SOFTENGER
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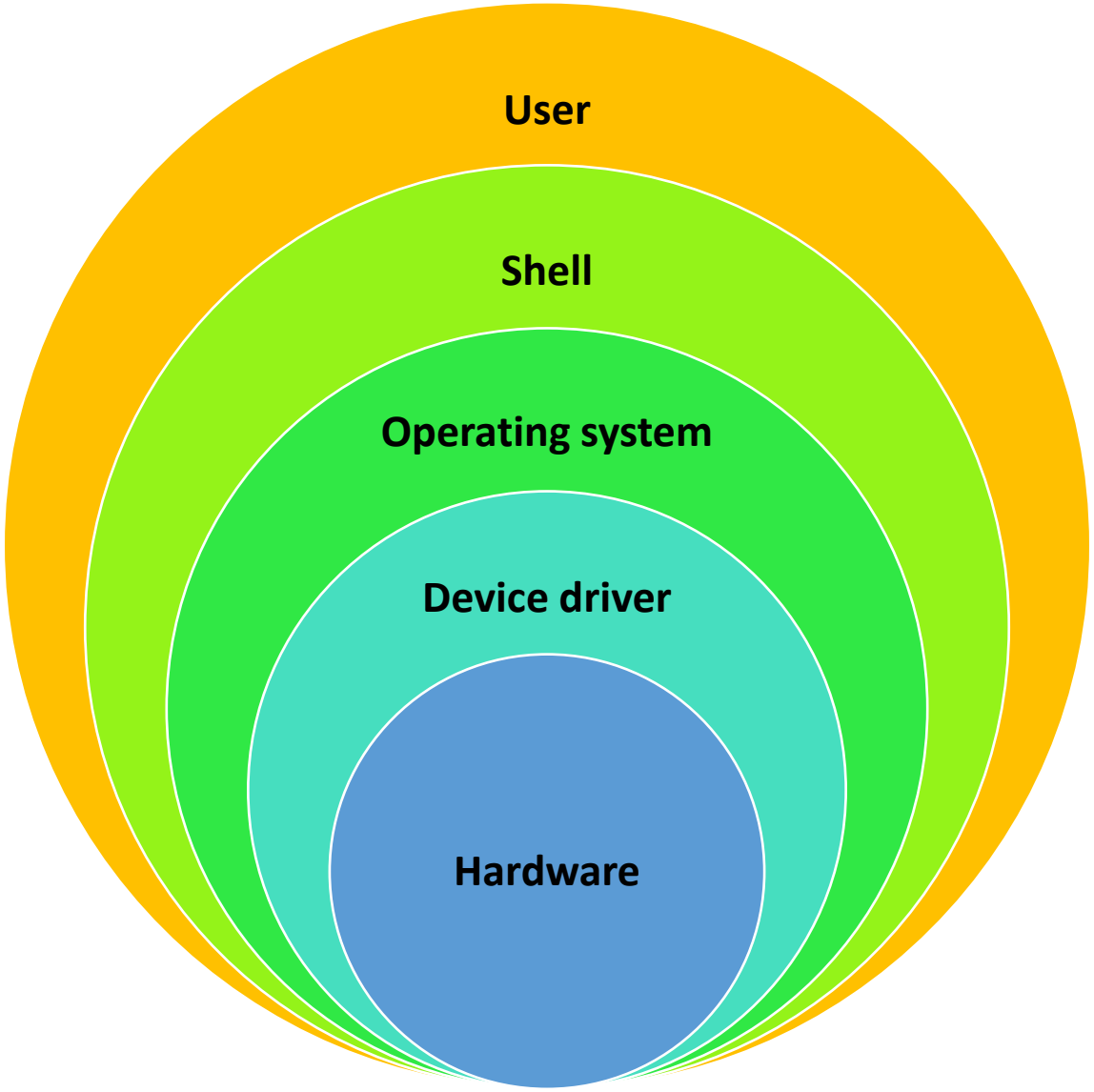
LVM

Logical Volume Manager

Linux OS

Recap: Fundamentals: Unix architecture



- Device driver:
  - It is a software that can perform I/O (input/output) with one type of hardware
- Major number:
  - Points to the Name of device driver loaded in the kernel
- Minor number:
  - Points to the instance of a device associated with a particular device driver
- Backward compatibility:
  - When a new s/w is released, it continues to support features available in previous 1 or 2 versions.

