /run/user/1000
```

```
[root@Dexter-Server ~]# mkfs.xfs /dev/sdd
meta-data=/dev/sdd               isize=512    agcount=4, agsize=327680 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=0 inobtcount=0
data     =                       bsize=4096   blocks=1310720, imaxpct=25
         =                       sunit=0      swidth=0 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=2560, version=2
         =                       sectsz=4096  sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
Discarding blocks...Done.
[root@Dexter-Server ~]# mkdir -p /zaxv/hanzo
```

```
[root@Dexter-Server ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Fri Sep  5 09:17:25 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
UUID=[redacted] /                       xfs     defaults        0 0
UUID=[redacted] /boot                   xfs     defaults        0 0
UUID=[redacted]             /boot/efi               vfat    defaults,uid=0,gid=0,umask=077,shortname=winnt 0 2
/dev/disk/cloud/azure_resource-part1    /mnt    auto    defaults,nofail,x-systemd.requires=cloud-init.service,_netdev,comment=cloudconfig      0       2

/dev/sdd /zaxv/hanzo xfs defaults 0 0
[root@Dexter-Server ~]# mount -a
```

```
[root@Dexter-Server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  406M     0  406M   0% /dev
tmpfs          tmpfs     449M     0  449M   0% /dev/shm
tmpfs          tmpfs     449M   12M  438M   3% /run
tmpfs          tmpfs     449M     0  449M   0% /sys/fs/cgroup
/dev/sda4      xfs        34G  2.9G   31G   9% /
/dev/sda3      xfs      1014M  225M  790M  23% /boot
/dev/sda2      vfat      200M  5.9M  194M   3% /boot/efi
/dev/sdb1      ext4      3.9G   28K  3.7G   1% /mnt
tmpfs          tmpfs      90M     0   90M   0% /run/user/1000
/dev/sdd       xfs        5.0G   68M  5.0G   2% /zaxv/hanzo
```

```
[root@Dexter-Server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.32.1).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Device does not contain a recognized partition table.
Created a new DOS disklabel with disk identifier 0xbdbbbf64.

Command (m for help): n
Partition type
   p   primary (0 primary, 0 extended, 4 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (1-4, default 1):
First sector (2048-20971519, default 2048):
Last sector, +sectors or +size{K,M,G,T,P} (2048-20971519, default 20971519): +2G

Created a new partition 1 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Selected partition 1
Hex code (type L to list all codes): 83
Changed type of partition 'Linux' to 'Linux'.

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@Dexter-Server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.32.1).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.


Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (2-4, default 2):
First sector (4196352-20971519, default 4196352):
Last sector, +sectors or +size{K,M,G,T,P} (4196352-20971519, default 20971519): +2G

Created a new partition 2 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Partition number (1,2, default 2):
Hex code (type L to list all codes): 83

Changed type of partition 'Linux' to 'Linux'.

Command (m for help): p
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0xbdbbbf64

Device     Boot   Start     End Sectors Size Id Type
/dev/sdc1          2048 4196351 4194304   2G 83 Linux
/dev/sdc2       4196352 8390655 4194304   2G 83 Linux
```

```
Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

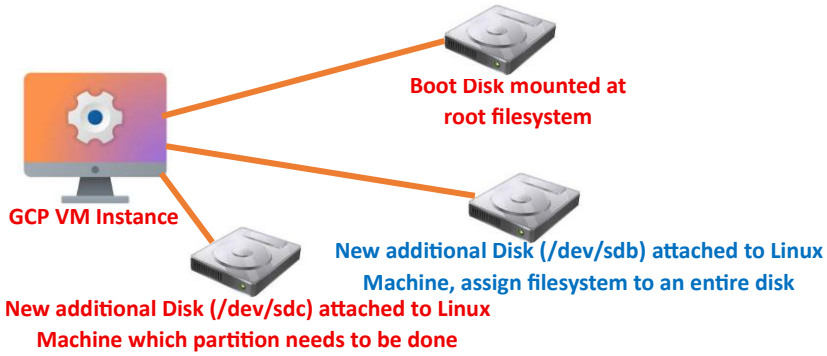
```
[root@Dexter-Server ~]# partprobe /dev/sdc
```

```
[root@Dexter-Server ~]# mkfs.xfs /dev/sdc1
meta-data=/dev/sdc1              isize=512    agcount=4, agsize=131072 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=0 inobtcount=0
data     =                       bsize=4096   blocks=524288, imaxpct=25
         =                       sunit=0      swidth=0 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=2560, version=2
         =                       sectsz=4096  sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
Discarding blocks...Done.
[root@Dexter-Server ~]# mkfs.ext4 /dev/sdc2
mke2fs 1.45.6 (20-Mar-2020)
Discarding device blocks: done
Creating filesystem with 524288 4k blocks and 131072 inodes
Filesystem UUID: 910842a7-4748-4217-81fa-155f803af7a6
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done

[root@Dexter-Server ~]# mkdir /zaxv/mederma
[root@Dexter-Server ~]# mkdir /zaxv/dexter
```

```
[root@Dexter-Server ~]# cat /etc/fstab

#
# /etc/fstab
# Created by anaconda on Fri Sep  5 09:17:25 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
UUID=[redacted] /                       xfs     defaults        0 0
UUID=[redacted] /boot                   xfs     defaults        0 0
UUID=[redacted]          /boot/efi              vfat    defaults,uid=0,gid=0,umask=077,shortname=winnt 0 2
/dev/disk/cloud/azure_resource-part1    /mnt    auto    defaults,nofail,x-systemd.requires=cloud-init.service,_netdev,comment=cloudconfig      0       2

/dev/sdd /zaxv/hanzo xfs defaults 0 0

/dev/sdc1 /zaxv/mederma xfs defaults 0 0

/dev/sdc2 /zaxv/dexter ext4 defaults 0 0
[root@Dexter-Server ~]# mount -a
```

```
[root@Dexter-Server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  406M     0  406M   0% /dev
tmpfs          tmpfs     449M     0  449M   0% /dev/shm
tmpfs          tmpfs     449M   12M  437M   3% /run
tmpfs          tmpfs     449M     0  449M   0% /sys/fs/cgroup
/dev/sda4      xfs        34G  2.9G   31G   9% /
/dev/sda3      xfs      1014M  225M  790M  23% /boot
/dev/sda2      vfat      200M  5.9M  194M   3% /boot/efi
/dev/sdb1      ext4      3.9G   28K  3.7G   1% /mnt
tmpfs          tmpfs      90M     0   90M   0% /run/user/1000
/dev/sdd       xfs       5.0G   68M  5.0G   2% /zaxv/hanzo
/dev/sdc1      xfs       2.0G   47M  2.0G   3% /zaxv/mederma
/dev/sdc2      ext4      2.0G   24K  1.8G   1% /zaxv/dexter
```

Google Cloud Platform (GCP) Environment



In industry you may face the problem that on a Running GCP VM Instance the attached boot disk may full, in that case you need to increase the size of boot disk. For this project I had created the GCP VM Instance using terraform script and as per the project requirement I need to increase the size of boot disk from 20GB to 25GB. In terraform script of azure vm I increased the size using the parameter **size = 25** (targeted size in GB) under the block **boot_disk** in terraform script. As per the project requirement you may need to create new Data Disks and attach it to the Running Azure VM. I created two data disks of size 10GB each and attached to the running Azure VM using the terraform script. I had used Rocky Linux 8.10 as the Operating System.

```
[root@mederma-server ~]# cat /etc/os-release
NAME="Rocky Linux"
VERSION="8.10 (Green Obsidian)"
ID="rocky"
ID_LIKE="rhel centos fedora"
VERSION_ID="8.10"
PLATFORM_ID="platform:el8"
PRETTY_NAME="Rocky Linux 8.10 (Green Obsidian)"
ANSI_COLOR="0;32"
LOGO="fedora-logo-icon"
CPE_NAME="cpe:/o:rocky:rocky:8:GA"
HOME_URL="https://rockylinux.org/"
BUG_REPORT_URL="https://bugs.rockylinux.org/"
SUPPORT_END="2029-05-31"
ROCKY_SUPPORT_PRODUCT="Rocky-Linux-8"
ROCKY_SUPPORT_PRODUCT_VERSION="8.10"
REDHAT_SUPPORT_PRODUCT="Rocky Linux"
REDHAT_SUPPORT_PRODUCT_VERSION="8.10"
```

```
[root@mederma-server ~]# lsblk
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda      8:0    0   20G  0 disk
├─sda1   8:1    0  200M  0 part /boot/efi
└─sda2   8:2    0 19.8G  0 part /
[root@mederma-server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs          tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs          tmpfs     1.8G   17M  1.8G   1% /run
tmpfs          tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/sda2      xfs        20G  4.3G   16G  22% /
/dev/sda1      vfat      200M  5.8M  194M   3% /boot/efi
tmpfs          tmpfs     367M     0  367M   0% /run/user/1000
```

After running the terraform script, size of boot disk had been increased and attached two extra disks to the GCP VM Instance as shown in the screenshot attached below.

```
[root@mederma-server ~]# lsblk
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda      8:0    0   25G  0 disk
├─sda1   8:1    0  200M  0 part /boot/efi
└─sda2   8:2    0 19.8G  0 part /
sdb      8:16   0   10G  0 disk
sdc      8:32   0   10G  0 disk
[root@mederma-server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs          tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs          tmpfs     1.8G   17M  1.8G   1% /run
tmpfs          tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/sda2      xfs        20G  5.0G   15G  26% /
/dev/sda1      vfat      200M  5.8M  194M   3% /boot/efi
tmpfs          tmpfs     367M     0  367M   0% /run/user/1000
```

For extra disk **/dev/sdb** I assigned xfs filesystem to it and then mounted it to a directory. For extra disk **/dev/sdc** I created two primary partitions **/dev/sdc1** and **/dev/sdc2** then assigned filesystem xfs and ext4 then mounted it to the directory to make it usable.

For boot disk you can see from above attached screenshot that size had been increased but not reflecting in the mounted partition, which can be achieved as discussed below.

In GCP Rocky Linux 8.10 VM Instance **growpart** command is not available to make it available you need to install the package **cloud-utils-growpart**, you can install it using the command **yum install cloud-utils-growpart -y**.

```
[root@mederma-server ~]# yum install cloud-utils-growpart -y
```

```
[root@mederma-server ~]# growpart /dev/sda 2
CHANGED: partition=2 start=411648 old: size=41529344 end=41940991 new: size=52017119 end=52428766
[root@mederma-server ~]# xfs_growfs /dev/sda2
meta-data=/dev/sda2              isize=512    agcount=4, agsize=1297792 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=0 inobtcount=0
data     =                       bsize=4096   blocks=5191168, imaxpct=25
         =                       sunit=0      swidth=0 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=2560, version=2
         =                       sectsz=4096  sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
data blocks changed from 5191168 to 6502139
[root@mederma-server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs          tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs          tmpfs     1.8G   17M  1.8G   1% /run
tmpfs          tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/sda2      xfs        25G  5.1G   20G  21% /
/dev/sda1      vfat      200M  5.8M  194M   3% /boot/efi
tmpfs          tmpfs     367M     0  367M   0% /run/user/1000
```

```
[root@mederma-server ~]# mkdir -p /pablo/pather
```

```
[root@mederma-server ~]# mkfs.xfs /dev/sdb
meta-data=/dev/sdb               isize=512    agcount=4, agsize=655360 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=0 inobtcount=0
data     =                       bsize=4096   blocks=2621440, imaxpct=25
         =                       sunit=0      swidth=0 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=2560, version=2
         =                       sectsz=4096  sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
Discarding blocks...Done.
```

```
[root@mederma-server ~]# cat /etc/fstab
#
# /etc/fstab
# Created by anaconda on Tue Oct 14 09:28:19 2025
#
# Accessible filesystems, by reference, are maintained under '/dev/disk/'.
# See man pages fstab(5), findfs(8), mount(8) and/or blkid(8) for more info.
#
# After editing this file, run 'systemctl daemon-reload' to update systemd
# units generated from this file.
#
UUID=[redacted] /                       xfs     defaults        0 0
UUID=[redacted]          /boot/efi              vfat    defaults,uid=0,gid=0,umask=077,shortname=winnt 0 2

/dev/sdb /pablo/pather xfs defaults 0 0
[root@mederma-server ~]# mount -a
```

```
[root@mederma-server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs          tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs          tmpfs     1.8G   17M  1.8G   1% /run
tmpfs          tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/sda2      xfs        25G  5.1G   20G  21% /
/dev/sda1      vfat      200M  5.8M  194M   3% /boot/efi
tmpfs          tmpfs     367M     0  367M   0% /run/user/1000
/dev/sdb       xfs        10G  104M  9.9G   2% /pablo/pather
```

```
[root@mederma-server ~]# fdisk /dev/sdc

Welcome to fdisk (util-linux 2.32.1).
Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Device does not contain a recognized partition table.
Created a new DOS disklabel with disk identifier 0x3b60d6a9.

Command (m for help): n
Partition type
   p   primary (0 primary, 0 extended, 4 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (1-4, default 1):
First sector (2048-20971519, default 2048):
Last sector, +sectors or +size{K,M,G,T,P} (2048-20971519, default 20971519): +2G

Created a new partition 1 of type 'Linux' and of size 2 GiB.

Command (m for help): t
Selected partition 1
Hex code (type L to list all codes): 83
Changed type of partition 'Linux' to 'Linux'.

Command (m for help): n
Partition type
   p   primary (1 primary, 0 extended, 3 free)
   e   extended (container for logical partitions)
Select (default p):

Using default response p.
Partition number (2-4, default 2):
First sector (4196352-20971519, default 4196352):
Last sector, +sectors or +size{K,M,G,T,P} (4196352-20971519, default 20971519): +2G

Created a new partition 2 of type 'Linux' and of size 2 GiB.
```

```
Command (m for help): t
Partition number (1,2, default 2):
Hex code (type L to list all codes): 83

Changed type of partition 'Linux' to 'Linux'.

Command (m for help): p
Disk /dev/sdc: 10 GiB, 10737418240 bytes, 20971520 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 4096 bytes
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disklabel type: dos
Disk identifier: 0x3b60d6a9

Device     Boot   Start     End Sectors Size Id Type
/dev/sdc1          2048 4196351 4194304   2G 83 Linux
/dev/sdc2       4196352 8390655 4194304   2G 83 Linux

Command (m for help): w
The partition table has been altered.
Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@mederma-server ~]# partprobe /dev/sdc
```

```
[root@mederma-server ~]# mkdir /pablo/hexa
[root@mederma-server ~]# mkdir /pablo/maxo
```

```
[root@mederma-server ~]# mkfs.xfs /dev/sdc1
meta-data=/dev/sdc1              isize=512    agcount=4, agsize=131072 blks
         =                       sectsz=4096  attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1    bigtime=0 inobtcount=0
data     =                       bsize=4096   blocks=524288, imaxpct=25
         =                       sunit=0      swidth=0 blks
naming   =version 2              bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=2560, version=2
         =                       sectsz=4096  sunit=1 blks, lazy-count=1
realtime =none                   extsz=4096   blocks=0, rtextents=0
Discarding blocks...Done.
```

```
[root@mederma-server ~]# mkfs.ext4 /dev/sdc2
mke2fs 1.45.6 (20-Mar-2020)
Discarding device blocks: done
Creating filesystem with 524288 4k blocks and 131072 inodes
Filesystem UUID:
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

Allocating group tables: done
Writing inode tables: done
Creating journal (16384 blocks): done
Writing superblocks and filesystem accounting information: done
```

```
[root@mederma-server ~]# mount -a
```

```
[root@mederma-server ~]# df -hT
Filesystem     Type      Size  Used Avail Use% Mounted on
devtmpfs       devtmpfs  1.8G     0  1.8G   0% /dev
tmpfs          tmpfs     1.8G     0  1.8G   0% /dev/shm
tmpfs          tmpfs     1.8G   17M  1.8G   1% /run
tmpfs          tmpfs     1.8G     0  1.8G   0% /sys/fs/cgroup
/dev/sda2      xfs        25G  5.1G   20G  21% /
/dev/sda1      vfat      200M  5.8M  194M   3% /boot/efi
/dev/sdb       xfs        10G  104M  9.9G   2% /pablo/pather
tmpfs          tmpfs     367M     0  367M   0% /run/user/1000
/dev/sdc1      xfs       2.0G   47M  2.0G   3% /pablo/hexa
/dev/sdc2      ext4      2.0G   24K  1.8G   1% /pablo/maxo
```

Types of Linux File Systems

File system is nothing but way to manage data on storage device. There are several types of native File system used in Linux as for example ext, ext2, ext3, ext4, XFS and Btrfs (used in SUSE Linux) some of them are explained below.

ext3 (extended version 3 filesystem) supports maximum filesystem size of 32TB and it also supports Journaling.

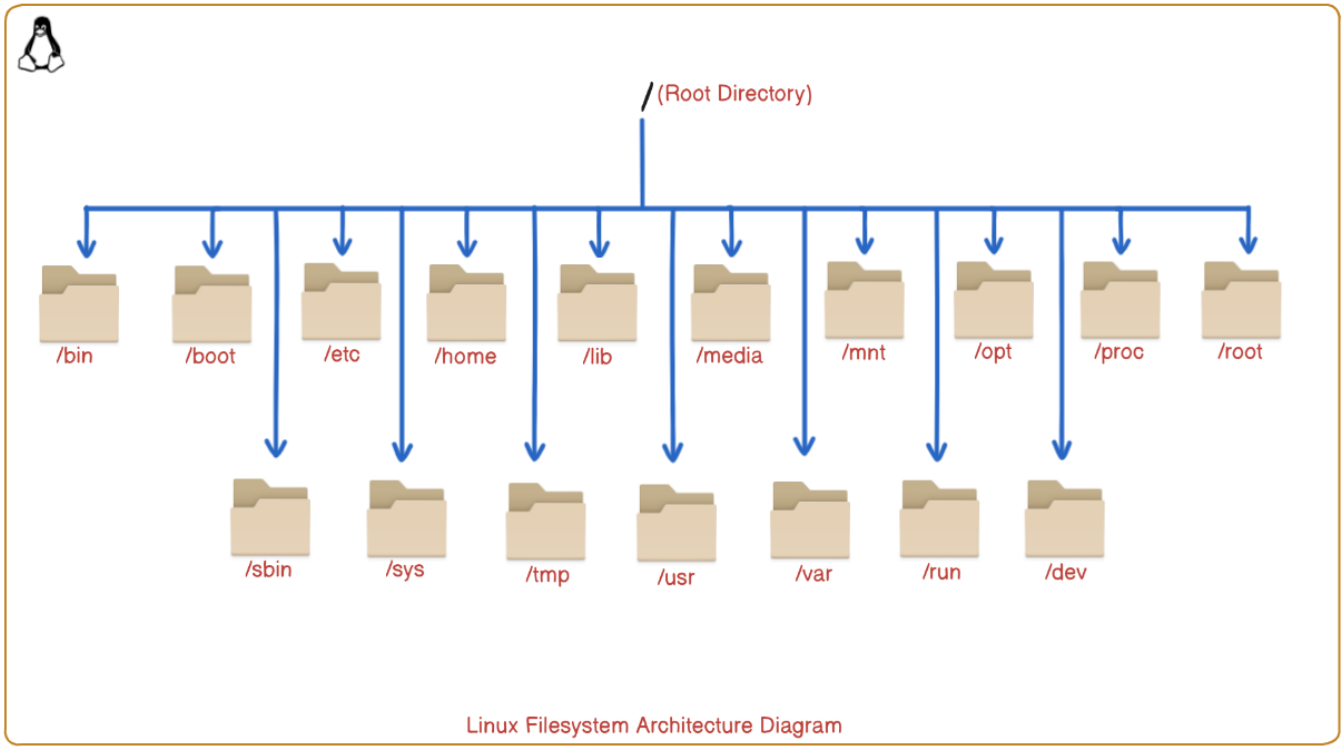
ext4 (extended version 4 filesystem) supports maximum filesystem size of 1EB and it supports Journaling.

XFS is a high-performance filesystem. It is used for large files and volumes. It supports Journaling.

These three are most frequently used native filesystems in Linux.

Journaling in Linux Filesystem means metadata and logs will be stored to special area called journal before writing them permanently to disk. Whenever there is a system crash using Journaling, it will restore the data. Journaling concept was introduced in ext3 filesystem.

Linux Filesystem Hierarchy



Linux Filesystem Architecture Diagram

/ (Root Level Directory or Top-Level Directory) in Linux is the highest point in the Linux filesystem hierarchy. It contains all other directory.

/bin contains system binaries, these are executable files. Each file corresponds to the Linux commands which can be used by all the users.

/boot contains files and directory which will be used to boot the Linux machine. This directory contains the Linux Kernel (vmlinuz file) and bootloader (grub2 directory).

/etc containers configuration files for Linux System.

/home is the home directory for Linux normal users. This directory contains personal directories for Linux normal users.

/lib directory contains libraries which will be utilized by the commands present in the directory /bin and /sbin.

/media is automatic mount point for removable devices, like CD-ROM, USB.

/mnt is the temporary mount point for removable devices. It is used by system administrators.

/opt is optional directory which is used to install third party software.

/proc is virtual filesystem and contains the information about kernel and linux processes.

/root is the home directory for root user (or superuser).

/sbin directory contains system binaries, which are the linux commands executable by Linux Administrator.

/sys is virtual filesystem and provides an interface to kernel and hardware.

/tmp directory contains temporary files which will be removed on system reboot.