Recap: RAID theory

- RAID is a storage virtualization technology which is used to organize multiple drives into various arrangements to meet certain goals like reliability, availability, and serviceability (RAS).
- RAID can be categorized into Software RAID and Hardware RAID.
- In software RAID, a software (logical volume manager) implements RAID concepts.
- In case of hardware RAID, there is a dedicated controller and processor present inside the disks that manage the memory.

Recap: RAID theory (Traditional)

RAID 0	Concatenation, i.e. appending at the bottom of existing device
RAID 1	Stripe / Striping data, i.e. Spread evenly across different disks
RAID 2	Mirroring, i.e. maintain 2 or more identical copies of data
RAID 3	Single Parity i.e. stripped user data, Single dedicated parity disk
RAID 4	Stripped user data with multiple but dedicated Parity disks holding same parity values
RAID 5	Stripped data, Single Parity information that is stored on all disks equally
RAID 6	Multiple Circular Parity, Stripped data, Multiple Parity information, that is stored in all disks equally

Recap: RAID theory (Operational)

RAID 0	**Stripe / Striping data, i.e. user data is spread evenly across different disks**
RAID 1	**Mirroring, i.e. maintain 2 or more identical copies of data, data may or may not be stripped**
RAID 4	**Multiple Parity i.e. stripped user data, multiple parity disk, group parity**
RAID 5	**Stripped data, Single Parity information, parity information is circularly stored on all disks (equally)**
RAID 6	**Stripped data, two or more different Parity information, that is stored circularly on all disks (equally)**
RAID 10	**(RAID 1 + 0) : Stipe and mirror the stripe**

Reference: https://www.booleanworld.com/raid-levels-explained

Introduction to LVM in Linux

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- **Dynamic Storage Allocation**

LVM allows you to resize logical volumes dynamically, enabling efficient use of storage by allocating space according to needs without downtime.

- **Flexible Backup Solution**

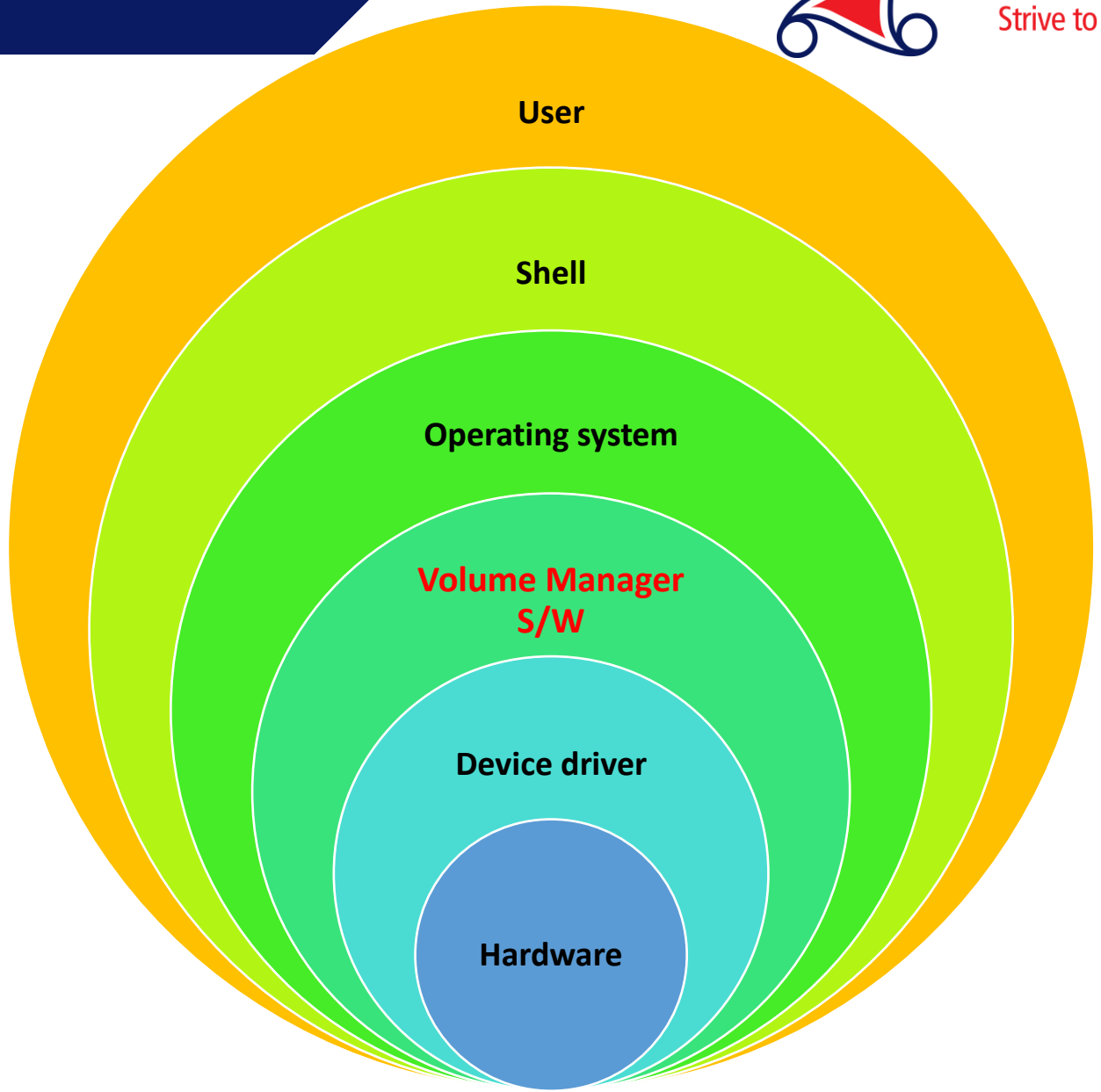
LVM snapshots facilitate creating backup copies of the system instantly, providing a reliable point-in-time backup solution for data protection.