/usr contains user-level applications, their binaries and documentation.

/var contains files and directories which size changes when Linux system is up.

/run directory lost the files and directories which it contains on system reboot. Contains information about currently running daemons or processes.

/dev directory contains device files for hardware interface.

Linux File Permission

Linux file permissions controls who can access and manipulate files and directories.

1. Permission Categories:
    - Owner (u): The user who owns the file or directory.
    - Group (g): Users who are members of the group assigned to the file or directory.
    - Others (o): All other users on the system.

2. Permission Types:

- Read (r or 4):
    - For files: Allows viewing the file's contents.
    - For directories: Allows listing the contents of the directory (e.g., using ls).
- Write (w or 2):
    - For files: Allows modifying or deleting the file.
    - For directories: Allows creating, deleting, or renaming files within the directory, and modifying files within the directory if the user also has write permissions to those specific files.
- Execute (x or 1):
    - For files: Allows running the file as a program or script.
    - For directories: Allows accessing or traversing into the directory (e.g., using cd) and accessing metadata about its contents.

Permissions are typically viewed using the ls -l command. It is represented as a 10-character string:

-rwxrwxrwx

```
[root@Mederma-Server medoko]# chmod 755 myfile.sh
```

Grant read, write, and execute permissions to the owner, and read and execute to group and others as shown in the screenshot attached above.

```
[root@Mederma-Server medoko]# ls -l
total 0
-rwxr-xr-x. 1 root root 0 Nov  3 17:15 myfile.sh
```

Ownership Management

The **chown** command changes the owner of a file or directory, and **chgrp** changes the group ownership, -R is used to assign permission recursively.

```
[root@Mederma-Server ~]# chown -R john bali
```

```
[root@Mederma-Server ~]# chgrp -R maxo bali/
[root@Mederma-Server ~]# ls -ld bali/
drwxr-xr-x. 2 john maxo 4096 Nov  3 17:23 bali/
[root@Mederma-Server ~]# ls -ltr bali/
total 0
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file12.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file11.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file10.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file20.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file19.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file18.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file17.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file16.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file15.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file14.txt
-rw-r--r--. 1 john maxo 0 Nov  3 17:23 file13.txt
```

Instead of using **chown** and **chgrp** command the same ownership could be achieved by using **chown** command as shown below.

```
[root@Mederma-Server ~]# chown -R yokimov:nobellauraete nanofibers/
[root@Mederma-Server ~]# ls -ld nanofibers/
drwxr-xr-x. 2 yokimov nobellauraete 177 Nov  3 17:31 nanofibers/
[root@Mederma-Server ~]# ls -ltr nanofibers/
total 0
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech9.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech8.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech7.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech6.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech5.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech4.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech3.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech2.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech10.txt
-rw-r--r--. 1 yokimov nobellauraete 0 Nov  3 17:31 tech1.txt
```

Manage Access Control List in Linux for files and directories

The **setfacl** command in Linux is used to manage Access Control Lists (ACLs) for files and directories, it provides more granular permission than standard chmod permissions.

-m (modify) modifies or adds an ACL entry

setfacl -m u:username:<permissions> <filename>

setfacl -m u:john:rw dexter.txt, gives user john read and write permission for the file dexter.txt.

```
[root@Mederma-Server ~]# setfacl -m u:john:rw dexter.txt
[root@Mederma-Server ~]# getfacl dexter.txt
# file: dexter.txt
# owner: root
# group: root
user::rw-
user:john:rw-
group::r--
mask::rw-
other::r--
```

-x (remove) Removes a specific ACL Permission.

setfacl -x u:username <filename>

setfacl -x u:john dexter.txt, removes john's ACL permission.

```
[root@Mederma-Server ~]# setfacl -x u:john dexter.txt
[root@Mederma-Server ~]# getfacl dexter.txt
# file: dexter.txt
# owner: root
# group: root
user::rw-
group::r--
mask::r--
other::r--
```

User management in Linux

A new user can be added using the command as shown below. Where **-m** flag will create the home directory if already does not exist and **-s** flag will be used for login shell. Passwd command is used to provide the password for the user.

```
[root@Mederma-Server ~]# useradd -m -s /bin/bash xikonov
[root@Mederma-Server ~]# passwd xikonov
Changing password for user xikonov.
New password:
BAD PASSWORD: The password is shorter than 8 characters
Retype new password:
passwd: all authentication tokens updated successfully.
```

```
[john@Mederma-Server ~]$ su - xikonov
Password:
[xikonov@Mederma-Server ~]$
```

User details are present in /etc/passwd and its encrypted passwd is present in /etc/shadow file. The file /etc/shadow can only be open by root (superuser) user.

Using **usermod** I had added the existing user xikonov to the group nobellauraete as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# usermod -aG nobellauraete xikonov
[root@Mederma-Server ~]# getent group nobellauraete
nobellauraete:x:1004:xikonov
```

To delete a user with its home directory you can use the command **userdel -r <username>**.

```
[root@Mederma-Server ~]# userdel -r xikonov
```

To delete the group, you can use the command **groupdel <groupname>**

```
[root@Mederma-Server ~]# groupdel nobellauraete
```

If Linux Administrator wants to lock the user account, then the **usermod john --lock** command should be used as shown below. Now the user will not be able to login using his password.

```
[root@Mederma-Server ~]# usermod john --lock
```

```
[ritesh@Mederma-Server ~]$ su - john
Password:
su: Authentication failure
```

After unlock the user account the user can login again as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# usermod john --unlock
```

```
[ritesh@Mederma-Server ~]$ su - john
Password:
[john@Mederma-Server ~]$
```

Here, I am showing you the use case when all the users are only allowed with the SSH Keys and password is disabled to login on the server.

In such a situation you can generate the SSH Keys (public and private keys) using the command as shown below.

```
[root@herema-server ~]# ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Created directory '/root/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:[redacted]A root@herema-server
The key's randomart image is:
+---[RSA 3072]----+
|[redacted]|
+----[SHA256]-----+
```

The user who run **ssh-keygen** command, in the home directory of that user in the **.ssh** directory private key (id_rsa) and public key (id_rsa.pub) had been generated.

Then using ssh-copy-id command copy the public key to remote server which remote session you are interested into using SSH.

```
[root@herema-server ~]# ssh-copy-id john@192.168.40.227
/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/root/.ssh/id_rsa.pub"
/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
john@192.168.40.227's password:

Number of key(s) added: 1

Now try logging into the machine, with:   "ssh 'john@192.168.40.227'"
and check to make sure that only the key(s) you wanted were added.
```

```
[root@Mederma-Server ~]# cat /home/john/.ssh/authorized_keys
ssh-rsa A
                                                                                k= root@herema-server
```

Then disable password authentication in the file **sshd_config** present at the absolute path **/etc/ssh/sshd_config** which remote session you are interested into.

```
[root@Mederma-Server ~]# vim /etc/ssh/sshd_config
```

Change **PasswordAuthentication** from **yes** to **no**.

```
PasswordAuthentication no
```

```
[root@Mederma-Server ~]# systemctl reload sshd
```

The user who wants to login into the server must have the private key.

```
ritesh@DESKTOP-0      F:~$ chmod 600 dexter.pem
```

```
ritesh@DESKTOP-0      F:~$ ssh -i dexter.pem john@192.168.40.227
Activate the web console with: systemctl enable --now cockpit.socket

Last login: Mon Nov  3 20:24:22 2025 from 192.168.40.1
[john@Mederma-Server ~]$
```

Process Management in Linux

Linux **Processes** are programs which is running commands and utilizing resources. Each process is identified by a unique Process ID. To list the processes, you can run the command **ps -ef**. If you want to search any process using specific string then use the command **ps -ef | grep <string-name>**.

```
[root@Mederma-Server ~]# ps -ef
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 11:22 ?        00:00:04 /usr/lib/systemd/systemd --switched-root --system --deserialize 18
root           2       0  0 11:22 ?        00:00:00 [kthreadd]
root           3       2  0 11:22 ?        00:00:00 [rcu_gp]
root           4       2  0 11:22 ?        00:00:00 [rcu_par_gp]
root           5       2  0 11:22 ?        00:00:00 [slub_flushwq]
root          10       2  0 11:22 ?        00:00:00 [mm_percpu_wq]
root          11       2  0 11:22 ?        00:00:00 [rcu_tasks_rude_]
root          12       2  0 11:22 ?        00:00:00 [rcu_tasks_trace]
root          13       2  0 11:22 ?        00:00:00 [ksoftirqd/0]
root          14       2  0 11:22 ?        00:00:00 [rcu_sched]
root          15       2  0 11:22 ?        00:00:00 [migration/0]
root          16       2  0 11:22 ?        00:00:00 [watchdog/0]
root          17       2  0 11:22 ?        00:00:00 [cpuhp/0]
root          18       2  0 11:22 ?        00:00:00 [cpuhp/1]
root          19       2  0 11:22 ?        00:00:00 [watchdog/1]
root          20       2  0 11:22 ?        00:00:00 [migration/1]
root          21       2  0 11:22 ?        00:00:00 [ksoftirqd/1]
root          26       2  0 11:22 ?        00:00:00 [kdevtmpfs]
root          27       2  0 11:22 ?        00:00:00 [netns]
root          28       2  0 11:22 ?        00:00:00 [kauditd]
root          30       2  0 11:22 ?        00:00:00 [khungtaskd]
root          31       2  0 11:22 ?        00:00:00 [oom_reaper]
root          32       2  0 11:22 ?        00:00:00 [writeback]
root          33       2  0 11:22 ?        00:00:00 [kcompactd0]
root          34       2  0 11:22 ?        00:00:00 [ksmd]
root          35       2  0 11:22 ?        00:00:02 [khugepaged]
root          36       2  0 11:22 ?        00:00:00 [crypto]
root          37       2  0 11:22 ?        00:00:00 [kintegrityd]
root          38       2  0 11:22 ?        00:00:00 [kblockd]
root          39       2  0 11:22 ?        00:00:00 [blkcg_punt_bio]
root          40       2  0 11:22 ?        00:00:00 [tpm_dev_wq]
root          41       2  0 11:22 ?        00:00:00 [md]
root          42       2  0 11:22 ?        00:00:00 [md_bitmap]
root          43       2  0 11:22 ?        00:00:00 [edac-poller]
root          44       2  0 11:22 ?        00:00:00 [watchdogd]
root          46       2  0 11:22 ?        00:00:00 [kworker/0:1H-kblockd]
root          63       2  0 11:22 ?        00:00:00 [kswapd0]
```

```
[root@Mederma-Server ~]# ps -ef|grep -i "ssh"
root        1144       1  0 11:23 ?        00:00:00 /usr/sbin/sshd -D -oCiphers=aes256-gcm@openssh.com,chacha20-poly1305@openssh.com,aes256-ctr,aes256-cbc,aes
128-gcm@openssh.com,aes128-ctr,aes128-cbc -oMACs=hmac-sha2-256-etm@openssh.com,hmac-sha1-etm@openssh.com,umac-128-etm@openssh.com,hmac-sha2-512-etm@openssh.co
m,hmac-sha2-256,hmac-sha1,umac-128@openssh.com,hmac-sha2-512 -oGSSAPIKexAlgorithms=gss-curve25519-sha256-,gss-nistp256-sha256-,gss-group14-sha256-,gss-group16
-sha512-,gss-gex-sha1-,gss-group14-sha1- -oKexAlgorithms=curve25519-sha256,curve25519-sha256@libssh.org,ecdh-sha2-nistp256,ecdh-sha2-nistp384,ecdh-sha2-nistp5
21,diffie-hellman-group-exchange-sha256,diffie-hellman-group14-sha256,diffie-hellman-group16-sha512,diffie-hellman-group18-sha512,diffie-hellman-group-exchang
e-sha1,diffie-hellman-group14-sha1 -oHostKeyAlgorithms=ecdsa-sha2-nistp256,ecdsa-sha2-nistp256-cert-v01@openssh.com,ecdsa-sha2-nistp384,ecdsa-sha2-nistp384-ce
rt-v01@openssh.com,ecdsa-sha2-nistp521,ecdsa-sha2-nistp521-cert-v01@openssh.com,ssh-ed25519,ssh-ed25519-cert-v01@openssh.com,rsa-sha2-256,rsa-sha2-256-cert-v0
1@openssh.com,rsa-sha2-512,rsa-sha2-512-cert-v01@openssh.com,ssh-rsa,ssh-rsa-cert-v01@openssh.com -oPubkeyAcceptedKeyTypes=ecdsa-sha2-nistp256,ecdsa-sha2-nist
p256-cert-v01@openssh.com,ecdsa-sha2-nistp384,ecdsa-sha2-nistp384-cert-v01@openssh.com,ecdsa-sha2-nistp521,ecdsa-sha2-nistp521-cert-v01@openssh.com,ssh-ed2551
9,ssh-ed25519-cert-v01@openssh.com,rsa-sha2-256,rsa-sha2-256-cert-v01@openssh.com,rsa-sha2-512,rsa-sha2-512-cert-v01@openssh.com,ssh-rsa,ssh-rsa-cert-v01@opes
sh.com -oCASignatureAlgorithms=ecdsa-sha2-nistp256,ecdsa-sha2-nistp384,ecdsa-sha2-nistp521,ssh-ed25519,rsa-sha2-256,rsa-sha2-512,ssh-rsa
root        4143    1144  0 12:26 ?        00:00:00 sshd: ritesh [priv]
ritesh      4147    4143  0 12:26 ?        00:00:00 sshd: ritesh@pts/1
root        4257    4189  0 12:30 pts/1    00:00:00 grep --color=auto -i ssh
```

You can see in the above command I had used **-i** with grep which means perform search with case-insensitive.

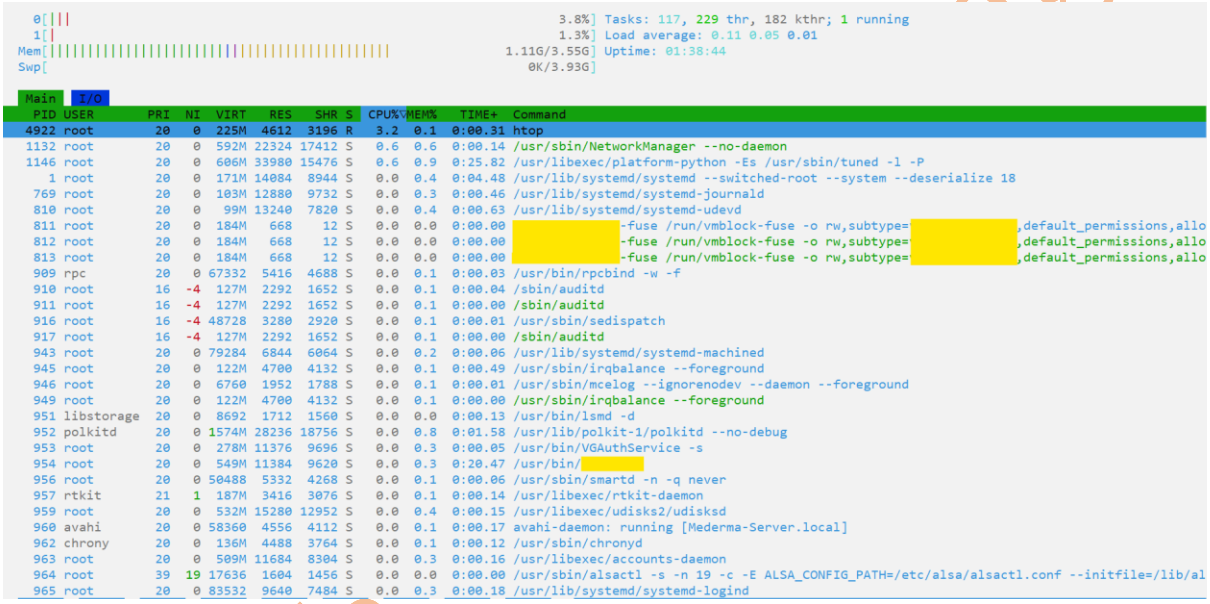
To list all running processes on Linux system you can run the command **ps aux** as shown below.

```
[root@Mederma-Server ~]# ps aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  0.0  0.3 175848 14064 ?        Ss   11:22   0:04 /usr/lib/systemd/systemd --switched-root --system --deserialize 18
root           2  0.0  0.0      0     0 ?        S    11:22   0:00 [kthreadd]
root           3  0.0  0.0      0     0 ?        I<   11:22   0:00 [rcu_gp]
root           4  0.0  0.0      0     0 ?        I<   11:22   0:00 [rcu_par_gp]
root           5  0.0  0.0      0     0 ?        I<   11:22   0:00 [slub_flushwq]
root          10  0.0  0.0      0     0 ?        I<   11:22   0:00 [mm_percpu_wq]
root          11  0.0  0.0      0     0 ?        S    11:22   0:00 [rcu_tasks_rude_]
root          12  0.0  0.0      0     0 ?        S    11:22   0:00 [rcu_tasks_trace]
root          13  0.0  0.0      0     0 ?        S    11:22   0:00 [ksoftirqd/0]
root          14  0.0  0.0      0     0 ?        I    11:22   0:00 [rcu_sched]
root          15  0.0  0.0      0     0 ?        S    11:22   0:00 [migration/0]
root          16  0.0  0.0      0     0 ?        S    11:22   0:00 [watchdog/0]
root          17  0.0  0.0      0     0 ?        S    11:22   0:00 [cpuhp/0]
root          18  0.0  0.0      0     0 ?        S    11:22   0:00 [cpuhp/1]
root          19  0.0  0.0      0     0 ?        S    11:22   0:00 [watchdog/1]
root          20  0.0  0.0      0     0 ?        S    11:22   0:00 [migration/1]
root          21  0.0  0.0      0     0 ?        S    11:22   0:00 [ksoftirqd/1]
root          26  0.0  0.0      0     0 ?        S    11:22   0:00 [kdevtmpfs]
root          27  0.0  0.0      0     0 ?        I<   11:22   0:00 [netns]
root          28  0.0  0.0      0     0 ?        S    11:22   0:00 [kauditd]
root          30  0.0  0.0      0     0 ?        S    11:22   0:00 [khungtaskd]
root          31  0.0  0.0      0     0 ?        S    11:22   0:00 [oom_reaper]
root          32  0.0  0.0      0     0 ?        I<   11:22   0:00 [writeback]
root          33  0.0  0.0      0     0 ?        S    11:22   0:00 [kcompactd0]
root          34  0.0  0.0      0     0 ?        SN   11:22   0:00 [ksmd]
root          35  0.0  0.0      0     0 ?        SN   11:22   0:02 [khugepaged]
root          36  0.0  0.0      0     0 ?        I<   11:22   0:00 [crypto]
root          37  0.0  0.0      0     0 ?        I<   11:22   0:00 [kintegrityd]
root          38  0.0  0.0      0     0 ?        I<   11:22   0:00 [kblockd]
```

To list processes and resource utilization you can use the command **top** or **htop** but htop provides a feature-rich experience. In Almalinux by-default htop command is not installed you need to install it as shown below. It is a useful command for **monitoring** or **Root Cause Analysis (RCA)**. You can find out which process is utilizing maximum resource and can kill the same using **kill** command if the process is of no use at present point of time. If that process is important to run and no resource is free then scale up (vertical scaling) the resources of your Linux machine. This activity should be done during non-production hours. However, if you are using a cloud environment like **AWS, Azure, or GCP (Google Cloud Platform)** then it is suggested to perform Autoscale (Scale out or horizontal scaling) your EC2 Instances or VM Instances.

```
[root@Mederma-Server ~]# yum install -y htop
```

```
[root@Mederma-Server ~]# htop
```



Managing priority in Linux

In Linux when we execute a command a priority getting assigned to that (when we execute a command in Linux then kernel assigns a priority to that) a command or process with higher priority will be executed first. You can priorities the priority of a command execution using the nice command.

nice -n <nice_value> <command>

Lower is the nice_value and higher will be priority, among two command **nice -n 10 bash test.sh** and **nice -n 5 bash demo.sh**. Second command priority will be more than first command. For its execution I opened three terminals and on one terminal I ran **nice -n 10 bash test.sh** and on another terminal, I ran **nice -n 5 bash demo.sh**. On third terminal I ran **ps -lef | grep sleep** as shown below.

```
[root@Mederma-Server ~]# nice -n 10 bash test.sh
```

```
[root@Mederma-Server ~]# nice -n 5 bash demo.sh
```

```
[root@Mederma-Server ~]# ps -efl | grep bash
```

```
0 R root        6255    5749 26  90  10 - 57441 -      15:24 pts/4    00:00:17 bash test.sh
0 S root        6256    5670 35  85   5 - 57441 -      15:24 pts/3    00:00:22 bash demo.sh
```

As shown in the screenshot attached above a process with **PRI** value **85** has higher priority than a process with **PRI** value **90**. Which means kernel will listen first **bash demo.sh** and then **bash test.sh**.

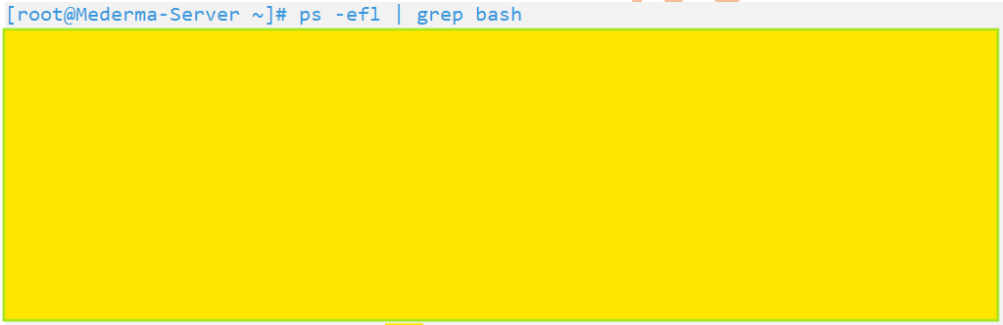
It is possible to change the priority of a running process or command using **renice** command as shown in the screenshot attached below.

renice <priority> <PID>

```
[root@Mederma-Server ~]# bash test.sh
```

```
[root@Mederma-Server ~]# bash demo.sh
```

```
[root@Mederma-Server ~]# ps -efl | grep bash
```



```
0 S root        6353    5749 62  80   0 - 57441 -      15:54 pts/4    00:00:04 bash test.sh
0 R root        6354    5670 35  80   0 - 57441 -      15:54 pts/3    00:00:01 bash demo.sh
0 R root        6356    6120  0  80   0 - 57294 -      15:54 pts/5    00:00:00 grep --color=auto bash
[root@Mederma-Server ~]# renice 5 6354
6354 (process ID) old priority 0, new priority 5
[root@Mederma-Server ~]# renice 2 6353
6353 (process ID) old priority 0, new priority 2
[root@Mederma-Server ~]# ps -efl | grep bash
```

```
0 S root        6353    5749 46  82   2 - 57441 -      15:54 pts/4    00:00:26 bash test.sh
0 R root        6354    5670 33  85   5 - 57441 -      15:54 pts/3    00:00:18 bash demo.sh
0 R root        6360    6120  0  80   0 - 57294 -      15:55 pts/5    00:00:00 grep --color=auto bash
```

As explain in the attached screenshot I executed two shell scripts **bash test.sh** and **bash demo.sh** and changed its priority using renice command and finally found that its priority had been changed as expected.

There is command **sleep 60** (Sleep for 60 Seconds) is running and you want to kill this process, the same can be achieved with the command as shown below.

kill -9 <PID>

```
[root@Mederma-Server ~]# sleep 60
```

```
[root@Mederma-Server ~]# ps -ef|grep sleep
root        6381    5749  0 16:06 pts/4    00:00:00 sleep 60
root        6383    6120  0 16:06 pts/5    00:00:00 grep --color=auto sleep
[root@Mederma-Server ~]# kill -9 6381
[root@Mederma-Server ~]# ps -ef|grep sleep
root        6385    6120  0 16:06 pts/5    00:00:00 grep --color=auto sleep
```

Cronjob in Linux

Cron Job is used in Linux to schedule the periodic task. While scheduling task using cronjob we use five fields **minute**, **hour**, **day**, **month,** and **day-of-a-week** (left to right in crontab -e).

Fields	**Range of Value**
minute:	0-59
hour:	0-23
day:	1-31
month:	1-12

day-of-a-week: 0-7 where 0 and 7 used for Sunday.

I am explaining cronjob using a use case, consider that in your project you are using an application which is generating shared files and libraries at the path **/mederma** which will be of no use after one month and there is no need to take its backup and you can simply delete these files and libraries on 28th of each month at 12:00 PM, this can be achieved using crontab as shown below.

```
[root@Mederma-Server ~]# crontab -l
0 12 28 * * sh dexter.sh
```

```
[root@Mederma-Server ~]# cat dexter.sh
#!/bin/bash

df -hT | grep "Filesystem                Type      Size  Used Avail Use% Mounted on" > therema.txt
df -hT | grep "/dev/sd" >> therema.txt
df -hT | grep "/dev/mapper" >> therema.txt
cat therema.txt

rm -rf /mederma/* ### Removes all the files and directories present in the directory /mederma/
[root@Mederma-Server ~]# cat therema.txt
Filesystem                Type      Size  Used Avail Use% Mounted on
/dev/sda1                 xfs      1014M  282M  733M  28% /boot
/dev/sdb                  xfs        10G  104M  9.9G   2% /mederma
/dev/mapper/almalinux-root xfs       46G   36G  9.9G  79% /
```

You can check the logs for cron as shown below.

```
[root@Mederma-Server ~]# vim /var/log/cron
```

```
Nov  4 17:21:01 Mederma-Server CROND[3314]: (root) CMD (sh dexter.sh)
Nov  4 17:21:01 Mederma-Server CROND[3295]: (root) CMDOUT (Filesystem                Type      Size  Used Avail Use% Mounted on)
Nov  4 17:21:01 Mederma-Server CROND[3295]: (root) CMDOUT (/dev/sda1                xfs      1014M  282M  733M  28% /boot)
Nov  4 17:21:01 Mederma-Server CROND[3295]: (root) CMDOUT (/dev/sdb                 xfs        10G  104M  9.9G   2% /mederma)
Nov  4 17:21:01 Mederma-Server CROND[3295]: (root) CMDOUT (/dev/mapper/almalinux-root xfs        46G   36G  9.9G  79% /)
Nov  4 17:21:02 Mederma-Server crontab[3324]: (root) BEGIN EDIT (root)
Nov  4 17:21:09 Mederma-Server crontab[3324]: (root) REPLACE (root)
Nov  4 17:21:09 Mederma-Server crontab[3324]: (root) END EDIT (root)
Nov  4 17:21:13 Mederma-Server crontab[3331]: (root) LIST (root)
```

After successfully running the cronjob I checked the /mederma directory and found no files or directory was present as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# ll /mederma/
total 0
```

Boot Process in Linux

Linux boot process is nothing but loading the Operating system and making the Linux machine On. Below are the steps involved in booting process.

1. Initialization of BIOS (Basic Input/Output System).
2. Load the bootloader (in RHEL7 or later versions GRUB2 is the bootloader).
3. bootloader loads the Linux kernel and initializes initramfs.
4. Initialize kernel and mount the root filesystem.
5. Execute init process, init process is the first process in Linux with PID 1.
6. Finally, runlevels will be executed. There are seven runlevels in Linux system **Runlevel 0**, **Runlevel 1**, **Runlevel 2**, **Runlevel 3**, **Runlevel 4**, **Runlevel 5** and **Runlevel 6**.

Runlevel 0: system halt or shutdown

Runlevel 1: Single-user mode without networking.

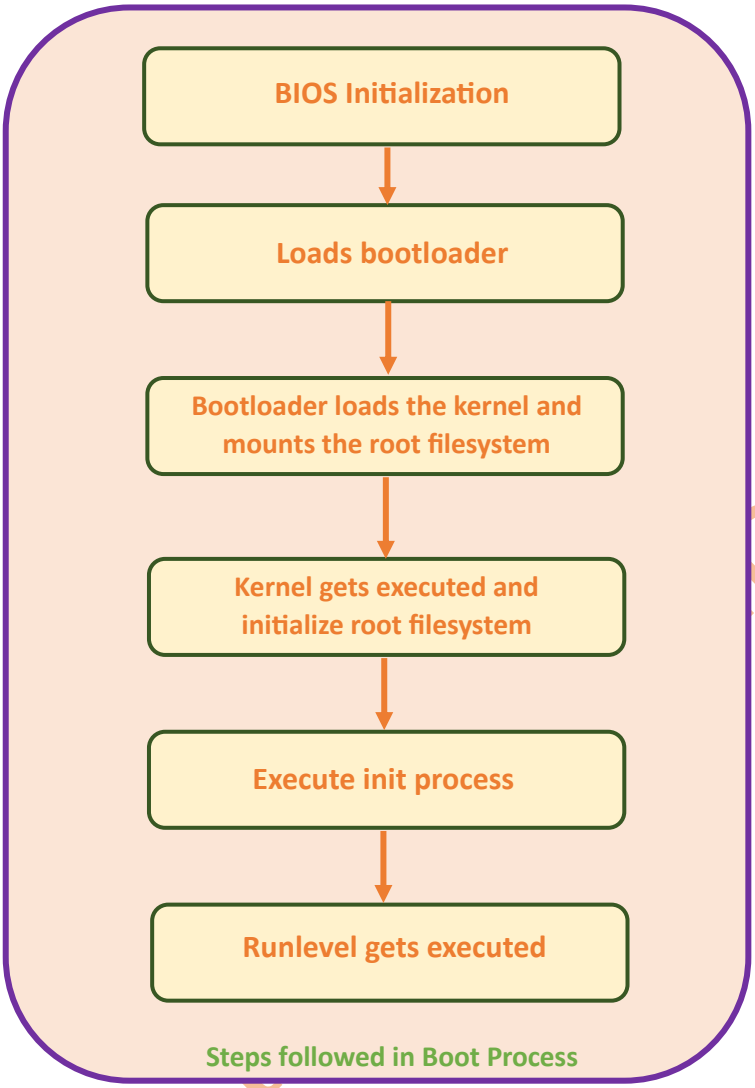
Runlevel 2: Multi-user mode without networking.

Runlevel 3: Multi-user mode with networking

Runlevel 4: User-definable or unused

Runlevel 5: GUI mode

Runlevel 6: Reboot the system.



Steps followed in Boot Process

File attributes in Linux

File attributes are metadata properties that provides additional information about the file or directories.

chattr command: - **chattr** command in linux is used to change the attribute of a file or directory in Linux and hence allow who can edit the file or delete the file or directory. With chattr command it is possible to use two flags, **i** and **a** flag. When **i** flag is used no one can edit or delete the file or directory and when **a** flag is used then no one can delete the file, only append the file.

To list the attributes, you can use the command **lsattr**. You can use the flags -a (all files and directories including hidden files and directories), -d (at the directory level), -R (recursively) with **lsattr** command.

```
[root@Mederma-Server ~]# mkdir dexter
[root@Mederma-Server ~]# touch dexter/file{1..10}.txt
[root@Mederma-Server ~]# chattr -R +i dexter
[root@Mederma-Server ~]# lsattr -d dexter
----i--------------- dexter
[root@Mederma-Server ~]# lsattr -R dexter
----i--------------- dexter/file1.txt
----i--------------- dexter/file2.txt
----i--------------- dexter/file3.txt
----i--------------- dexter/file4.txt
----i--------------- dexter/file5.txt
----i--------------- dexter/file6.txt
----i--------------- dexter/file7.txt
----i--------------- dexter/file8.txt
----i--------------- dexter/file9.txt
----i--------------- dexter/file10.txt
[root@Mederma-Server ~]# rm -f dexter/file10.txt
rm: cannot remove 'dexter/file10.txt': Operation not permitted
[root@Mederma-Server ~]# rm -rf dexter
rm: cannot remove 'dexter/file1.txt': Operation not permitted
rm: cannot remove 'dexter/file2.txt': Operation not permitted
rm: cannot remove 'dexter/file3.txt': Operation not permitted
rm: cannot remove 'dexter/file4.txt': Operation not permitted
rm: cannot remove 'dexter/file5.txt': Operation not permitted
rm: cannot remove 'dexter/file6.txt': Operation not permitted
rm: cannot remove 'dexter/file7.txt': Operation not permitted
rm: cannot remove 'dexter/file8.txt': Operation not permitted
rm: cannot remove 'dexter/file9.txt': Operation not permitted
rm: cannot remove 'dexter/file10.txt': Operation not permitted
```

When I removed the **i** attribute, I was able to delete the directory as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# chattr -R -i dexter
[root@Mederma-Server ~]# lsattr -d dexter
-------------------- dexter
[root@Mederma-Server ~]# lsattr -R dexter
-------------------- dexter/file1.txt
-------------------- dexter/file2.txt
-------------------- dexter/file3.txt
-------------------- dexter/file4.txt
-------------------- dexter/file5.txt
-------------------- dexter/file6.txt
-------------------- dexter/file7.txt
-------------------- dexter/file8.txt
-------------------- dexter/file9.txt
-------------------- dexter/file10.txt
[root@Mederma-Server ~]# rm -rf dexter
```

```
[root@Mederma-Server ~]# mkdir mederma
[root@Mederma-Server ~]# touch mederma/dexo{1..5}.txt
[root@Mederma-Server ~]# chattr +a mederma/*
[root@Mederma-Server ~]# rm -rf mederma
rm: cannot remove 'mederma/dexo1.txt': Operation not permitted
rm: cannot remove 'mederma/dexo2.txt': Operation not permitted
rm: cannot remove 'mederma/dexo3.txt': Operation not permitted
rm: cannot remove 'mederma/dexo4.txt': Operation not permitted
rm: cannot remove 'mederma/dexo5.txt': Operation not permitted
```

```
[root@Mederma-Server ~]# echo "Hi, Hello" > mederma/dexo1.txt
-bash: mederma/dexo1.txt: Operation not permitted
[root@Mederma-Server ~]# echo "Hi, Hello" >> mederma/dexo1.txt
[root@Mederma-Server ~]# cat mederma/dexo1.txt
Hi, Hello
```

As shown above after applying **a** attribute to the files it was allowed to append into the files but not to delete the files.

```
[root@Mederma-Server ~]# chattr -a mederma/*
[root@Mederma-Server ~]# rm -rf mederma
[root@Mederma-Server ~]#
```

Linux inode

Inode in Linux also called as **index node** will give the address where actual data block is stored. Every inode is associated with inode number. When you assign a filesystem to a partition in Linux and mount it on a directory then an **inode table** will be created. When you create a file or directory where that partition is mounted then an inode number is associated with that and inode number will be kept in the inode table. To check the details of inode you can use the command as shown below.

```
[root@Mederma-Server ~]# df -ihT
Filesystem                Type     Inodes IUsed IFree IUse% Mounted on
devtmpfs                  devtmpfs   447K   416  447K    1% /dev
tmpfs                     tmpfs      455K     1  455K    1% /dev/shm
tmpfs                     tmpfs      455K   926  454K    1% /run
tmpfs                     tmpfs      455K    17  455K    1% /sys/fs/cgroup
/dev/mapper/almalinux-root xfs        20M  128K   20M    1% /
/dev/sdb                  xfs        5.0M     3  5.0M    1% /mederma
/dev/sda1                 xfs        512K   311  512K    1% /boot
tmpfs                     tmpfs      455K    27  455K    1% /run/user/1000
```

```
[root@Mederma-Server ~]# ls -li /mederma/
total 0
131 -rw-r--r--. 1 root root 0 Nov  6 13:53 therema1.txt
132 -rw-r--r--. 1 root root 0 Nov  6 13:53 therema2.txt
133 -rw-r--r--. 1 root root 0 Nov  6 13:53 therema3.txt
134 -rw-r--r--. 1 root root 0 Nov  6 13:53 therema4.txt
135 -rw-r--r--. 1 root root 0 Nov  6 13:53 therema5.txt
```

As shown in the screenshot attached above the inode of the files inside the mederma directory is listed with the numbers 131, 132, 133, 134 and 135.

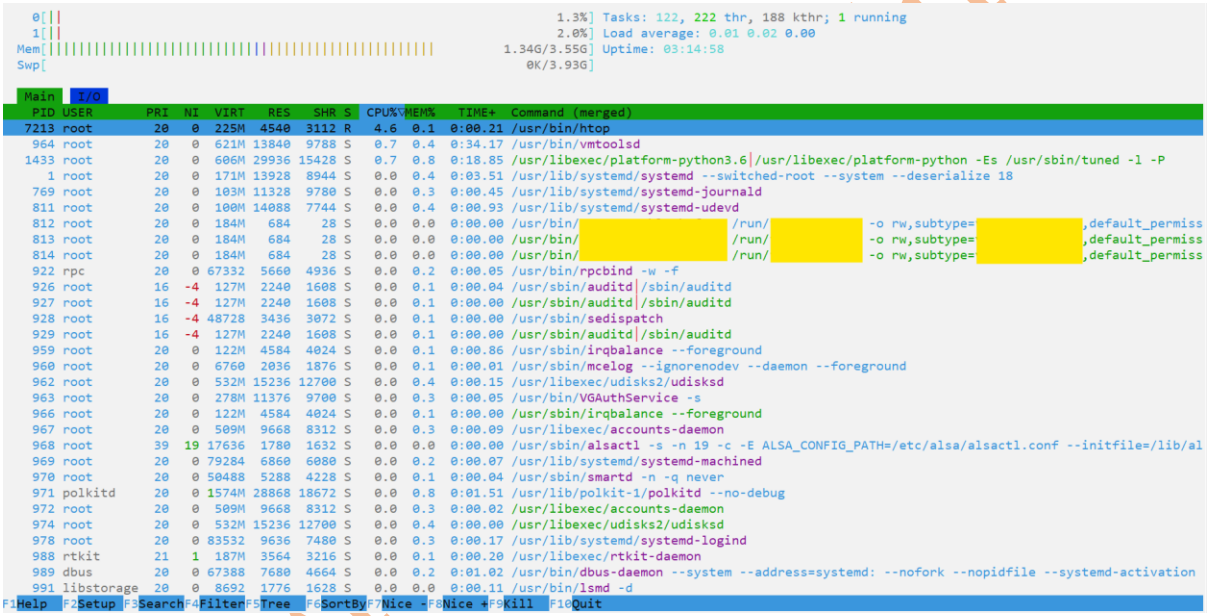
Performance Monitoring

Linux provides a wide variety of commands for performance monitoring, some of the commands are as written below.

htop (to use htop you must need to install the package htop), **mpstat** (to use mpstat you must need to install sysstat package), **iftop** (to install iftop you must need to install the package iftop), **free**, **vmstat**, **uptime**, **du** and **lsof**.

Using htop command you can continuously monitor system resources as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# htop
```



To monitor Linux system performance and resource usage you can use mpstat command. To use mpstat command you need to install the package **sysstat**. The mpstat command is used for processor related statistics, individual core usage, and CPU metrics.

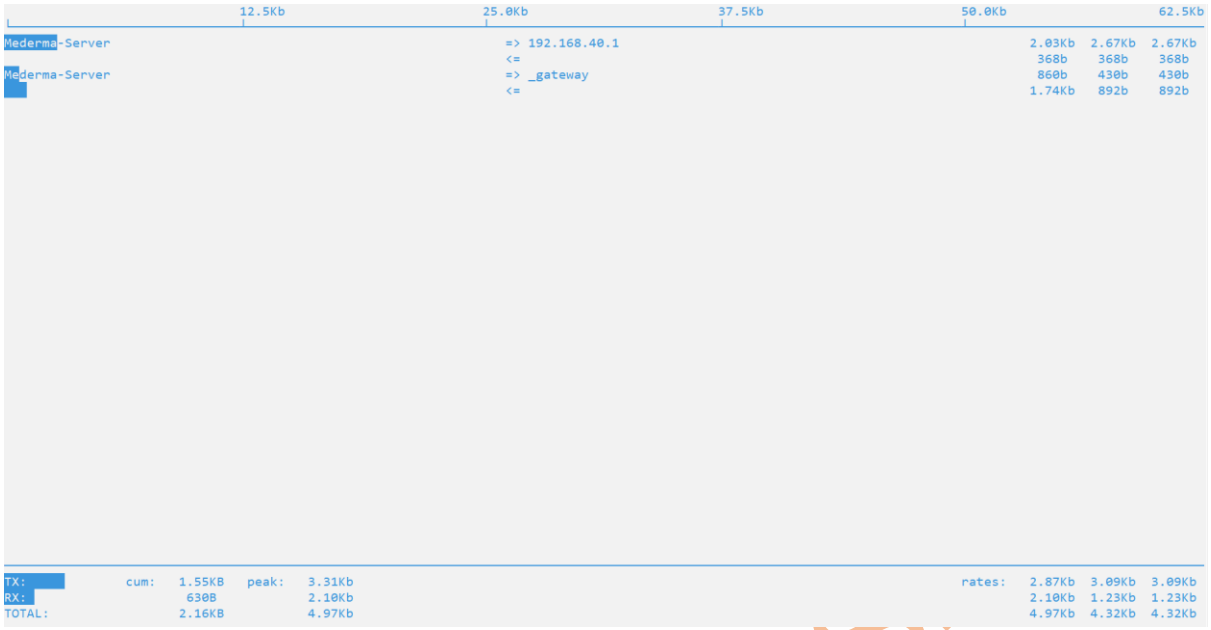
```
[root@Mederma-Server ~]# yum install -y sysstat
```

```
[root@Mederma-Server ~]# mpstat
Linux 4.18.0-553.81.1.el8_10.x86_64 (Mederma-Server)    11/06/25        _x86_64_        (2 CPU)

15:21:50     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest  %gnice   %idle
15:21:50     all    0.54    0.04    0.36    0.27    0.20    0.08    0.00    0.00    0.00   98.50
```

To display network traffic, you can use the command **iftop**.

```
[root@Mederma-Server ~]# yum install -y iftop
```

```
[root@Mederma-Server ~]# iftop
```




```
[root@Mederma-Server ~]# iftop
interface: ens33
IP address is: 192.168.40.227
MAC address is:
```

The **free -mh** command is used in Linux to see the **memory** and **swap** usage as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# free -mh
              total        used        free      shared  buff/cache   available
Mem:           3.5Gi       1.3Gi       1.1Gi        21Mi       1.1Gi       1.9Gi
Swap:          3.9Gi          0B       3.9Gi
```

To see the **swap** and **memory** statistics you can use the command **vmstat** as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# vmstat
procs -----------memory---------- ---swap-- -----io---- -system-- ------cpu-----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 1  0      0 1107652   3352 1196388    0    0    37    12   73  110  1  1 98  0  0
```

The **uptime** command in linux is used to show from how much time the server is up as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# uptime
 15:48:55 up  3:47,  4 users,  load average: 0.08, 0.08, 0.03
```

The **du** command is used to show the disk usage (how much space is occupied) as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# du -sh /root
29G     /root
```

As shown in the screenshot attached above it shows how much space is occupied for /root directory.

The **lsof** command in linux is used to check which process has opened the file as shown in the screenshot attached below. It is specially used when you want to delete any file and it will throw the error that file is in use then you can use the command to check which process is utilizing it. Kill those processes and then delete the file.