- **Simplified Volume Management**

With LVM, managing disk space becomes easier, allowing for the quick creation, deletion, and modification of volume groups and logical volumes.

LVM Architecture

- Logical volume manager (LVM) software introduces an extra layer between the operating system and device drivers (thus the disk hardware)



LVM Components

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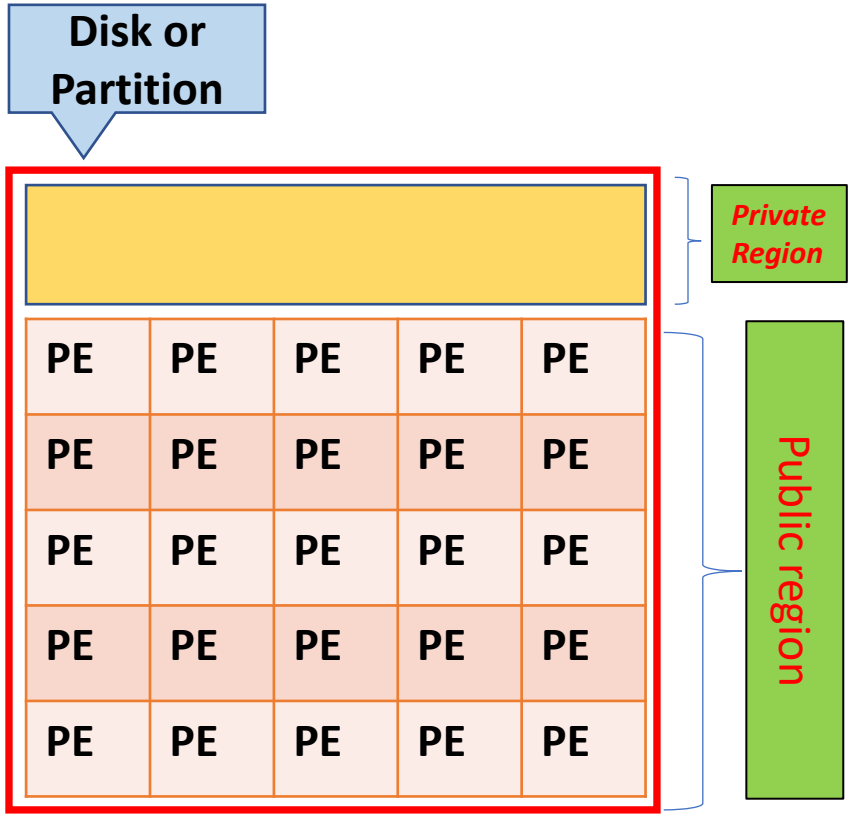
- **Physical Volume (PV)**: A storage device initialized for LVM use.
- **Volume Group (VG)**: A pool of storage created from one or more physical volumes.
- **Logical Volume (LV)**: A virtual partition within a volume group used by the operating system.
- **Physical Extent (PE)**: The smallest unit of storage on a physical volume.
- **Logical Extent (LE)**: The smallest unit of storage on a logical volume.
- **Volume Group Name (VG Name)**: The name assigned to a volume group.
- **LVM Metadata**: Configuration information about physical volumes, volume groups, and logical volumes.
- **LVM Snapshots**: Point-in-time copies of logical volumes for backup or recovery.
- **LVM Thin Provisioning**: Allows for on-demand allocation of storage space to logical volumes.