```
[root@Mederma-Server ~]# lsof /mederma/therema1.txt
lsof: WARNING: can't stat() fuse.gvfsd-fuse file system /run/user/1000/gvfs
      Output information may be incomplete.
COMMAND  PID USER   FD   TYPE DEVICE SIZE/OFF NODE NAME
sh      8700 root    1w   REG   8,16     4152  131 /mederma/therema1.txt
sh      8769 root    1w   REG   8,16     4458  131 /mederma/therema1.txt
sh      8820 root    1w   REG   8,16     4716  131 /mederma/therema1.txt
```

The **iostat** command provides the I/O statistics for block devices and CPUs as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# iostat
Linux 4.18.0-553.81.1.el8_10.x86_64 (Mederma-Server)    11/06/25        _x86_64_        (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           5.32    0.03    7.56    0.56    0.00   86.52

Device             tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
sda               1.41        60.31        20.35     990172     334047
sdb              68.68         0.20       259.03       3247    4253013
scd0              0.00         0.00         0.00          2          0
dm-0              1.36        56.99        20.22     935694     331913
dm-1              0.01         0.14         0.00       2220          0
```

Logrotate

To install **logrotate** the required package is **logrotate**, I used Almalinux 8.10 and it is by default installed on it. as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# rpm -qa|grep -i "logrotate*"
logrotate-3.14.0-6.el8.x86_64
```

Applications generate the logs in logfiles, there will be time when size of these logfiles may be very large and hence affect the performance of the application. So, you can use **Logrotate** to rotate the logfiles and drop them periodically as explained below.

```
[root@Mederma-Server ~]# mkdir /var/log/httpd/newlog
```

Here rotate is 3 which means last three rotated logs will be kept and others are dropped. For rotated logfiles the extension used will be in the format of day, month, year, hour, minute and second, notifempty is used which means do not rotate the logfiles if logfile is empty. Compress the logfiles after rotation and store at the absolute path provided by olddir as shown below. Execute the commands as provided below under postrotate.

```
[root@Mederma-Server ~]# cat /etc/logrotate.d/httpd.conf
/var/log/httpd/* {
    rotate 3
    dateext
    dateformat -%d%m%Y-%H%M%S
    notifempty
    compress
    olddir /var/log/httpd/newlog/
    postrotate
        echo "A rotation just took place."
        systemctl reload httpd
    endscript
}
```

```
[root@Mederma-Server ~]# crontab -e
crontab: installing new crontab
[root@Mederma-Server ~]# crontab -l
0 12 14,28 * * /sbin/logrotate -f /etc/logrotate.d/httpd.conf
```

Forcefully execute the logrotate using crontab as shown in the screenshot attached above. It will be executed on 14th and 28th of every month at 12:00 PM.

How to create a Service in Linux

Here I had created a service in Linux to execute a shell script as shown in screenshot attached below.

```
[root@Mederma-Server ~]# cat /opt/dexter.sh
echo "My custom service is running!" >> /var/log/dexter_service.log
```

```
[root@Mederma-Server ~]# cat /etc/systemd/system/dexter.service
[Unit]
Description=Dexter Service
After=network.target

[Service]
ExecStart=/bin/bash /opt/dexter.sh
Type=simple
#User=root ### Run as a specific user
#Group=root ### Run as a specific group
Restart=on-failure
RestartSec=60

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

```
[root@Mederma-Server ~]# systemctl daemon-reload
```

```
[root@Mederma-Server ~]# systemctl start dexter.service
```

```
[root@Mederma-Server ~]# systemctl status dexter.service
● dexter.service - Dexter Service
   Loaded: loaded (/etc/systemd/system/dexter.service; disabled; vendor preset: disabled)
   Active: inactive (dead)

Nov 06 19:21:15 Mederma-Server systemd[1]: dexter.service: Failed with result 'exit-code'.
Nov 06 19:22:15 Mederma-Server systemd[1]: dexter.service: Service RestartSec=1min expired, scheduling restart.
Nov 06 19:22:15 Mederma-Server systemd[1]: dexter.service: Scheduled restart job, restart counter is at 2.
Nov 06 19:22:15 Mederma-Server systemd[1]: Stopped Dexter Service.
Nov 06 19:22:15 Mederma-Server systemd[1]: Started Dexter Service.
Nov 06 19:22:15 Mederma-Server systemd[1]: dexter.service: Main process exited, code=exited, status=217/USER
Nov 06 19:22:15 Mederma-Server systemd[1]: dexter.service: Failed with result 'exit-code'.
Nov 06 19:22:57 Mederma-Server systemd[1]: Stopped Dexter Service.
Nov 06 19:22:57 Mederma-Server systemd[1]: Started Dexter Service.
Nov 06 19:22:58 Mederma-Server systemd[1]: dexter.service: Succeeded.
```

```
[root@Mederma-Server ~]# cat /var/log/dexter_service.log
My custom service is running!
```

Different component used in the file **/etc/systemd/system/dexter.service** is as explained below.

Description: - Description about the service

After=network.target Start the network management stack

ExecStart will talk about the shell script to be executed

Type will say about how service has started or stopped; type of the service is simple which means Systemd considers the service started immediately after the main service process is forked.

WantedBy=multi-user.target Start the service when the system boots into a normal, multi-user state.

This how you can create the service in Linux and start the same when needed.

Auditd

In Linux if you want to monitor system activity then you can monitor the same using audit as explained below.

First check audit package is installed or not if not then install it using the command **yum install -y audit**.

```
[root@Mederma-Server ~]# rpm -qa|grep "audit"
python3-audit-3.1.2-1.el8_10.1.x86_64
audit-3.1.2-1.el8_10.1.x86_64
audit-libs-3.1.2-1.el8_10.1.x86_64
```

I am using **Almalinux 8.10** and audit package is already installed on that Linux machine as shown in the screenshot attached above. In the service configuration file for auditd present at the absolute path **/usr/lib/systemd/system/auditd.service**, **RefuseManualStop** was kept as **yes**. So, it was not possible to restart the **auditd** service. I changed it to **RefuseManualStop=no** reload the daemon using the command **systemctl daemon-reload** as shown in the screenshot attached below.

```
[Unit]
Description=Security Auditing Service
DefaultDependencies=no
## If auditd is sending or recieving remote logging, copy this file to
## /etc/systemd/system/auditd.service and comment out the first After and
## uncomment the second so that network-online.target is part of After.
## then comment the first Before and uncomment the second Before to remove
## sysinit.target from "Before".
After=local-fs.target systemd-tmpfiles-setup.service
##After=network-online.target local-fs.target systemd-tmpfiles-setup.service
Before=sysinit.target shutdown.target
##Before=shutdown.target
Conflicts=shutdown.target
RefuseManualStop=no
ConditionKernelCommandLine=!audit=0
ConditionKernelCommandLine=!audit=off

Documentation=man:auditd(8) https://github.com/linux-audit/audit-documentation

[Service]
Type=forking
PIDFile=/run/auditd.pid
ExecStart=/sbin/auditd
## To not use augenrules, copy this file to /etc/systemd/system/auditd.service
## and comment/delete the next line and uncomment the auditctl line.
## NOTE: augenrules expect any rules to be added to /etc/audit/rules.d/
ExecStartPost=-/sbin/augenrules --load
#ExecStartPost=-/sbin/auditctl -R /etc/audit/audit.rules
# By default we don't clear the rules on exit. To enable this, uncomment
# the next line after copying the file to /etc/systemd/system/auditd.service
#ExecStopPost=/sbin/auditctl -R /etc/audit/audit-stop.rules
Restart=on-failure
# Do not restart for intentional exits. See EXIT CODES section in auditd(8).
RestartPreventExitStatus=2 4 6

### Security Settings ###
MemoryDenyWriteExecute=true
LockPersonality=true
"/usr/lib/systemd/system/auditd.service" 47L, 1851C
```

```
[root@Mederma-Server ~]# systemctl daemon-reload
```

Then I opened the file **/etc/audit/rules.d/audit.rules** and wrote the audit rule as shown below.

```
[root@Mederma-Server ~]# vim /etc/audit/rules.d/audit.rules
```

```
## First rule - delete all
-D

## Increase the buffers to survive stress events.
## Make this bigger for busy systems
-b 8192

## This determine how long to wait in burst of events
--backlog_wait_time 60000

## Set failure mode to syslog
-f 1

-w /etc/ssh/sshd_config -p warx -k sshd_config_changes
```

```
[root@Mederma-Server ~]# systemctl restart auditd
```

```
[root@Mederma-Server ~]# systemctl status auditd
● auditd.service - Security Auditing Service
   Loaded: loaded (/usr/lib/systemd/system/auditd.service; enabled; vendor preset: enabled)
   Active: active (running) since Fri 2025[redacted] IST; 43min ago
     Docs: man:auditd(8)
           https://github.com/linux-audit/audit-documentation
  Process: 4074 ExecStartPost=/sbin/augenrules --load (code=exited, status=0/SUCCESS)
  Process: 4067 ExecStart=/sbin/auditd (code=exited, status=0/SUCCESS)
 Main PID: 4069 (auditd)
    Tasks: 4 (limit: 22875)
   Memory: 1.6M
   CGroup: /system.slice/auditd.service
           ├─4069 /sbin/auditd
           └─4071 /usr/sbin/sedispatch
```

Log files for audit are kept at the absolute path **/var/log/audit/audit.log**. User **john** tried to change the log I check the same using tail -f as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# tail -f /var/log/audit/audit.log
```

```
type=SYSCALL msg=audit([redacted]): arch=[redacted] syscall=257 success=no exit=-13 a0=[redacted] a1=[redacted] a2=0 a3=0 items=1 ppid=4492 pid=4596 aui
d=1000 uid=1001 gid=1001 euid=1001 suid=1001 fsuid=1001 egid=1001 sgid=1001 fsgid=1001 tty=pts1 ses=4 comm="cat" exe="/usr/bin/cat" subj=unconfined_u:unconfin
ed_r:unconfined_t:s0-s0:c0.c1023 key="sshd_config_changes"ARCH=x86_64 SYSCALL=openat AUID="ritesh" UID="john" GID="john" EUID="john" SUID="john" FSUID="john"
EGID="john" SGID="john" FSGID="john"
type=CWD msg=audit([redacted]): cwd="/home/john"
type=PATH msg=audit([redacted]): item=0 name="/etc/ssh/sshd_config" inode=35674990 dev=fd:00 mode=0100600 ouid=0 ogid=0 rdev=00:00 obj=system_u:object
_r:etc_t:s0 nametype=NORMAL cap_fp=0 cap_fi=0 cap_fe=0 cap_fver=0 cap_frootid=0OUID="root" OGID="root"
type=PROCTITLE msg=audit([redacted]): proctitle=[redacted]
```

As we know that **/etc** directory kept the configuration files and hence as a Linux Administrator I want to monitor which normal user tried to open that file. For that I applied the audit rule in the file **/etc/audit/rules.d/audit.rules** and then restarted the auditd service and then checked the audit logs as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# vim /etc/audit/rules.d/audit.rules
```

```
-w /etc -p warx -k etc_config_changes
```

```
[root@Mederma-Server ~]# systemctl restart auditd
```

```
[root@Mederma-Server ~]# systemctl status auditd
● auditd.service - Security Auditing Service
   Loaded: loaded (/usr/lib/systemd/system/auditd.service; enabled; vendor preset: enabled)
   Active: active (running) since Fri 2025-11-07 11:59:18 IST; 14min ago
     Docs: man:auditd(8)
           https://github.com/linux-audit/audit-documentation
  Process: 4652 ExecStartPost=/sbin/augenrules --load (code=exited, status=0/SUCCESS)
  Process: 4645 ExecStart=/sbin/auditd (code=exited, status=0/SUCCESS)
 Main PID: 4647 (auditd)
    Tasks: 4 (limit: 22875)
   Memory: 1.8M
   CGroup: /system.slice/auditd.service
           ├─4647 /sbin/auditd
           └─4649 /usr/sbin/sedispatch
```

The use **john** opened the file **/etc/passwd** and found that it was reported in the audit log as shown below.

```
type=SYSCALL msg=audit([redacted]): arch=c000003e syscall=257 success=yes exit=3 a0=ffffff9c a1=7f6bf2cd1e44 a2=80000 a3=0 items=1 ppid=4492 pid=4841
auid=1000 uid=1001 gid=1001 euid=1001 suid=1001 fsuid=1001 egid=1001 sgid=1001 fsgid=1001 tty=pts1 ses=4 comm="cat" exe="/usr/bin/cat" subj=unconfined_u:uncon
fined_r:unconfined_t:s0-s0:c0.c1023 key="etc_config_changes"ARCH=x86_64 SYSCALL=openat AUID="ritesh" UID="john" GID="john" EUID="john" SUID="john" FSUID="john
" EGID="john" SGID="john" FSGID="john"
type=CWD msg=audit([redacted]): cwd="/home/john"
type=PATH msg=audit([redacted]): item=0 name="/etc/ld.so.cache" inode=37150208 dev=fd:00 mode=0100644 ouid=0 ogid=0 rdev=00:00 obj=unconfined_u:object
_r:ld_so_cache_t:s0 nametype=NORMAL cap_fp=0 cap_fi=0 cap_fe=0 cap_fver=0 cap_frootid=0OUID="root" OGID="root"
type=PROCTITLE msg=audit([redacted]): proctitle=[redacted]
type=SYSCALL msg=audit([redacted]): arch=c000003e syscall=257 success=yes exit=3 a0=ffffff9c a1=7ffe05420627 a2=0 a3=0 items=1 ppid=4492 pid=4841 auid
=1000 uid=1001 gid=1001 euid=1001 suid=1001 fsuid=1001 egid=1001 sgid=1001 fsgid=1001 tty=pts1 ses=4 comm="cat" exe="/usr/bin/cat" subj=unconfined_u:unconfine
d_r:unconfined_t:s0-s0:c0.c1023 key="etc_config_changes"ARCH=x86_64 SYSCALL=openat AUID="ritesh" UID="john" GID="john" EUID="john" SUID="john" FSUID="john" EG
ID="john" SGID="john" FSGID="john"
type=CWD msg=audit([redacted]): cwd="/home/john"
type=PATH msg=audit([redacted]): item=0 name="/etc/passwd" inode=37150355 dev=fd:00 mode=0100644 ouid=0 ogid=0 rdev=00:00 obj=system_u:object_r:passwd
_file_t:s0 nametype=NORMAL cap_fp=0 cap_fi=0 cap_fe=0 cap_fver=0 cap_frootid=0OUID="root" OGID="root"
type=PROCTITLE msg=audit([redacted]): proctitle=[redacted]
```

Lock grub bootloader with a password

On a Linux machine it is safe to lock grub bootloader with a password, below is the procedure how do we lock the grub boot loader with a password. Login to your Linux machine and then run the command as shown below.

```
[root@Mederma-Server ~]# grub2-setpassword
Enter password:
Confirm password:
```

As shown in the above screenshot I had provided the password and confirmed with the same password. The hashed value of the password will show in the file present at the absolute path **/boot/grub2/user.cfg**.

```
[root@Mederma-Server ~]# cat /boot/grub2/user.cfg
GRUB2_PASSWORD=[redacted]
```

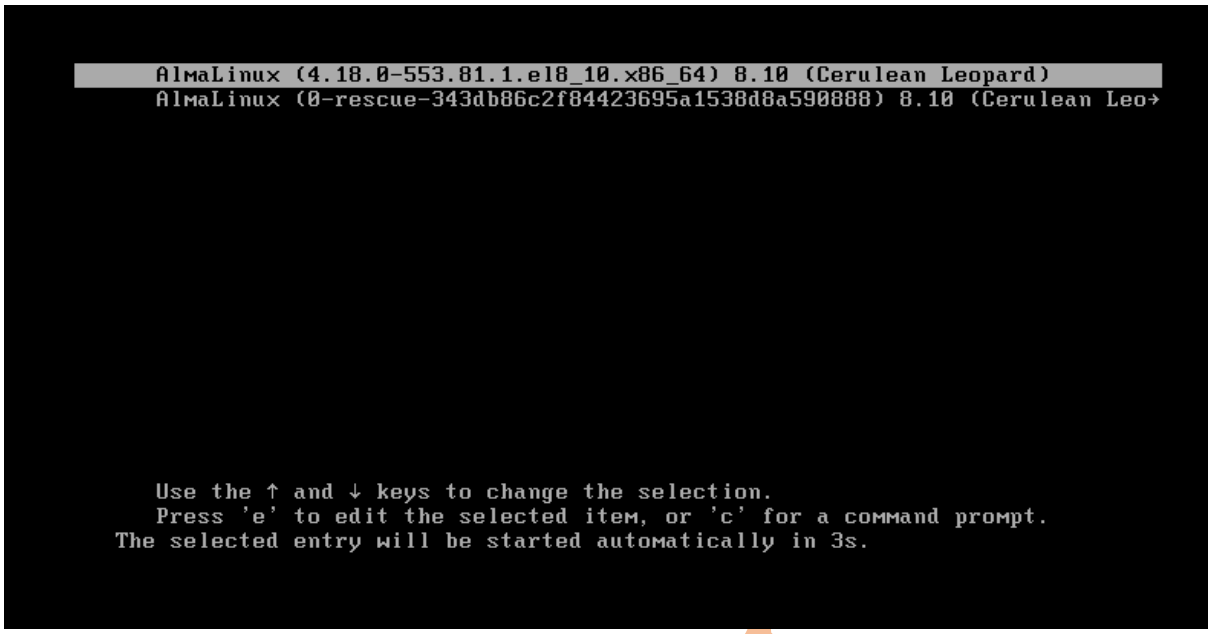
Then open the file **40_custom** present at the absolute path /etc/grub.d/40_custom and edit it with username and hashed password value as obtained from the previous step.

```
[root@Mederma-Server ~]# cat /etc/grub.d/40_custom
#!/bin/sh
exec tail -n +3 $0
# This file provides an easy way to add custom menu entries.  Simply type the
# menu entries you want to add after this comment.  Be careful not to change
# the 'exec tail' line above.
set superusers="sysuser"
password_pbkdf2 sysuser [redacted]
```

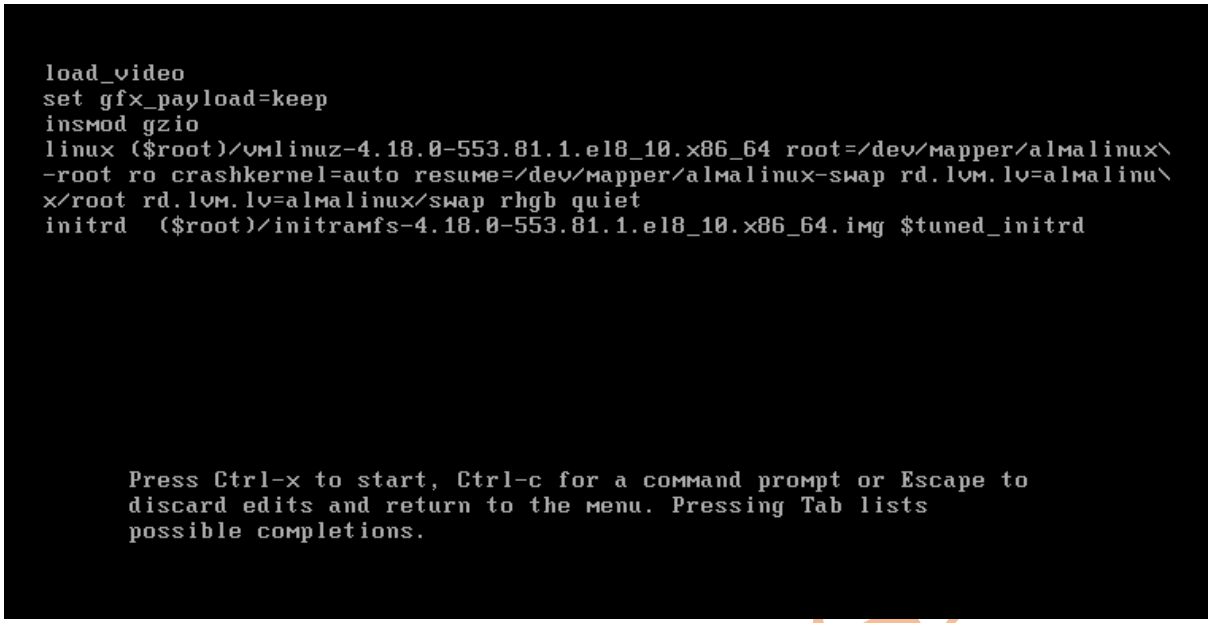
Regenerate the file **grub.cfg** as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# grub2-mkconfig -o /boot/grub2/grub.cfg
Generating grub configuration file ...
done
```

Now, reboot your Linux machine and select the key **e** to break the normal boot process as shown in the screenshot attached below.



Provide the username and password then it will redirect to edit the Grub configuration as shown in the screenshot attached below.



For security reasons it is suggested to lock your grub bootloader.

SELinux and AppArmor

SELinux stands for **security enhanced linux** it is a security system which is built-in into Linux Kernel. It is possible to configure SELINUX temporarily (on reboot the system will ineffective) or permanently (need to configure at absolute path **/etc/selinux/config**).

In SELinux there will be three modes **1. enforcing**, **2. permissive** and **3. disabled**.

Enforcing mode is the default and most secure mode.

Permissive mode SELinux logs actions that would have been denied but does not actually deny them.

Disabled mode SELinux is completely turned off, and no security policies are loaded or enforced.

If you need to configure selinux with permissive mode then you can use the command **setenforce 0**, you can check the selinux status using the command **sestatus** as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# setenforce 0
[root@Mederma-Server ~]# sestatus
SELinux status:                 enabled
SELinuxfs mount:                /sys/fs/selinux
SELinux root directory:         /etc/selinux
Loaded policy name:             targeted
Current mode:                   permissive
Mode from config file:          enforcing
Policy MLS status:              enabled
Policy deny_unknown status:     allowed
Memory protection checking:     actual (secure)
Max kernel policy version:      33
```

```
[root@Mederma-Server ~]# setenforce 1
[root@Mederma-Server ~]# sestatus
SELinux status:                 enabled
SELinuxfs mount:                /sys/fs/selinux
SELinux root directory:         /etc/selinux
Loaded policy name:             targeted
Current mode:                   enforcing
Mode from config file:          enforcing
Policy MLS status:              enabled
Policy deny_unknown status:     allowed
Memory protection checking:     actual (secure)
Max kernel policy version:      33
```

But when you will reboot the system this temporary configuration will no longer exist. So, you need to configure it from the file **/etc/selinux/config** as shown below.

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

Then **reboot** the system and check the selinux status using the command **sestatus** as shown below.

```
[root@Mederma-Server ~]# sestatus
SELinux status:                 enabled
SELinuxfs mount:                /sys/fs/selinux
SELinux root directory:         /etc/selinux
Loaded policy name:             targeted
Current mode:                   enforcing
Mode from config file:          enforcing
Policy MLS status:              enabled
Policy deny_unknown status:     allowed
Memory protection checking:     actual (secure)
Max kernel policy version:      33
```

By applying appropriate selinux stamping a process will be able to access the files. As for example check the selinux stamping for file **/etc/passwd**.

```
[root@Mederma-Server ~]# ls -Z /etc/passwd
system_u:object_r:passwd_file_t:s0 /etc/passwd
```

I changed the stamping from **passwd_file_t** to **admin_home_t** as shown below.

```
[root@Mederma-Server ~]# chcon -t admin_home_t /etc/passwd
[root@Mederma-Server ~]# ls -Z /etc/passwd
system_u:object_r:admin_home_t:s0 /etc/passwd
```

Then I tried to change the password of user **john** using the command as shown below and my finds are as shown below.

```
[root@Mederma-Server ~]# passwd john
passwd: Unknown user name 'john'.
```

Now, rechange the stamping as shown below.

```
[root@Mederma-Server ~]# restorecon /etc/passwd
[root@Mederma-Server ~]# ls -Z /etc/passwd
system_u:object_r:passwd_file_t:s0 /etc/passwd
```

Here you will find that after appropriate stamping, you will be able to change the password as shown below.

```
[root@Mederma-Server ~]# passwd john
Changing password for user john.
New password:
Retype new password:
passwd: all authentication tokens updated successfully.
```

Here I am showing you how to change the Selinux Boolean, first I checked the SELinux status and then listed the SELinux Boolean using the command as shown below.

```
[root@Mederma-Server ~]# getenforce
Enforcing
[root@Mederma-Server ~]#
```

```
[root@Mederma-Server ~]# getsebool -a|grep "httpd_enable_homedirs"
httpd_enable_homedirs --> off
```

If SELinux if the Boolean **httpd_enable_homedirs** is **on** then Apache httpd can use the users home directory which is not good for security point of view. But for readers to demonstrate I had on it permanently as shown in the screenshot attached below.

```
[root@Mederma-Server ~]# setsebool -P httpd_enable_homedirs on
```

```
[root@Mederma-Server ~]# getsebool -a|grep "httpd_enable_homedirs"
httpd_enable_homedirs --> on
```

```
[root@Mederma-Server ~]# setsebool -P httpd_enable_homedirs off
[root@Mederma-Server ~]# getsebool -a|grep "httpd_enable_homedirs"
httpd_enable_homedirs --> off
```

In the same way you can on or off other SELinux Booleans.

AppArmor

Apparmor is mandatory access control (MAC) for Linux where access to resources is centrally managed by the system. In Apparmor a user needs to create the profiles (which is nothing but security policy defining its access rules and restrictions). Apparmor can be used with OpenSUSE or Ubuntu. For present case I am using Ubuntu 20.04 in which Apparmor was by default installed.

Types of Apparmor profile modes – **Complain mode**, **Enforcing mode** and **Unconfined mode**.

Complain mode: - In complain mode violations are blocked and Apparmor logs the attempts.

Enforcing mode: - In enforcing mode if a program performs a forbidden action, then action is denied. Violations will be logged.

Unconfined mode: - Violations are not blocked and Apparmor not logged the restrictions.

To install Apparmor in Ubuntu you can use the command **apt-get install -y apparmor**. You can check the status Apparmor using the command **systemctl status apparmor** and enable it from the boot time using the command **systemctl enable apparmor**.

If Apparmor is installed then you use the command **aa-status** to know what profiles are loaded and in which states they are in. As shown below there are 33 profiles are loaded and they are in enforcing modes.

```
root@ubuntu-2204:~# aa-status
apparmor module is loaded.
33 profiles are loaded.
33 profiles are in enforce mode.
```

To use the command **aa-genprof** you need to install the package **apparmor-utils** using the command **apt-get install -y apparmor-utils**. The command **aa-genprof** is used to create the apparmor profiles.

```
root@ubuntu-2204:~# apt-get install -y apparmor-utils
```

I had created a directory **/mederma** as shown below and I need to create the file and delete the created file in this directory using the shell script as shown below.

```
root@ubuntu-2204:~# mkdir /mederma
```

```
root@ubuntu-2204:~# mv example.sh thamu.sh
root@ubuntu-2204:~# chmod +x thamu.sh
root@ubuntu-2204:~# cat thamu.sh
#!/bin/bash

echo "This is an apparmor example."

touch /mederma/sample.txt
echo "File created"

rm /mederma/sample.txt
echo "File deleted"
```

Now, create the apparmor profile with aa-genprof then enforce the apparmor profile as shown below.

```
root@ubuntu-2204:~# aa-genprof /root/thamu.sh

Before you begin, you may wish to check if a
profile already exists for the application you
wish to confine. See the following wiki page for
more information:
https://gitlab.com/apparmor/apparmor/wikis/Profiles

Profiling: /root/thamu.sh

Please start the application to be profiled in
another window and exercise its functionality now.

Once completed, select the "Scan" option below in
order to scan the system logs for AppArmor events.

For each AppArmor event, you will be given the
opportunity to choose whether the access should be
allowed or denied.

[(S)can system log for AppArmor events] / (F)inish
Reading log entries from /var/log/audit/audit.log.
Updating AppArmor profiles in /etc/apparmor.d.

Profiling: /root/thamu.sh

Please start the application to be profiled in
another window and exercise its functionality now.

Once completed, select the "Scan" option below in
order to scan the system logs for AppArmor events.

For each AppArmor event, you will be given the
opportunity to choose whether the access should be
allowed or denied.

[(S)can system log for AppArmor events] / (F)inish
Reading log entries from /var/log/audit/audit.log.
```

```
Profile:  /root/thamu.sh
Execute:  /usr/bin/touch
Severity: 3

(I)nherit / (C)hild / (N)amed / (X) ix On / (D)eny / Abo(r)t / (F)inish

Are you specifying a transition to a local profile?

(Y)es / [(N)o]

Enter profile name to transition to: /usr/bin/touch

Should AppArmor sanitise the environment when
switching profiles?

Sanitising environment is more secure,
but some applications depend on the presence
of LD_PRELOAD or LD_LIBRARY_PATH.

[(Y)es] / (N)o

Profile:  /root/thamu.sh
Execute:  /usr/bin/rm
Severity: unknown

(I)nherit / (C)hild / (N)amed / (X) ix On / (D)eny / Abo(r)t / (F)inish

Are you specifying a transition to a local profile?

(Y)es / [(N)o]

Enter profile name to transition to: /usr/bin/rm

Should AppArmor sanitise the environment when
switching profiles?

Sanitising environment is more secure,
but some applications depend on the presence
```

```
of LD_PRELOAD or LD_LIBRARY_PATH.

[(Y)es] / (N)o
Complain-mode changes:

Profile:  /root/thamu.sh
Path:     /dev/tty
New Mode: owner rw
Severity: 9

 [1 - #include <abstractions/consoles>]
  2 - owner /dev/tty rw,
(A)llow / [(D)eny] / (I)gnore / (G)lob / Glob with (E)xtension / (N)ew / Audi(t) / (O)wner permissions off / Abo(r)t / (F)inish
Adding #include <abstractions/consoles> to profile.

Profile:  /root/thamu.sh^/usr/bin/rm
Path:     /mederma/sample.txt
New Mode: owner w
Severity: unknown

 [1 - owner /mederma/sample.txt w,]
(A)llow / [(D)eny] / (I)gnore / (G)lob / Glob with (E)xtension / (N)ew / Audi(t) / (O)wner permissions off / Abo(r)t / (F)inish
Adding owner /mederma/sample.txt w, to profile.

Profile:  /root/thamu.sh^/usr/bin/touch
Path:     /mederma/sample.txt
New Mode: owner w
Severity: unknown

 [1 - owner /mederma/sample.txt w,]
(A)llow / [(D)eny] / (I)gnore / (G)lob / Glob with (E)xtension / (N)ew / Audi(t) / (O)wner permissions off / Abo(r)t / (F)inish
Adding owner /mederma/sample.txt w, to profile.

= Changed Local Profiles =

The following local profiles were changed. Would you like to save them?

 [1 - /root/thamu.sh]
(S)ave Changes / Save Selec(t)ed Profile / [(V)iew Changes] / View Changes b/w (C)lean profiles / Abo(r)t
```

```
Writing updated profile for /root/thamu.sh.

Profiling: /root/thamu.sh

Please start the application to be profiled in
another window and exercise its functionality now.

Once completed, select the "Scan" option below in
order to scan the system logs for AppArmor events.

For each AppArmor event, you will be given the
opportunity to choose whether the access should be
allowed or denied.

[(S)can system log for AppArmor events] / (F)inish

Reloaded AppArmor profiles in enforce mode.

Please consider contributing your new profile!
See the following wiki page for more information:
https://gitlab.com/apparmor/apparmor/wikis/Profiles

Finished generating profile for /root/thamu.sh.
root@ubuntu-2204:~# aa-enforce /etc/apparmor.d/root.thamu.sh
Setting /etc/apparmor.d/root.thamu.sh to enforce mode.
root@ubuntu-2204:~# ./thamu.sh
This is an apparmor example.
File created
File deleted
```

It is possible to keep your apparmor profile in complain mode as shown below.

```
root@ubuntu-2204:~# aa-complain /etc/apparmor.d/root.thamu.sh
Setting /etc/apparmor.d/root.thamu.sh to complain mode.
```

Apparmor uses security profiles to restrict application access, here I installed nginx and restricting it access using apparmor profile as shown below.

```
root@dexter-server:~# apt-get install -y nginx
```

```
root@dexter-server:~# systemctl start nginx && systemctl enable nginx
Synchronizing state of nginx.service with SysV service script with /lib/systemd/systemd-sysv-install.
Executing: /lib/systemd/systemd-sysv-install enable nginx
root@dexter-server:~# systemctl status nginx
● nginx.service - A high performance web server and a reverse proxy server
     Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset: enabled)
     Active: active (running) since Thu 2025-11-13 11:33:39 IST; 19s ago
```

```
root@dexter-server:~# ls /etc/apparmor.d/
abi           lsb_release      ubuntu_pro_apt_news   usr.bin.tcpdump                          usr.lib.libreoffice.program.xpdfimport  usr.sbin.rsyslogd
abstractions  nvidia_modprobe  ubuntu_pro_esm_cache  usr.lib.libreoffice.program.oosplash     usr.lib.snapd.snap-confine.real
disable       sbin.dhclient    usr.bin.evince        usr.lib.libreoffice.program.senddoc      usr.sbin.cups-browsed
local         tunables         usr.bin.man           usr.lib.libreoffice.program.soffice.bin  usr.sbin.cupsd
```

After running the **aa-autodep nginx** command minimum profile for apparmor will be generated as shown below.

```
root@dexter-server:~# aa-autodep nginx
Writing updated profile for /usr/sbin/nginx.
root@dexter-server:~# ls /etc/apparmor.d/
abi           lsb_release      ubuntu_pro_apt_news   usr.bin.tcpdump                          usr.lib.libreoffice.program.xpdfimport  usr.sbin.nginx
abstractions  nvidia_modprobe  ubuntu_pro_esm_cache  usr.lib.libreoffice.program.oosplash     usr.lib.snapd.snap-confine.real         usr.sbin.rsyslogd
disable       sbin.dhclient    usr.bin.evince        usr.lib.libreoffice.program.senddoc      usr.sbin.cups-browsed
local         tunables         usr.bin.man           usr.lib.libreoffice.program.soffice.bin  usr.sbin.cupsd
root@dexter-server:~# cat /etc/apparmor.d/usr.sbin.nginx
# Last Modified: Thu Nov 13 11:35:31 2025
abi <abi/3.0>,

include <tunables/global>

/usr/sbin/nginx flags=(complain) {
  include <abstractions/base>

  /usr/sbin/nginx mr,

}
```

Now, I had activated complain mode so that it does not enforce policy but generates log when it detects violations of security policy. To make this effective I must restart the nginx service as shown below.

```
root@dexter-server:~# aa-complain /usr/sbin/nginx
Setting /usr/sbin/nginx to complain mode.
root@dexter-server:~# systemctl restart nginx
```

I edited the file **/etc/apparmor.d/usr.sbin.nginx** and restarted the nginx service and then ran the command **aa-logprof** to interactively review AppArmor log events and update security profiles, making the process of building or modifying profiles much more efficient.

```
root@dexter-server:~# mkdir -p /var/www/html/forbidden
```

```
root@dexter-server:~# vim /etc/apparmor.d/usr.sbin.nginx
root@dexter-server:~# apparmor_parser -r /etc/apparmor.d/usr.sbin.nginx
```

Here I restarted the nginx service using the command **systemctl restart nginx** but unable to restart then I ran the command **aa-logprof** to get insights about issues and the ability to add necessary lines in the custom profile.

```
root@dexter-server:~# aa-logprof
Updating AppArmor profiles in /etc/apparmor.d.
Reading log entries from /var/log/syslog.
Complain-mode changes:

Profile:  /usr/sbin/nginx
Path:     /usr/share/nginx/modules-available/mod-http-geoip2.conf
New Mode: owner r
Severity: unknown

 [1 - include <abstractions/evince>]
  2 - owner /usr/share/nginx/modules-available/mod-http-geoip2.conf r,
(A)llow / [(D)eny] / (I)gnore / (G)lob / Glob with (E)xtension / (N)ew / Audi(t) / (O)wner permissions off / Abo(r)t / (F)inish
Adding include <abstractions/evince> to profile.

Profile:  /usr/sbin/nginx
Path:     /etc/nginx/nginx.conf
New Mode: owner r
Severity: unknown

 [1 - owner /etc/nginx/nginx.conf r,]
(A)llow / [(D)eny] / (I)gnore / (G)lob / Glob with (E)xtension / (N)ew / Audi(t) / (O)wner permissions off / Abo(r)t / (F)inish
Adding owner /etc/nginx/nginx.conf r, to profile.
Enforce-mode changes:

Profile:    /usr/lib/snapd/snap-confine
Capability: net_admin
Severity:   8

 [1 - capability net_admin,]
(A)llow / [(D)eny] / (I)gnore / Audi(t) / Abo(r)t / (F)inish
Adding capability net_admin, to profile.

Profile:    /usr/lib/snapd/snap-confine
Capability: perfmon
Severity:   7

 [1 - capability perfmon,]
(A)llow / [(D)eny] / (I)gnore / Audi(t) / Abo(r)t / (F)inish
```

```
(A)llow / [(D)eny] / (I)gnore / Audi(t) / Abo(r)t / (F)inish
Adding capability perfmon, to profile.

Profile:    /usr/sbin/cupsd
Capability: net_admin
Severity:   8

 [1 - capability net_admin,]
(A)llow / [(D)eny] / (I)gnore / Audi(t) / Abo(r)t / (F)inish
Adding capability net_admin, to profile.

= Changed Local Profiles =

The following local profiles were changed. Would you like to save them?

 [1 - /usr/lib/snapd/snap-confine]
  2 - /usr/sbin/cupsd
  3 - /usr/sbin/nginx
(S)ave Changes / Save Selec(t)ed Profile / [(V)iew Changes] / View Changes b/w (C)lean profiles / Abo(r)t
Writing updated profile for /usr/lib/snapd/snap-confine.
Writing updated profile for /usr/sbin/cupsd.
Writing updated profile for /usr/sbin/nginx.
```

Then I enforced the nginx service, restarted it and checked its status as shown below.

```
root@dexter-server:~# aa-enforce /usr/sbin/nginx
Setting /usr/sbin/nginx to enforce mode.
root@dexter-server:~# systemctl restart nginx
root@dexter-server:~# systemctl status nginx
● nginx.service - A high performance web server and a reverse proxy server
     Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset: enabled)
     Active: active (running) since Thu 2025-11-13 11:53:40 IST; 2s ago
```

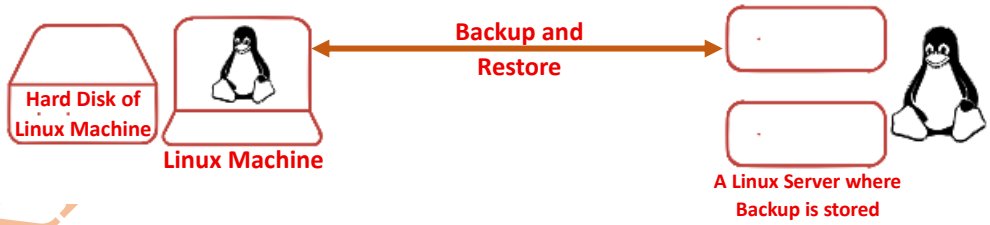
```
root@dexter-server:~# cat /etc/apparmor.d/usr.sbin.nginx
# Last Modified: Thu Nov 13 11:52:36 2025
include <tunables/global>

/usr/sbin/nginx {
  include <abstractions/apache2-common>
  include <abstractions/base>
  include <abstractions/evince>
  include <abstractions/nis>
  include <abstractions/web-data>

  capability dac_override,
  capability dac_read_search,
  capability net_bind_service,
  capability setgid,
  capability setuid,

  deny /var/www/html/forbidden/* r,

  /etc/group r,
  /etc/nginx/conf.d/ r,
  /etc/nginx/mime.types r,
  /etc/nsswitch.conf r,
  /etc/passwd r,
  /etc/ssl/openssl.cnf r,
  /run/nginx.pid rw,
  /usr/sbin/nginx mr,
  /var/log/nginx/access.log w,
  /var/log/nginx/error.log w,
  owner /etc/nginx/modules-enabled/ r,
  owner /etc/nginx/nginx.conf r,
  owner /etc/nginx/sites-available/default r,
  owner /etc/nginx/sites-enabled/ r,
  owner /usr/share/nginx/modules-available/mod-http-geoip.conf r,
  owner /usr/share/nginx/modules-available/mod-http-image-filter.conf r,
  owner /usr/share/nginx/modules-available/mod-http-xslt-filter.conf r,
  owner /usr/share/nginx/modules-available/mod-mail.conf r,
  owner /usr/share/nginx/modules-available/mod-stream-geoip.conf r,
  owner /usr/share/nginx/modules-available/mod-stream.conf r,

}
```

```
root@dexter-server:~# curl http://localhost/forbidden/index.html
<html>
<head><title>403 Forbidden</title></head>
<body>
<center><h1>403 Forbidden</h1></center>
<hr><center>nginx/1.18.0 (Ubuntu)</center>
</body>
</html>
```

Each time you are in complain or enforce mode for AppArmor and receive any errors with the service, you can use the logging utility aa-logprof that will give you more insights about issues and the ability to add necessary lines in your custom profile automatically.

```
root@dexter-server:~# curl http://localhost
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
```

How to backup and restore your Linux Servers



In the current scenario I am backing up the Linux Server using rsync on local server and on remote server both. However, you can take the backup only on remote server.

```
[root@Dexter-Server ~]# cat dexter.sh
#!/bin/bash

rsync -avz --delete --exclude={"/dev/*","/proc/*","/sys/*","/tmp/*","/run/*","/mnt/*","/media/*","/backup/*","/lost+found"} / /backup/
rsync -avz --delete /backup/ root@192.168.40.135:/zack/backup/

echo "Backup complete..."
echo "Backup complete..."
echo "Backup complete..."
[root@Dexter-Server ~]# chmod +x dexter.sh ^C
[root@Dexter-Server ~]# crontab -e
crontab: installing new crontab
[root@Dexter-Server ~]# crontab -l
15 13,22 * * * sh dexter.sh
```

```
cat dexter.sh

#!/bin/bash


rsync -avz --delete --
exclude={"/dev/*","/proc/*","/sys/*","/tmp/*","/run/*","/mnt/*","/media/*","/backup/*","/lost+found"}
/ /backup/

rsync -avz --delete /backup/ root@192.168.40.135:/zack/backup/


echo "Backup complete..."

echo "Backup complete..."

echo "Backup complete..."
```

You can restore the backup from local using the command **rsync -avz /backup/ /**.