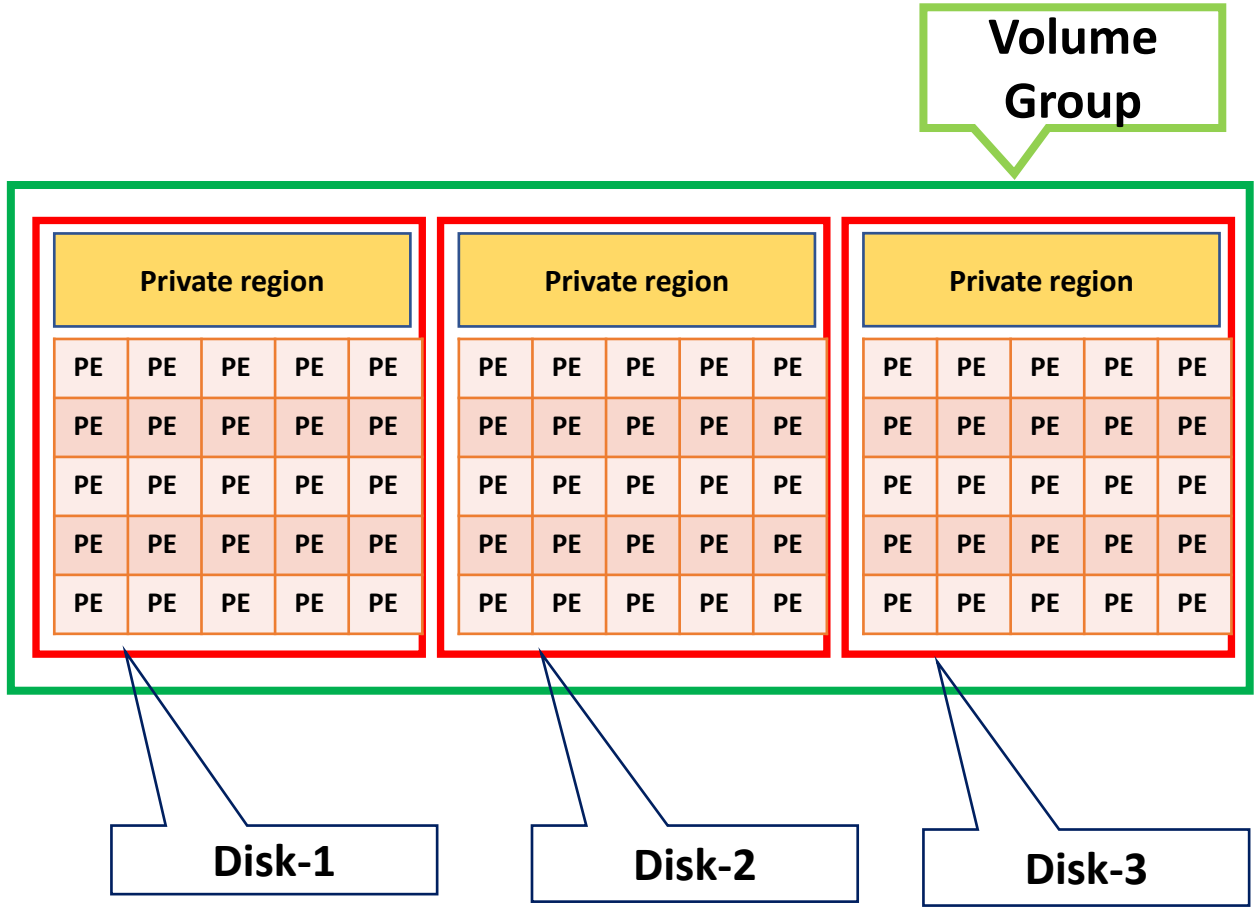
Physical Volume (PV)

- pvcreate command is used to convert the disk or disk partition into a physical volume (PV)
- When PV create runs, Disk partition is broken into two regions
  - Private region: This stores the meta-data associated with Volume manager such as
    - Name of the Volume group this disk/partition belongs to
    - Name of the logical volume created on this disk/partition
    - Numbers of the physical extents allocated to the given disk/partition
    - Type of logical volume (RAID theory)
  - Public region: This is the usable portion of the disk
- The Public region is further broken into uniform sized allocation units called as physical extents (PE)
- Each physical extent carries a unique identifier
- Default value of a physical extent (PE) is 4 MB.