As shown in the screenshot attached above the crontab will be executed at 1:15 PM and 10:15 PM. You can restore it as per your need. You can see in the screenshot attached above with rsync I had used --delete which is used in case of incremental backup.

Perform Security Checks and ensure compliance using OSCAP

In AWS Environment

OSCAP uses **CIS benchmark** for checking and improving system security compliance. For the current project I launched four EC2 Instances and an application LoadBalancer using Terraform on one EC2 Instance I installed httpd webserver on second EC2 Instance I installed ansible which I will use as an Ansible Controller node. On rest of the two EC2 Instances (One with RHEL 9 as Operating System and another with Amazon Linux 2023 as Operating System) I will check and improve the system security compliance using OSCAP with the help of Ansible.

I had generated the ansible playbook **playbook.yaml**, using bootstrap script as shown in the screenshot attached below.

```
################################## Install oscap ############################################

yum install -y openscap-scanner scap-security-guide
oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report.html /usr/share/xml/scap/ssg/content/ssg-rhel9-ds.xml
oscap xccdf generate fix --fix-type ansible --result-id "" --fetch-remote-resources /tmp/arf.xml > /opt/playbook-rhel9.yml
```

```
################################## Install OSCAP ############################################

yum install -y openscap-scanner scap-security-guide
oscap xccdf eval --oval-results --profile xccdf_org.ssgproject.content_profile_standard --results-arf /tmp/arf.xml --report /tmp/report.html /usr/share/xml/sc
ap/ssg/content/ssg-al2023-ds.xml
oscap xccdf generate fix --fix-type ansible --result-id "" --fetch-remote-resources /tmp/arf.xml > /opt/playbook-almalinux2023.yml
```

Then send this generated playbook and generated report to the Ansible Controller Node and httpd webserver respectively using the command as shown below.

```
[root@                ~]# scp -rv /opt/playbook-rhel9.yml root@              :~/
```

```
[root@                ~]# scp -rv /opt/playbook-almalinux2023.yml root@              :~/
```

```
[root@ ~]# scp -rv /tmp/report.html root@ :/var/www/html/report-rhel9-old.html
```

```
[root@ ~]# scp -rv /tmp/report.html root@ :/var/www/html/report-amazonlinux2023-old.html
```

On Ansible controller the inventory and the executed command output is as shown below.

```
[root@ansible-controller ~]# cat /home/ec2-user/inventory/hosts
[rhel9]
10.10.4.131
[amazonlinux2023]
10.10.4.148
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ec2-user/inventory/hosts --limit rhel9 playbook-rhel9.yml

TASK [Record Attempts to Alter the localtime File - Check if watch rule for /etc/localtime already exists in /etc/audit/audit.rules] ************************
ok: [10.10.4.131]

TASK [Record Attempts to Alter the localtime File - Add watch rule for /etc/localtime in /etc/audit/audit.rules] ************************************
changed: [10.10.4.131]

TASK [Gather the package facts] ********************************************************************************************************************
ok: [10.10.4.131]

TASK [Configure auditd Disk Error Action on Disk Error] ********************************************************************************************
changed: [10.10.4.131]

TASK [Gather the package facts] ********************************************************************************************************************
ok: [10.10.4.131]

TASK [Configure auditd Disk Full Action when Disk Space Is Full] ***********************************************************************************
changed: [10.10.4.131]

TASK [Gather the package facts] ********************************************************************************************************************
ok: [10.10.4.131]

TASK [Configure auditd admin_space_left Action on Low Disk Space] **********************************************************************************
changed: [10.10.4.131]

TASK [Gather the package facts] ********************************************************************************************************************
ok: [10.10.4.131]

TASK [Configure auditd max_log_file_action Upon Reaching Maximum Log Size] *************************************************************************
changed: [10.10.4.131]

TASK [Gather the package facts] ********************************************************************************************************************
ok: [10.10.4.131]

TASK [Configure auditd space_left Action on Low Disk Space] ****************************************************************************************
changed: [10.10.4.131]

PLAY RECAP *****************************************************************************************************************************************
10.10.4.131                : ok=2165 changed=346  unreachable=0    failed=0    skipped=635  rescued=0    ignored=0
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ec2-user/inventory/hosts --limit amazonlinux2023 playbook-almalinux2023.yml

TASK [Enable syslog plugin] ************************************************************************************************************************
changed: [10.10.4.148]

TASK [Find /lib/ file(s) recursively] **************************************************************************************************************
ok: [10.10.4.148]

TASK [Set permissions for /lib/ file(s)] ***********************************************************************************************************
changed: [10.10.4.148] => (item=/lib/python3.9/site-packages/urllib3/packages/ssl_match_hostname.py)

TASK [Find /lib64/ file(s) recursively] ************************************************************************************************************
ok: [10.10.4.148]

TASK [Set permissions for /lib64/ file(s)] *********************************************************************************************************
skipping: [10.10.4.148]

TASK [Find /usr/lib/ file(s) recursively] **********************************************************************************************************
ok: [10.10.4.148]

TASK [Set permissions for /usr/lib/ file(s)] *******************************************************************************************************
skipping: [10.10.4.148]

TASK [Find /usr/lib64/ file(s) recursively] ********************************************************************************************************
ok: [10.10.4.148]

TASK [Set permissions for /usr/lib64/ file(s)] *****************************************************************************************************
skipping: [10.10.4.148]

TASK [Check for duplicate values] ******************************************************************************************************************
ok: [10.10.4.148]

TASK [Deduplicate values from /etc/ssh/sshd_config] ************************************************************************************************
skipping: [10.10.4.148]

TASK [Insert correct line to /etc/ssh/sshd_config] *************************************************************************************************
changed: [10.10.4.148]

PLAY RECAP *****************************************************************************************************************************************
10.10.4.148                : ok=152  changed=29   unreachable=0    failed=0    skipped=36   rescued=0    ignored=0
```

Now, generate the report by executing the ansible playbook as shown below.

Go to Ansible Controller Node and run the playbook as shown below.

```
[root@ansible-controller ~]# cat playbook-report.yaml
---
- name: Install packages for OSCAP and generate report
  hosts: all
  become: true
  tasks:
  - name: On RHEL 9
    block:
    - name: Install packages for OSCAP
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rhel9.html /usr/share/xml/scap/ssg/
content/ssg-rhel9-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_os_family == "RedHat" and ansible_distribution_major_version == "9"
  - name: On AmazonLinux2023
    block:
    - name: Install packages for OSCAP
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile xccdf_org.ssgproject.content_profile_standard --results-arf /tmp/arf.xml --report /tmp/
report-amazonlinux2023.html /usr/share/xml/scap/ssg/content/ssg-al2023-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_distribution == 'Amazon' and ansible_distribution_major_version == '2023'
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ec2-user/inventory/hosts playbook-report.yaml

PLAY [Install packages for OSCAP and generate report] **************************************************************************************************************

TASK [Gathering Facts] *********************************************************************************************************************************************
[WARNING]: Platform linux on host 10.10.4.148 is using the discovered Python interpreter at /usr/bin/python3.9, but future installation of another Python
interpreter could change the meaning of that path. See https://docs.ansible.com/ansible-core/2.15/reference_appendices/interpreter_discovery.html for more
information.
ok: [10.10.4.148]
ok: [10.10.4.131]

TASK [Install packages for OSCAP] **********************************************************************************************************************************
skipping: [10.10.4.148]
ok: [10.10.4.131]

TASK [Create the Report] *******************************************************************************************************************************************
skipping: [10.10.4.148]
changed: [10.10.4.131]

TASK [Install packages for OSCAP] **********************************************************************************************************************************
skipping: [10.10.4.131]
ok: [10.10.4.148]

TASK [Create the Report] *******************************************************************************************************************************************
skipping: [10.10.4.131]
changed: [10.10.4.148]

PLAY RECAP *********************************************************************************************************************************************************
10.10.4.131                : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
10.10.4.148                : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
```

```
cat playbook-report.yaml

---

- name: Install packages for OSCAP and generate report

 hosts: all

 become: true

 tasks:

 - name: On RHEL 9

  block:

  - name: Install packages for OSCAP

    yum:

      name:

      - openscap-scanner

      - scap-security-guide

      state: present

  - name: Create the Report

    ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rhel9.html
/usr/share/xml/scap/ssg/content/ssg-rhel9-ds.xml

    args:

      chdir: /tmp

    register: oscap_scan_output

    failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower

  when: ansible_os_family == "RedHat" and ansible_distribution_major_version == "9"

 - name: On AmazonLinux2023

  block:

  - name: Install packages for OSCAP

    yum:

      name:

      - openscap-scanner

      - scap-security-guide

      state: present

  - name: Create the Report

    ansible.builtin.shell: oscap xccdf eval --oval-results --profile xccdf_org.ssgproject.content_profile_standard --results-arf /tmp/arf.xml --
report /tmp/report-amazonlinux2023.html /usr/share/xml/scap/ssg/content/ssg-al2023-ds.xml

    args:

      chdir: /tmp

    register: oscap_scan_output

    failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower

  when: ansible_distribution == 'Amazon' and ansible_distribution_major_version == '2023'
```

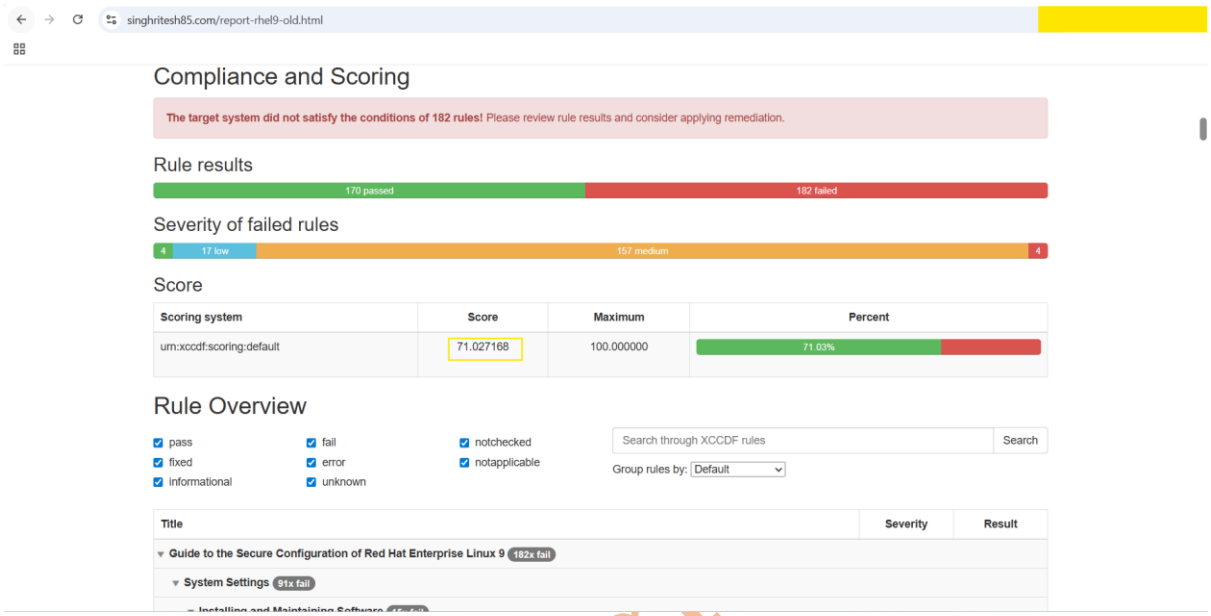
Then send the report.html to web server and open to verify as shown below.

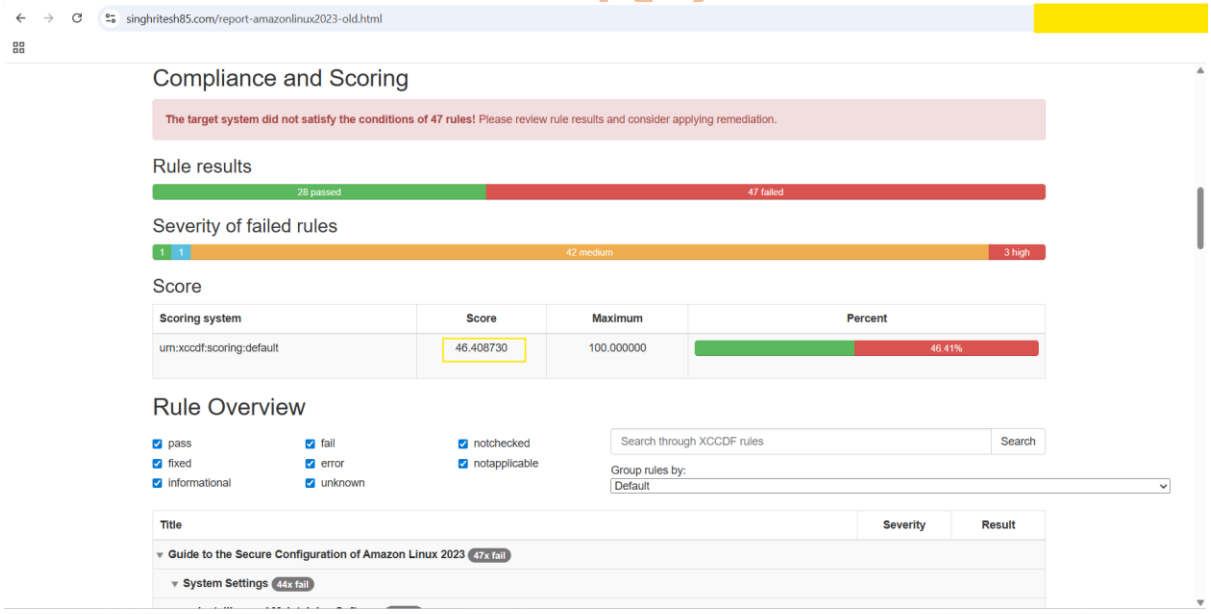
From 1st Server (RHEL9)

```
[root@                ~]# scp -rv /tmp/report-rhel9.html root@          :/var/www/html/
```

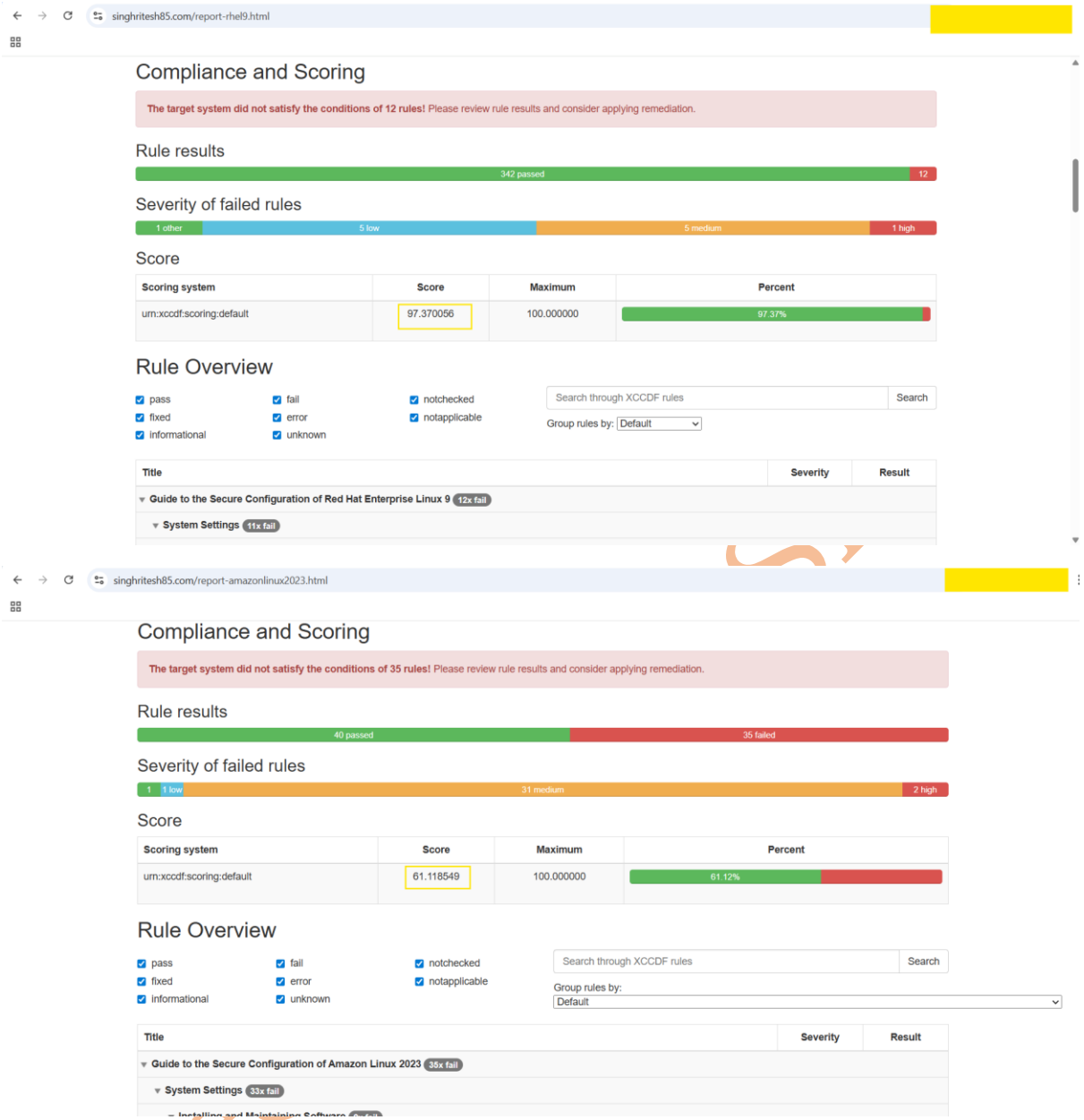
From 2nd Server (AmazonLinux2023)

```
[root@                ~]# scp -rv /tmp/report-amazonlinux2023.html root@          :/var/www/html/
```

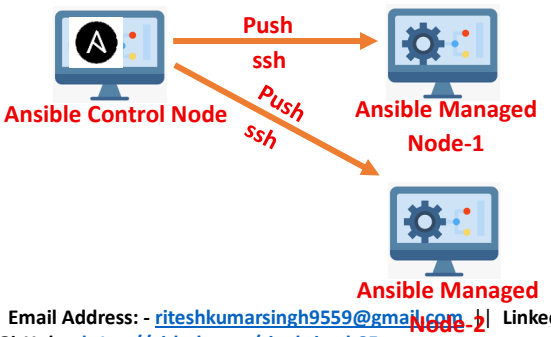




Below screenshot shows the report After running the Ansible Playbook. You can see the score had been improved to 97% and 61% for RHEL9 and AmazonLinux2023 servers respectively.



You can create an AMI of this EC2 instance and use as the Golden AMI. As I used Ansible here so I am explaining about it in brief. Ansible is a configuration management tool which works on push mechanism (**Ansible control node sends configurations, commands, and software to the managed nodes**).



For your reference I kept all the Ansible playbooks and Terraform script in the GitHub Repo https://github.com/singhritesh85/Linux-Administration-for-DevOps-Engineers.git.

In Azure Environment

Here I had created four Azure VMs one for Ansible Controller, second for httpd Web Server (and Application Gateway) and two more Azure VMs (one with Almalinux8 and another with Ubuntu 22.04 Operating System which I will scan using OSCAP for configuration and vulnerability scan) using Terraform.

Either you already have the playbooks or generate it using the procedure as shown below. For this I installed OSCAP on both Almalinux8 and ubuntu 22.04 as shown below.

On Almalinux8

yum install -y openscap-scanner scap-security-guide

oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report.html /usr/share/xml/scap/ssg/content/ssg-almalinux8-ds.xml

oscap xccdf generate fix --fix-type ansible --result-id "" --fetch-remote-resources /tmp/arf.xml > playbook-almalinux8.yaml

On Ubuntu 22.04

apt-get update

apt-get install libopenscap8 -y

wget https://github.com/ComplianceAsCode/content/releases/download/v0.1.78/scap-security-guide-0.1.78.zip

apt-get install -y unzip

unzip scap-security-guide-0.1.78.zip

Securely copied these playbooks to ansible controller node as shown below.

```
[root@oscap-vm ~]# scp -rv playbook-almalinux8.yaml ritesh@172.203.81.125:~/
root@oscap-vm2:~# scp -rv scap-security-guide-0.1.78/ansible/ubuntu2404-playbook-cis_level2_server.yml ritesh@172.203.81.125:~/
[root@ansible-controller ~]# cp /home/ritesh/playbook-almalinux8.yaml .
[root@ansible-controller ~]# cp /home/ritesh/ubuntu2204-playbook-cis_level2_server.yml .
[root@ansible-controller ~]# ls
playbook-almalinux8.yaml  ubuntu2204-playbook-cis_level2_server.yml
```

```
[root@ansible-controller ~]# cat /home/ritesh/inventory/hosts
[almalinux8]
20.[redacted].77
[ubuntu22_04]
135.[redacted].120
```

Before running the ansible playbook, I established the password-less authentication between Ansible Controller and Ansible Managed Nodes as shown below.

```
[root@ansible-controller ~]# ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /root/.ssh/id_rsa.
Your public key has been saved in /root/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:[redacted]root@ansible-controller
The key's randomart image is:
+---[RSA 3072]----+
|[redacted]|
+----[SHA256]-----+
```

```
[root@ansible-controller ~]# ssh-copy-id root@20.[redacted].77
/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/root/.ssh/id_rsa.pub"
The authenticity of host '20.[redacted].77 (20.[redacted].77)' can't be established.
ECDSA key fingerprint is SHA256:[redacted].
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
root@20.[redacted].77's password:

Number of key(s) added: 1

Now try logging into the machine, with:   "ssh 'root@20.[redacted].77'"
and check to make sure that only the key(s) you wanted were added.

[root@ansible-controller ~]# ssh-copy-id root@135.[redacted].120
/bin/ssh-copy-id: INFO: Source of key(s) to be installed: "/root/.ssh/id_rsa.pub"
The authenticity of host '135.[redacted].120 (135.[redacted].120)' can't be established.
ECDSA key fingerprint is SHA256:[redacted].
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
/bin/ssh-copy-id: INFO: attempting to log in with the new key(s), to filter out any that are already installed
/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you are prompted now it is to install the new keys
root@135.[redacted].120's password:

Number of key(s) added: 1

Now try logging into the machine, with:   "ssh 'root@135.[redacted].120'"
and check to make sure that only the key(s) you wanted were added.

[root@ansible-controller ~]#
```

Finally, Run the Playbook as shown in the screenshot attached below.

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts --limit almalinux8 playbook-almalinux8.yaml
```

```
TASK [Record Attempts to Alter the localtime File - Add watch rule for /etc/localtime in /etc/audit/audit.rules] ***********************************************
changed: [20.[redacted].77]

TASK [Gather the package facts] ***********************************************************************************************************************************
ok: [20.[redacted].77]

TASK [Configure auditd Disk Error Action on Disk Error] ***********************************************************************************************************
changed: [20.[redacted].77]

TASK [Gather the package facts] ***********************************************************************************************************************************
ok: [20.[redacted].77]

TASK [Configure auditd Disk Full Action when Disk Space Is Full] **************************************************************************************************
changed: [20.[redacted].77]

TASK [Gather the package facts] ***********************************************************************************************************************************
ok: [20.[redacted].77]

TASK [Configure auditd admin_space_left Action on Low Disk Space] *************************************************************************************************
changed: [20.[redacted].77]

TASK [Gather the package facts] ***********************************************************************************************************************************
ok: [20.[redacted].77]

TASK [Configure auditd max_log_file_action Upon Reaching Maximum Log Size] ****************************************************************************************
changed: [20.[redacted].77]

TASK [Gather the package facts] ***********************************************************************************************************************************
ok: [20.[redacted].77]

TASK [Configure auditd space_left Action on Low Disk Space] *******************************************************************************************************
changed: [20.[redacted].77]

PLAY RECAP ********************************************************************************************************************************************************
20.[redacted].77              : ok=1940 changed=342  unreachable=0    failed=0    skipped=584  rescued=0    ignored=0
```

In Ansible playbook for ubuntu 22.04 I did below changes.

```
- name: Install cron and Network-Manager
  ansible.builtin.package:
    name:
    - cron
    - network-manager
    state: present
  when: '"linux-base" in ansible_facts.packages'
  tags:
  - CJIS-5.10.1.3
  - DISA-STIG-UBTU-22-651025
  - NIST-800-53-CM-6(a)
  - NIST-800-53-SI-7
  - NIST-800-53-SI-7(1)
  - PCI-DSS-Req-11.5
  - PCI-DSSv4-11.5.2
  - aide_periodic_cron_checking
  - low_complexity
  - low_disruption
  - medium_severity
  - no_reboot_needed
  - restrict_strategy
```

```
- name: Ensure NetworkManager is installed
  ansible.builtin.package:
    name: '{{ item }}'
    state: present
  with_items:
  - network-manager    ###NetworkManager
  when: ( not ( ansible_virtualization_type in ["docker", "lxc", "openvz", "podman",
    "container"] ) )
  tags:
  - DISA-STIG-UBTU-22-291015
  - NIST-800-171-3.1.16
  - NIST-800-53-AC-18(3)
  - NIST-800-53-AC-18(a)
  - NIST-800-53-CM-6(a)
  - NIST-800-53-CM-7(a)
  - NIST-800-53-CM-7(b)
  - NIST-800-53-MP-7
  - PCI-DSS-Req-1.3.3
  - PCI-DSSv4-1.3
  - PCI-DSSv4-1.3.3
  - low_complexity
  - medium_disruption
  - medium_severity
  - no_reboot_needed
  - unknown_strategy
  - wireless_disable_interfaces
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts --limit ubuntu22_04 ubuntu2204-playbook-cis_level2_server.yml

TASK [Ensure permission u-s,g-ws,o-wt on /sbin/autrace] ************************************************************************************************************
ok: [135.[redacted].120]

TASK [Test for existence /sbin/auditd] *****************************************************************************************************************************
ok: [135.[redacted].120]

TASK [Ensure permission u-s,g-ws,o-wt on /sbin/auditd] *************************************************************************************************************
ok: [135.[redacted].120]

TASK [Test for existence /sbin/audispd] ****************************************************************************************************************************
ok: [135.[redacted].120]

TASK [Ensure permission u-s,g-ws,o-wt on /sbin/audispd] ************************************************************************************************************
skipping: [135.[redacted].120]

TASK [Test for existence /sbin/augenrules] *************************************************************************************************************************
ok: [135.[redacted].120]

TASK [Ensure permission u-s,g-ws,o-wt on /sbin/augenrules] *********************************************************************************************************
ok: [135.[redacted].120]

TASK [Test for existence /etc/audit/auditd.conf] *******************************************************************************************************************
ok: [135.[redacted].120]

TASK [Ensure permission u-xs,g-xws,o-xwrt on /etc/audit/auditd.conf] ************************************************************************************************
ok: [135.[redacted].120]

TASK [Find /etc/audit/rules.d/ file(s)] ****************************************************************************************************************************
ok: [135.[redacted].120]

TASK [Set permissions for /etc/audit/rules.d/ file(s)] *************************************************************************************************************
changed: [135.[redacted].120] => (item=/etc/audit/rules.d/audit.rules)

PLAY RECAP *********************************************************************************************************************************************************
135.[redacted].120             : ok=2199 changed=381  unreachable=0    failed=0    skipped=629  rescued=0    ignored=0
```

Now, after scanning the Almalinux 8 and Ubuntu 22.04 Azure VMs generate the report by running the Ansible Playbook as shown in the screenshot attached below.

cat playbook-report.yaml

```
---
- name: Install packages for OSCAP and generate report
  hosts: all
  become: true
  tasks:
  - name: On Almalinux 8
    block:
   - name: Install packages for OSCAP in AlmaLinux 8
     yum:
       name:
       - openscap-scanner
       - scap-security-guide
       state: present
   - name: Create the Report in AlmaLinux 8
     ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-almalinux8.html
/usr/share/xml/scap/ssg/content/ssg-almalinux8-ds.xml
     args:
       chdir: /tmp
     register: oscap_scan_output
     failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
   when: ansible_distribution == "AlmaLinux" and ansible_distribution_major_version == "8"
  - name: On Ubuntu 22.04
    block:
   - name: Install packages for OSCAP in Ubuntu 22.04
     apt:
       name:
       - libopenscap8
       state: present
   - name: Create the Report
     ansible.builtin.shell: oscap xccdf eval --oval-results --profile xccdf_org.ssgproject.content_profile_cis_level2_server --results-arf
/tmp/arf.xml --report /tmp/report-ubuntu2204.html /root/scap-security-guide-0.1.78/ssg-ubuntu2204-ds.xml
     args:
       chdir: /tmp
     register: oscap_scan_output
     failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
   when: ansible_os_family == 'Debian' and ansible_distribution_version == '22.04'
```

```
[root@ansible-controller ~]# cat playbook-report.yaml
---
- name: Install packages for OSCAP and generate report
  hosts: all
  become: true
  tasks:
  - name: On Almalinux 8
    block:
    - name: Install packages for OSCAP in AlmaLinux 8
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report in AlmaLinux 8
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-almalinux8.html /usr/share/xml/scap
/ssg/content/ssg-almalinux8-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_distribution == "AlmaLinux" and ansible_distribution_major_version == "8"
  - name: On Ubuntu 22.04
    block:
    - name: Install packages for OSCAP in Ubuntu 22.04
      apt:
        name:
        - libopenscap8
        state: present
    - name: Create the Report
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile xccdf_org.ssgproject.content_profile_cis_level2_server --results-arf /tmp/arf.xml --rep
ort /tmp/report-ubuntu2204.html /root/scap-security-guide-0.1.78/ssg-ubuntu2204-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_os_family == 'Debian' and ansible_distribution_version == '22.04'
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts playbook-report.yaml
```

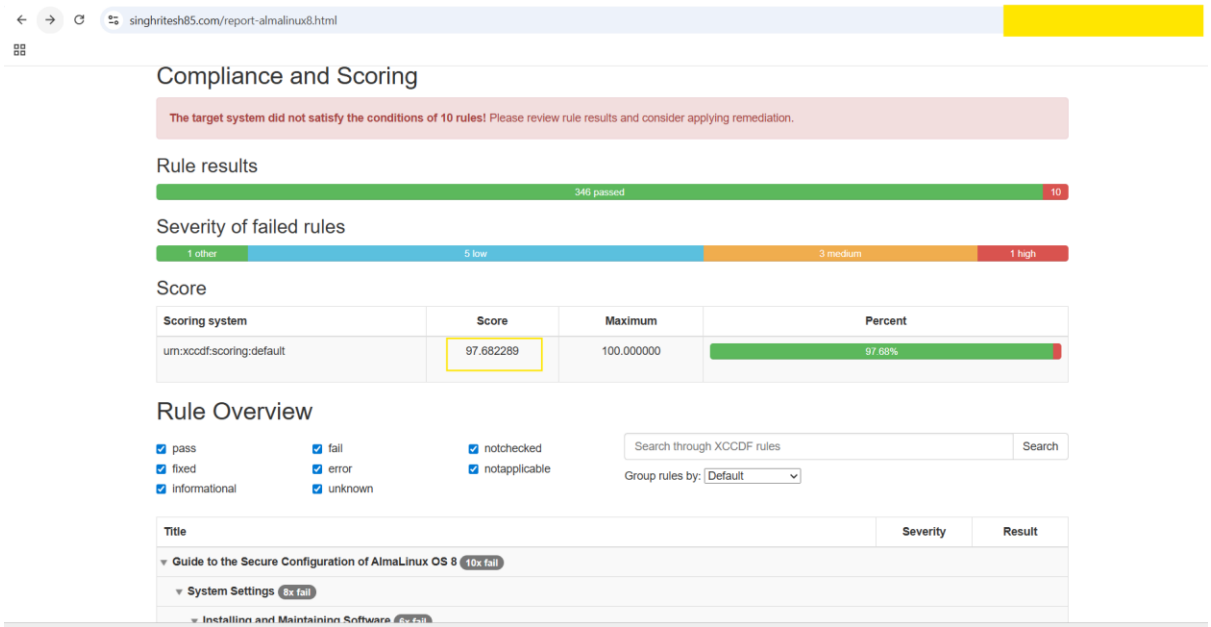
```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts playbook-report.yaml

PLAY [Install packages for OSCAP and generate report] **************************************************************************************************************

TASK [Gathering Facts] *********************************************************************************************************************************************
ok: [20.[redacted]77]
ok: [135[redacted].120]

TASK [Install packages for OSCAP in AlmaLinux 8] *******************************************************************************************************************
skipping: [135.[redacted].120]
ok: [20.[redacted].77]

TASK [Create the Report in AlmaLinux 8] ****************************************************************************************************************************
skipping: [135.[redacted].120]
changed: [20.[redacted].77]

TASK [Install packages for OSCAP in Ubuntu 22.04] ******************************************************************************************************************
skipping: [20.[redacted].77]
ok: [135.[redacted].120]

TASK [Create the Report] *******************************************************************************************************************************************
skipping: [20.[redacted].77]

changed: [135.[redacted].120]

PLAY RECAP *********************************************************************************************************************************************************
135.[redacted].120             : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
20.[redacted].77               : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
```

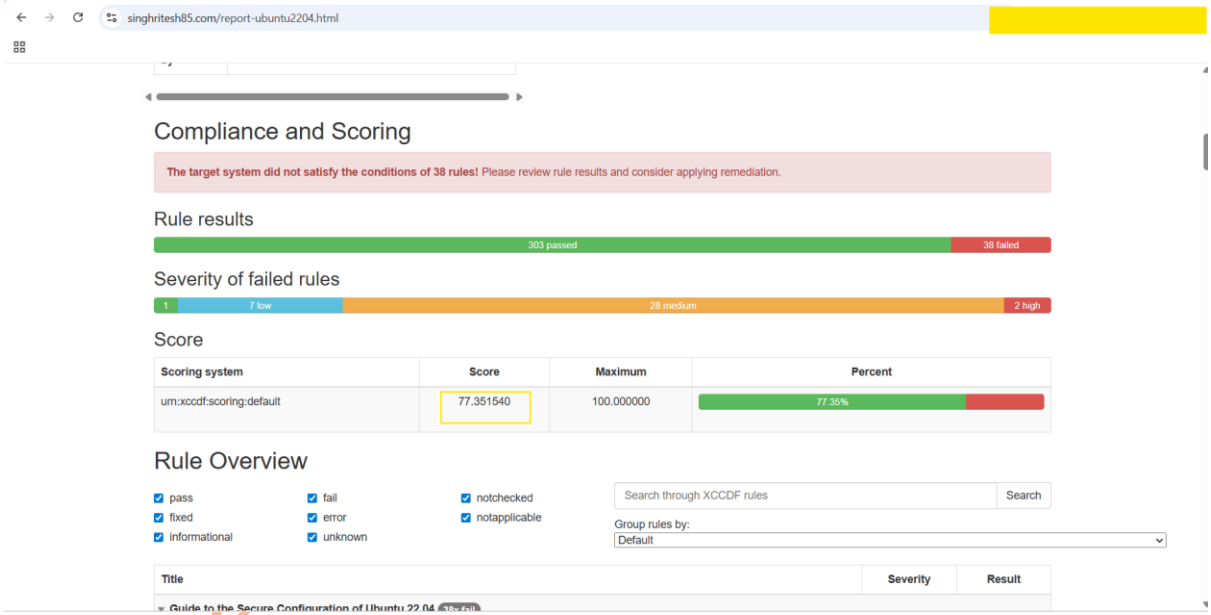
Securely copy the generated report to webserver as shown below.

```
[root@oscap-vm ~]# scp /tmp/report-almalinux8.html root@20.[redacted].114:/var/www/html/
root@20.[redacted].114's password:
report-almalinux8.html                                                                                    100% 3596KB  57.7MB/s   00:00
```

```
root@oscap-vm2:~# scp /tmp/report-ubuntu2204.html  root@20.[redacted].114:/var/www/html/
The authenticity of host '20.[redacted].114 (20.[redacted].114)' can't be established.
ED25519 key fingerprint is SHA256:[redacted]
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '20.[redacted]114' (ED25519) to the list of known hosts.
root@20.[redacted].114's password:
report-ubuntu2204.html                                                                                    100% 4293KB  59.0MB/s   00:00
```

Finally, check the report on webserver as shown in screenshot attached below.





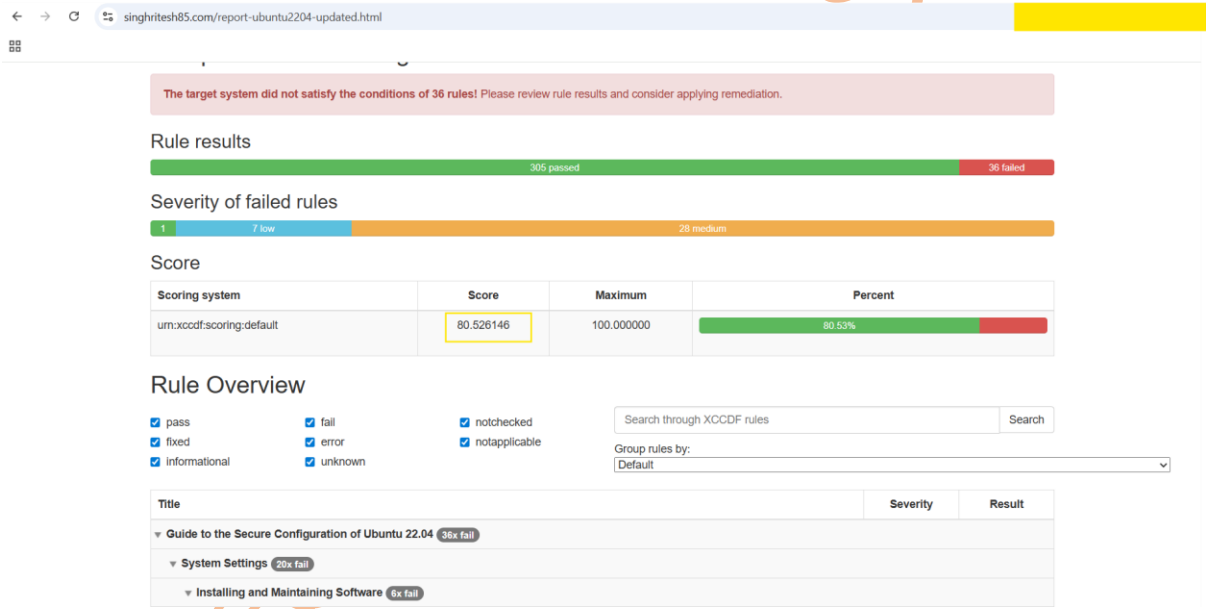
As you can see in the above attached screenshot the score is 77% which you can increase as for the current scenario the Grub2 Boot Loader password was not set, which I set by updating the playbook as shown below.