Volume Group (VG)

- Physical volumes are combined into volume groups (VGs). This creates a pool of disk space out of which logical volumes can be allocated.
- Within a volume group, the disk space available for allocation is divided into units of a fixed-size called logical extents (LE). An LE is the smallest unit of space that can be allocated.
- A logical volume is allocated into logical extents of the same size as the physical extents. The extent size is same for all logical volumes in the volume group.



DISK Vs DISK PARTITION

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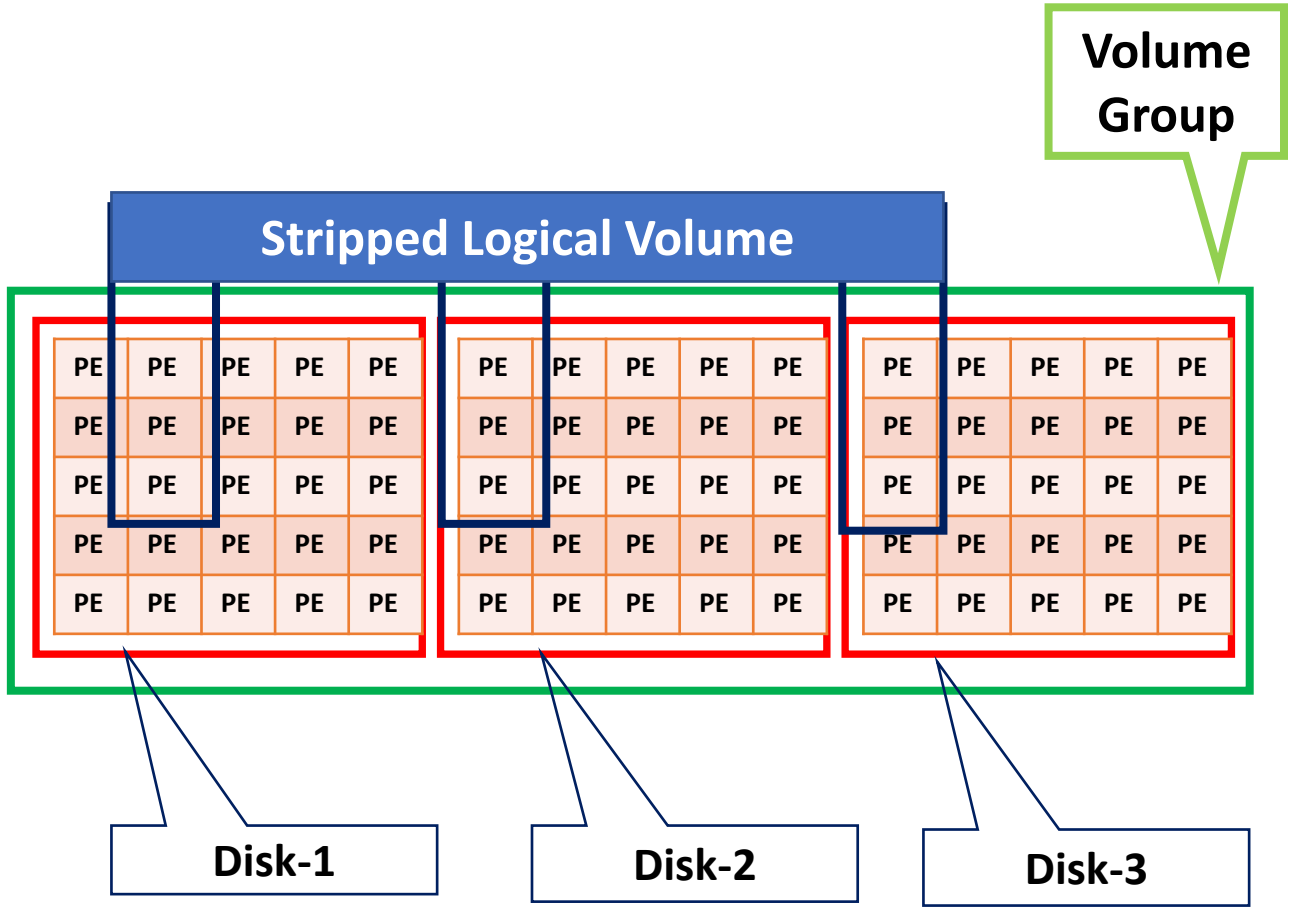
- It is generally recommended that you create a single partition that covers the whole disk to label as an LVM physical volume for the following reasons:
  - Administrative convenience
    - It is easier to keep track of the hardware in a system if each real disk only appears once.
    - This becomes particularly true if a disk fails.
    - In addition, multiple physical volumes on a single disk may cause a kernel warning about unknown partition types at boot-up.
  - Striping performance
    - LVM cannot tell that two physical volumes are on the same physical disk.
    - If you create a striped logical volume when two physical volumes are on the same physical disk, the stripes could be on different partitions on the same disk.
    - This would result in a decrease in performance rather than an increase.

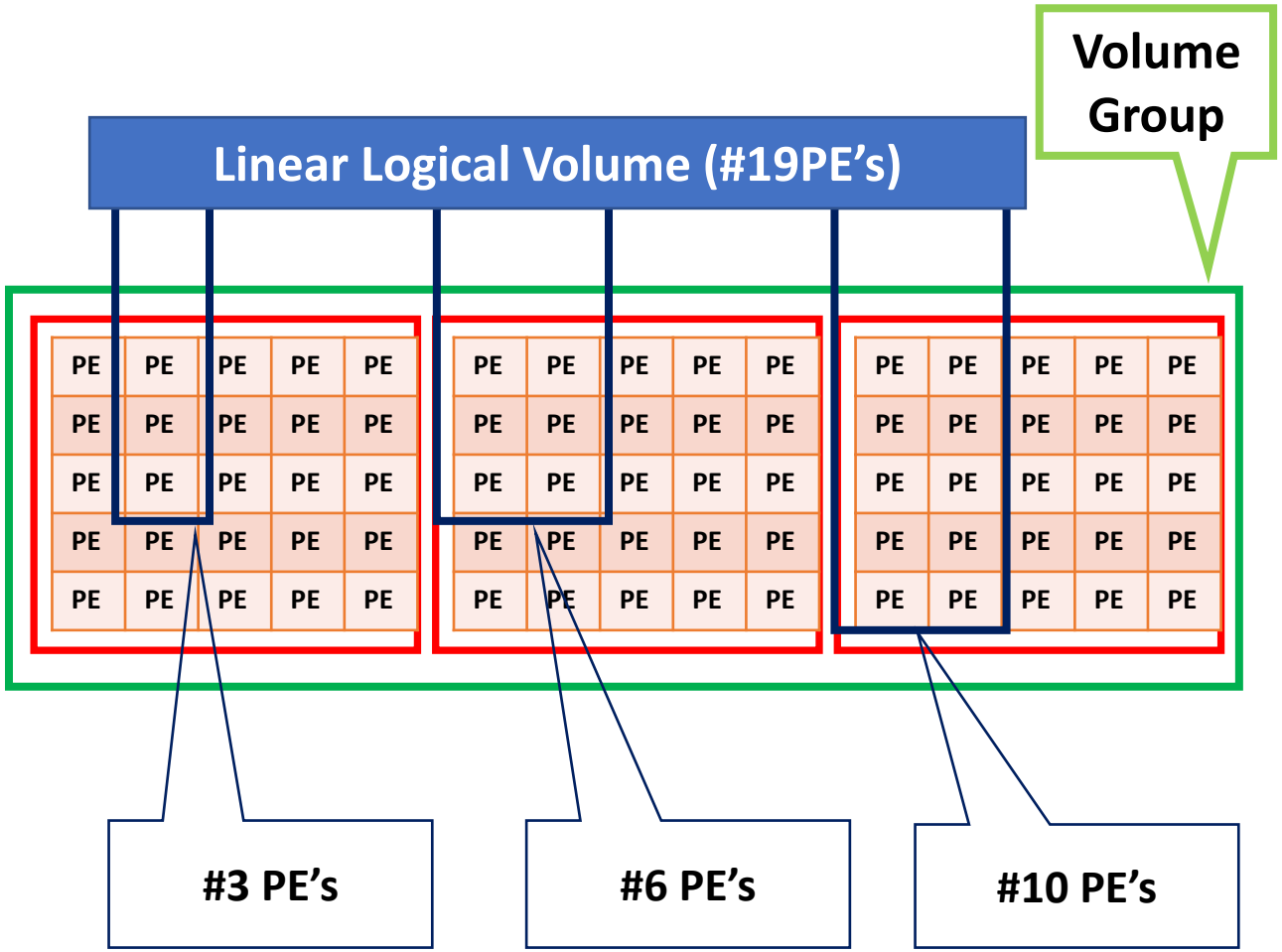
Logical Volume (LV)