```
- name: Create or modify 40_custom file with GRUB password
  blockinfile:
    path: /etc/grub.d/40_custom
    marker: "# {mark} ANSIBLE MANAGED BLOCK - GRUB PASSWORD"
    block: |
      set superusers="{{ grub_superuser }}"
      password_pbkdf2 {{ grub_superuser }} {{ grub_password_hash }}
      export grub_users
      export grub_password
- name: Update GRUB configuration
  command: update-grub
```

Then ran the playbook for ubuntu 22.04 as shown below followed by generation of report.

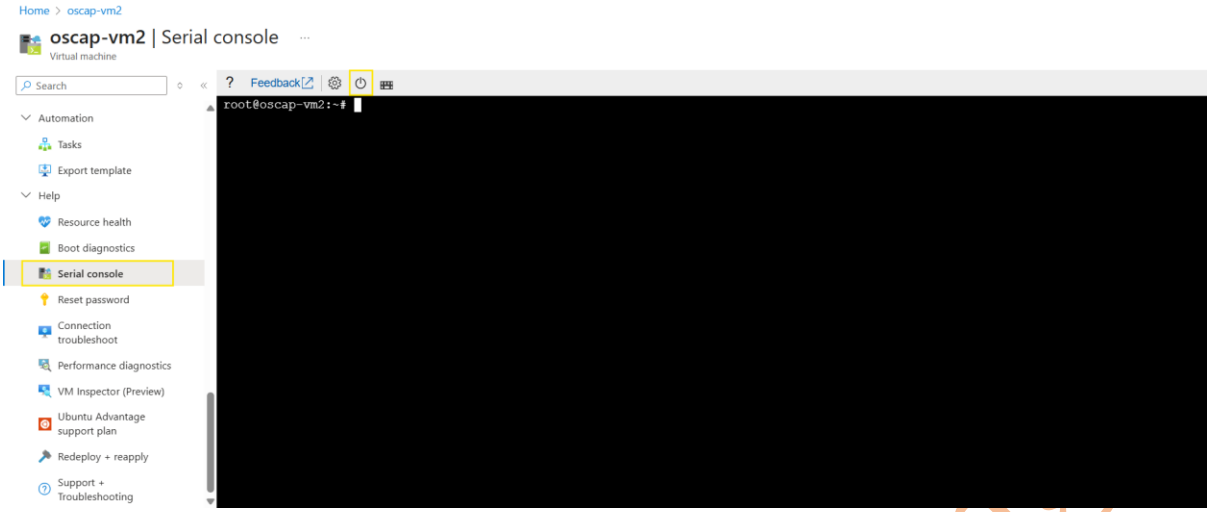
```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts --limit ubuntu22_04 ubuntu2204-playbook-cis_level2_server.yml
```

As shown in the screenshot attached below, the update report for ubuntu 22.04 and score had been increased from 77% to 80% as shown in screenshot attached below.

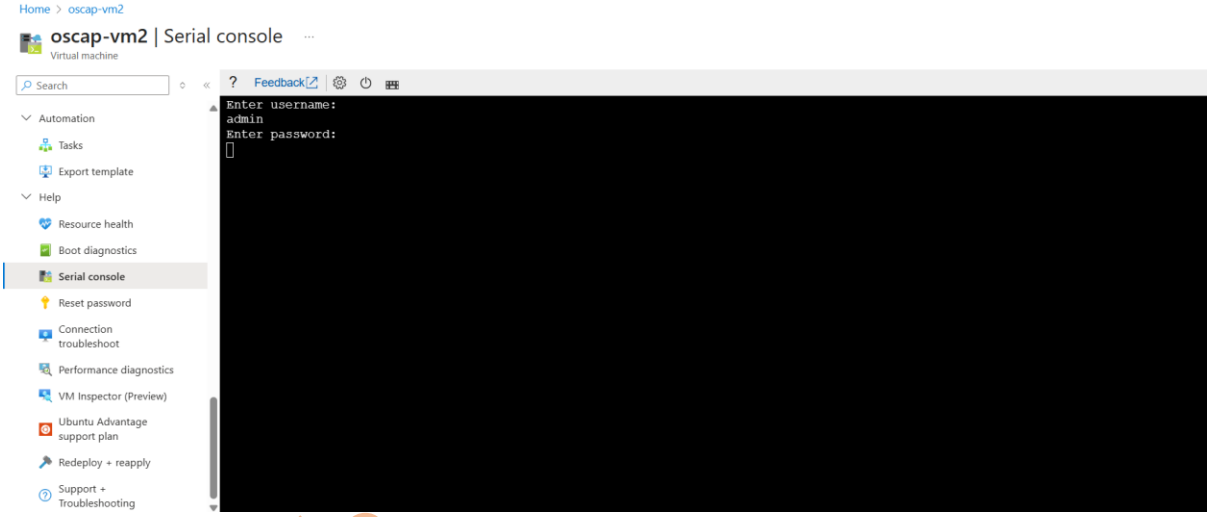


For your reference I kept the Ansible playbooks in the GitHub Repo https://github.com/singhritesh85/Linux-Administration-for-DevOps-Engineers.git.

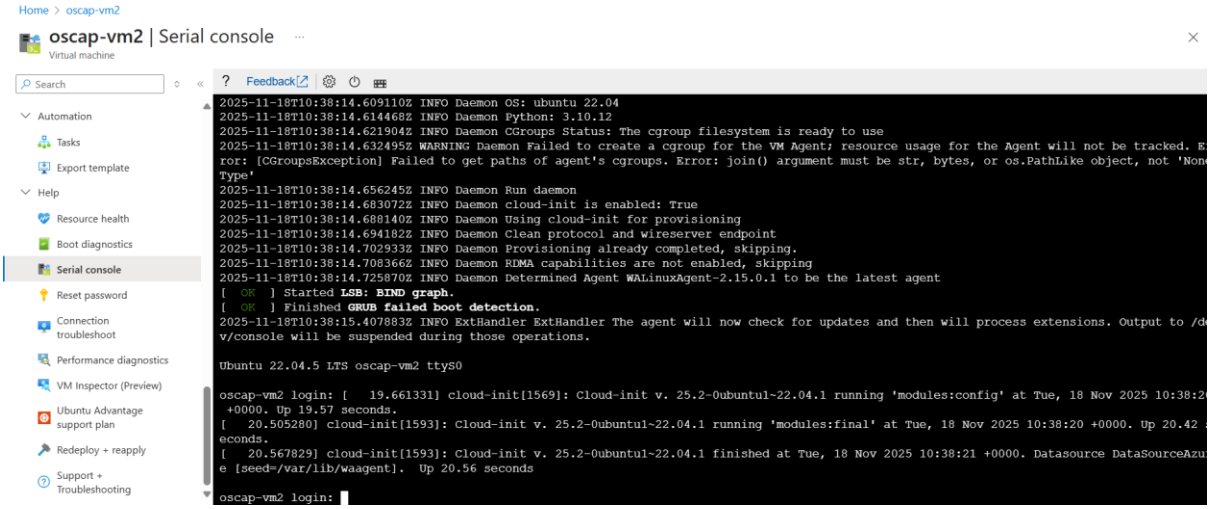
I checked the Grub2 Bootloader password (In Azure Console Go to Serial Console under the Help and restart the Azure VM) as shown in the screenshot attached below.



Provide the Grub2 Bootloader username and password as shown in screenshot attached below.



Then Azure VM will start booting.



In Google Cloud Platform (GCP) Environment

In GCP Environment I had created four GCP VM Instances and an application loadbalancer, on first VM Instance I installed httpd webserver, on second VM Instance I installed Ansible (will be treated as Ansible Controller) and two other VM Instances (one with Rocky Linux 8 and another with RHEL 9). For RHEL 9 I had already explained in AWS EC2 Instance.

Here I installed OSCAP and created the initial report and ansible playbook to scan for security and vulnerability using OSCAP using bootstrap script.

```
################################################ Required configuration and Packages ###############################################################

yum install -y openscap-scanner scap-security-guide
oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report.html /usr/share/xml/scap/ssg/content/ssg-rhel9-ds.xml
oscap xccdf generate fix --fix-type ansible --result-id "" --fetch-remote-resources /tmp/arf.xml > /opt/playbook-rhel9.yml
```

```
################################################ Required configuration and Packages ###############################################################

yum install -y openscap-scanner scap-security-guide
oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report.html /usr/share/xml/scap/ssg/content/ssg-rl8-ds.xml
oscap xccdf generate fix --fix-type ansible --result-id "" --fetch-remote-resources /tmp/arf.xml > /opt/playbook-rockeylinux8.yml
```

After VM Instances came into Running state and bootstrap script executed successfully (you can check this using the log file /var/log/messages with the help of the command **tail -f /var/log/messages**) I securely copied the generated playbook and old report (without scanning for security and vulnerability) to ansible controller node and httpd webserver respectively as shown in the screenshot attached below.

```
[root@oscap-vm-instance-1 ~]# scp -rv /opt/playbook-rhel9.yml root@34.[redacted].201:~/
```

```
[root@oscap-vm-instance-2 ~]# scp -rv /opt/playbook-rockeylinux8.yml root@34.[redacted].201:~/
```

```
[root@oscap-vm-instance-1 ~]# scp -rv /tmp/report.html root@34.[redacted].28:/var/www/html/report-rhel9-old.html
```

```
[root@oscap-vm-instance-2 ~]# scp -rv /tmp/report.html root@34.[redacted].28:/var/www/html/report-rockeylinux8-old.html
```

Now, to scan the Rockey Linux 8 and RHEL 9 servers using OSCAP I executed the ansible playbook as shown in the screenshot attached below.

```
[root@ansible-controller ~]# cat /home/ritesh/inventory/hosts
[rhel9]
172.20.0.100
[rockeylinux8]
172.20.0.101
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts --limit rhel9 playbook-rhel9.yml
```

```
TASK [Record Attempts to Alter the localtime File - Check if watch rule for /etc/localtime already exists in /etc/audit/audit.rules] ************************
ok: [172.20.0.100]

TASK [Record Attempts to Alter the localtime File - Add watch rule for /etc/localtime in /etc/audit/audit.rules] ****************************************
changed: [172.20.0.100]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.100]

TASK [Configure auditd Disk Error Action on Disk Error] ***********************************************************************************************
changed: [172.20.0.100]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.100]

TASK [Configure auditd Disk Full Action when Disk Space Is Full] **************************************************************************************
changed: [172.20.0.100]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.100]

TASK [Configure auditd admin_space_left Action on Low Disk Space] *************************************************************************************
changed: [172.20.0.100]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.100]

TASK [Configure auditd max_log_file_action Upon Reaching Maximum Log Size] ****************************************************************************
changed: [172.20.0.100]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.100]

TASK [Configure auditd space_left Action on Low Disk Space] *******************************************************************************************
changed: [172.20.0.100]

PLAY RECAP ********************************************************************************************************************************************
172.20.0.100               : ok=2121 changed=377  unreachable=0    failed=0    skipped=623  rescued=0    ignored=0
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts --limit rockeylinux8 playbook-rockeylinux8.yml
```

```
TASK [Record Attempts to Alter the localtime File - Check if watch rule for /etc/localtime already exists in /etc/audit/audit.rules] ************************
ok: [172.20.0.101]

TASK [Record Attempts to Alter the localtime File - Add watch rule for /etc/localtime in /etc/audit/audit.rules] ****************************************
changed: [172.20.0.101]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.101]

TASK [Configure auditd Disk Error Action on Disk Error] ***********************************************************************************************
changed: [172.20.0.101]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.101]

TASK [Configure auditd Disk Full Action when Disk Space Is Full] **************************************************************************************
changed: [172.20.0.101]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.101]

TASK [Configure auditd admin_space_left Action on Low Disk Space] *************************************************************************************
changed: [172.20.0.101]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.101]

TASK [Configure auditd max_log_file_action Upon Reaching Maximum Log Size] ****************************************************************************
changed: [172.20.0.101]

TASK [Gather the package facts] ***********************************************************************************************************************
ok: [172.20.0.101]

TASK [Configure auditd space_left Action on Low Disk Space] *******************************************************************************************
changed: [172.20.0.101]

PLAY RECAP ********************************************************************************************************************************************
172.20.0.101               : ok=2076 changed=357  unreachable=0    failed=0    skipped=627  rescued=0    ignored=0
```

After execution of the playbooks for scanning the Linux machines I created the report for RHEL 9 Server and Rockey Linux 8 Server using Ansible Playbook as shown in the screenshot attached below.

```
[root@ansible-controller ~]# cat playbook-report.yaml
---
- name: Install packages for OSCAP and generate report
  hosts: all
  become: true
  tasks:
  - name: On RockeyLinux 8
    block:
    - name: Install packages for OSCAP in RockeyLinux 8
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report in RockeyLinux 8
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rockeylinux8.html /usr/share/xml/sc
ap/ssg/content/ssg-rl8-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_distribution == 'Rocky' and ansible_distribution_major_version == '8'
  - name: On RHEL 9
    block:
    - name: Install packages for OSCAP in RHEL 9
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report in RHEL 9
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rhel9.html /usr/share/xml/scap/ssg/
content/ssg-rhel9-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_os_family == "RedHat" and ansible_distribution_major_version == "9"
```

```
[root@ansible-controller ~]# ansible-playbook -i /home/ritesh/inventory/hosts playbook-report.yaml

PLAY [Install packages for OSCAP and generate report] **************************************************************************************************************

TASK [Gathering Facts] *********************************************************************************************************************************************
ok: [172.20.0.101]
ok: [172.20.0.100]

TASK [Install packages for OSCAP in RockeyLinux 8] *****************************************************************************************************************
skipping: [172.20.0.100]
ok: [172.20.0.101]

TASK [Create the Report in RockeyLinux 8] **************************************************************************************************************************
skipping: [172.20.0.100]
changed: [172.20.0.101]

TASK [Install packages for OSCAP in RHEL 9] ************************************************************************************************************************
skipping: [172.20.0.101]
ok: [172.20.0.100]

TASK [Create the Report in RHEL 9] *********************************************************************************************************************************
skipping: [172.20.0.101]
changed: [172.20.0.100]

PLAY RECAP *********************************************************************************************************************************************************
172.20.0.100               : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
172.20.0.101               : ok=3    changed=1    unreachable=0    failed=0    skipped=2    rescued=0    ignored=0
```

cat playbook-report.yaml

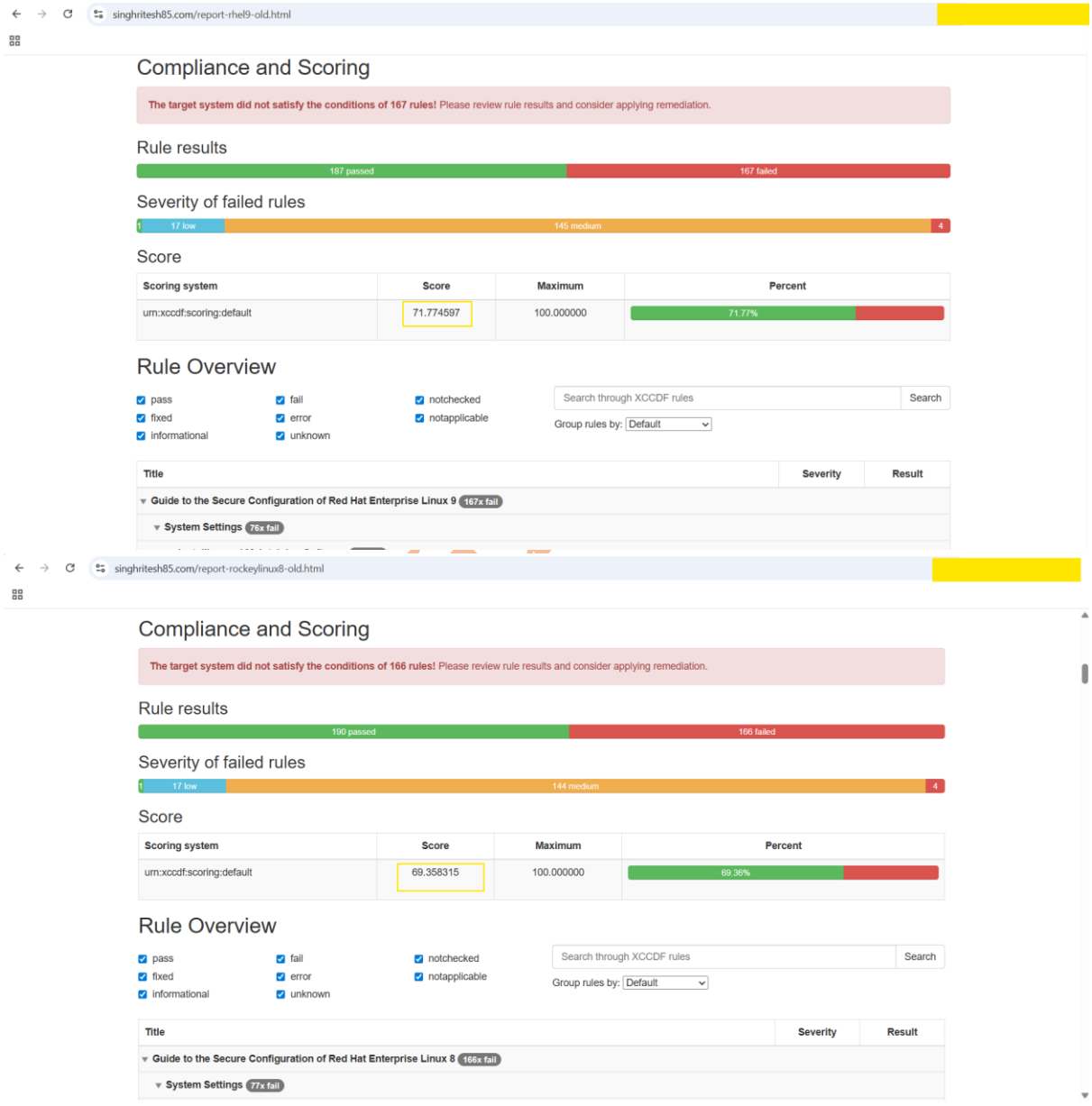
```
---
- name: Install packages for OSCAP and generate report
  hosts: all
  become: true
  tasks:
  - name: On RockeyLinux 8
    block:
    - name: Install packages for OSCAP in RockeyLinux 8
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report in RockeyLinux 8
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rockeylinux8.html /usr/share/xml/scap/ssg/content/ssg-rl8-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_distribution == 'Rocky' and ansible_distribution_major_version == '8'
  - name: On RHEL 9
    block:
    - name: Install packages for OSCAP in RHEL 9
      yum:
        name:
        - openscap-scanner
        - scap-security-guide
        state: present
    - name: Create the Report in RHEL 9
      ansible.builtin.shell: oscap xccdf eval --oval-results --profile cis --results-arf /tmp/arf.xml --report /tmp/report-rhel9.html /usr/share/xml/scap/ssg/content/ssg-rhel9-ds.xml
      args:
        chdir: /tmp
      register: oscap_scan_output
      failed_when: oscap_scan_output.rc != 0 and "fail" in oscap_scan_output.stderr | lower
    when: ansible_os_family == "RedHat" and ansible_distribution_major_version == "9"
```

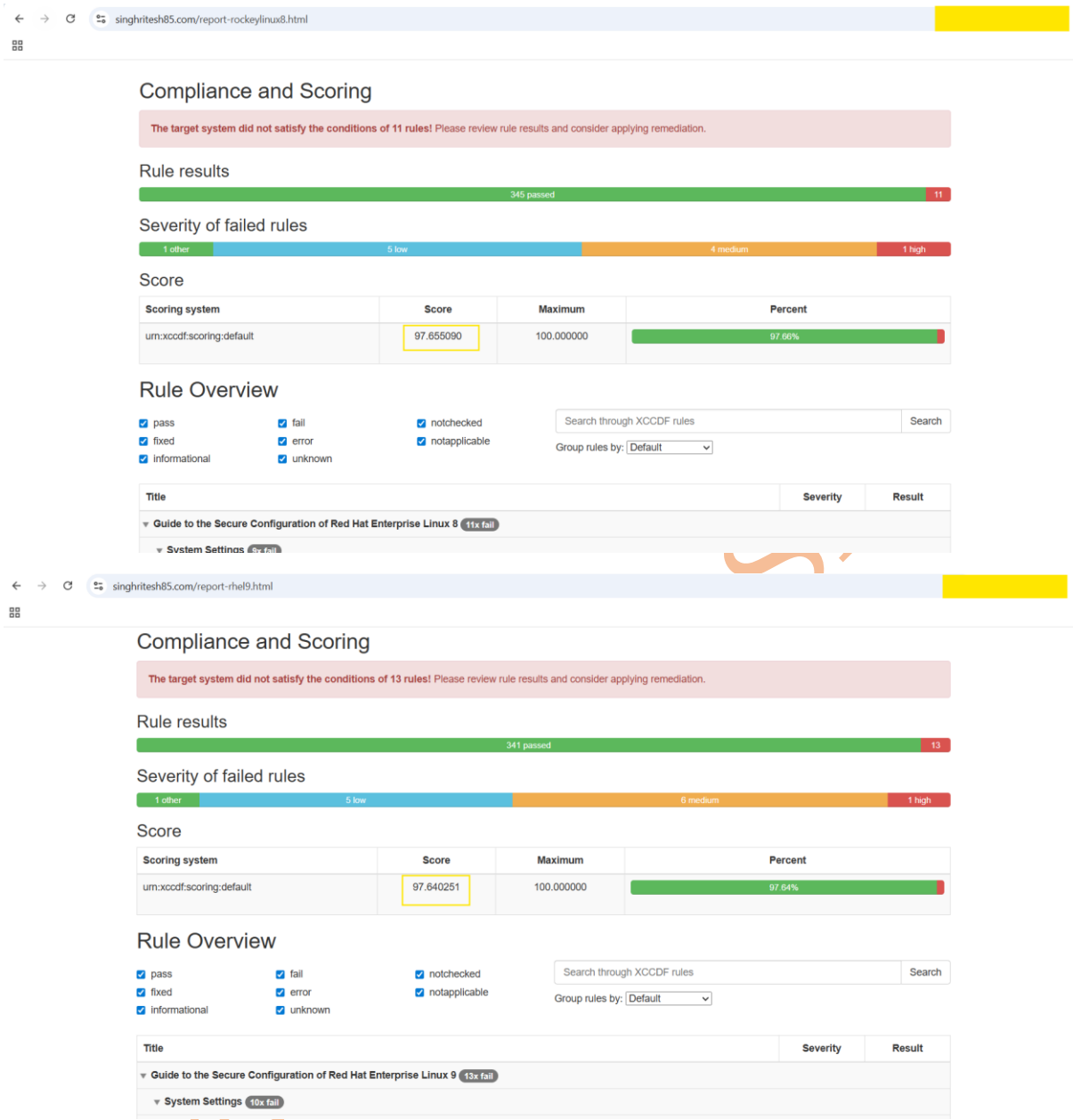
After generating the report, I securely copied the generated report from RHEL 9 Server and Rockey Linux 8 Server to httpd webserver as shown in the screen shot attached below.

```
[root@oscap-vm-instance-1 ~]# scp -rv /tmp/report-rhel9.html root@34.[redacted].28:/var/www/html/
```

```
[root@oscap-vm-instance-2 ~]# scp -rv /tmp/report-rockeylinux8.html root@34.[redacted].28:/var/www/html/
```

I found before scanning the compliance score was 71% and 69% for RHEL9 and Rockey Linux 8 Servers respectively and after scanning these scores had been improved to 97% for both RHEL9 and Rockey Linux 8 Servers as shown in the screenshot attached below.





For your reference I kept these playbooks and terraform script to provision the infrastructure in GitHub Repo https://github.com/singhritesh85/Linux-Administration-for-DevOps-Engineers.git.

Hard Link and Soft Link in Linux

Both hard links and soft links are method to create references for files. Hard link is direct link to the data on disk. If original file is deleted then data is still accessible using the hard link. You can create the hard link using the command **ln /root/file1.txt /mederma/therema**.

```
[root@therema-server ~]# cat file1.txt
Hello Dexter
[root@therema-server ~]# ln /root/file1.txt /mederma/therema
[root@therema-server ~]# cat /mederma/therema
Hello Dexter
[root@therema-server ~]# rm -f file1.txt
[root@therema-server ~]# cat /mederma/therema
Hello Dexter
```

Soft link is pointer to another file. If original file is deleted then soft link will be broken. You can create the soft link using the command **ln -s /root/file2.txt /therema/bingo**.

```
[root@therema-server ~]# ln -s /root/file2.txt /therema/bingo
[root@therema-server ~]# cat /root/file2.txt
Mederma
```

```
[root@therema-server ~]# ls -l /therema/bingo
lrwxrwxrwx. 1 root root 15 Nov 12 19:51 /therema/bingo -> /root/file2.txt
[root@therema-server ~]# cat /therema/bingo
Mederma
```

```
[root@therema-server ~]# rm -f file2.txt
[root@therema-server ~]# cat /therema/bingo
cat: /therema/bingo: No such file or directory
```