- In LVM, a volume group is divided up into logical volumes.
- There are three types of LVM logical volumes: *linear* volumes, *striped* volumes, and *mirrored* volumes.



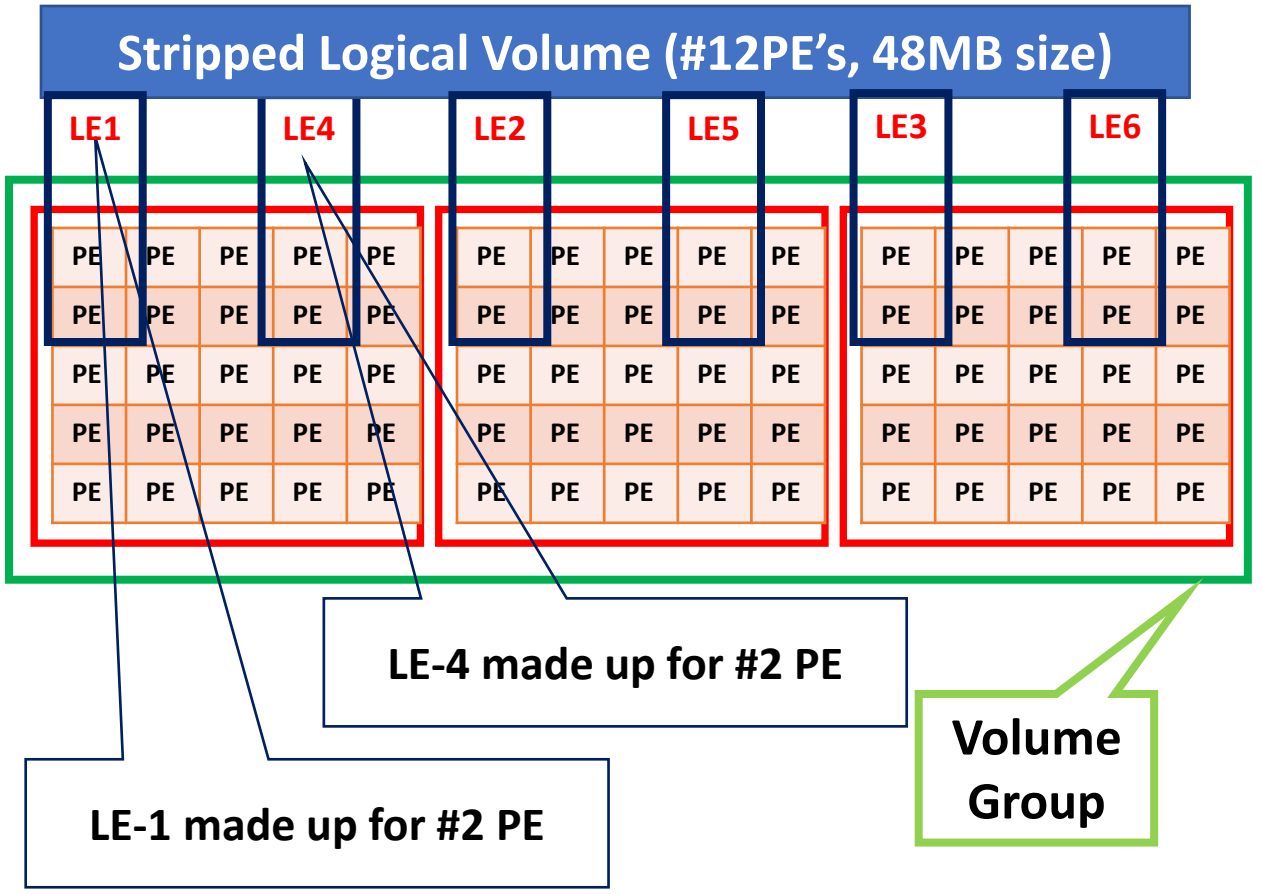
Types of Logical Volumes

- A *linear volume* aggregates space from one or more physical volumes into one logical volume. For example, if you have two 60GB disks, you can create a 120GB logical volume.
- The physical storage is concatenated.
- Example:
  - We can take different extents shown from different disks to create a linear logical volume as shown in the diagram.



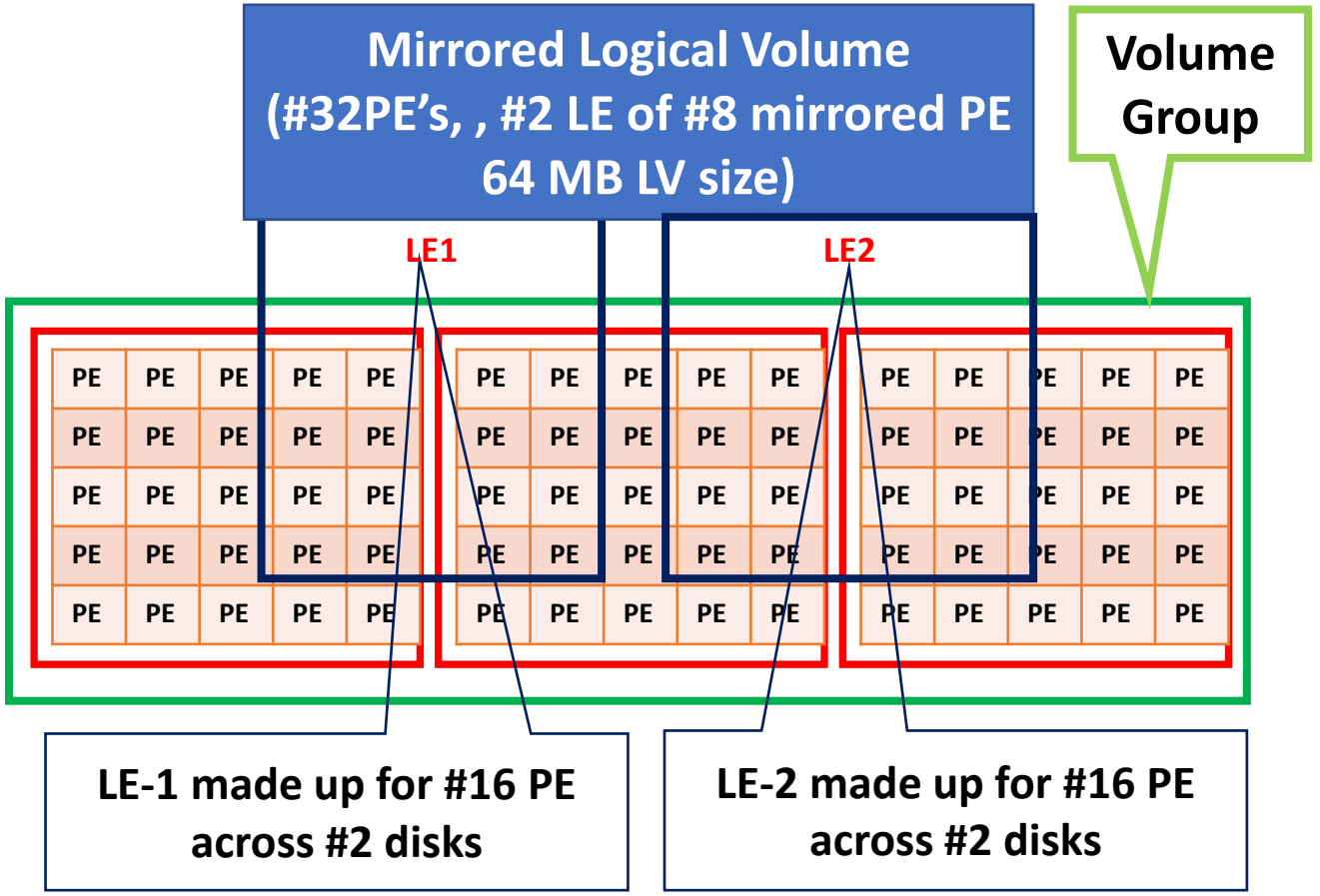
Types of Logical Volumes

- A ***Stripped volume*** aggregates space from one or more Logical extents into one logical However The logical extents will be from physical volumes within the VG.
- Example:
  - We can take different extents shown from different disks to create a linear logical volume as shown in the diagram.
  - Each LE is made up of two PE's
  - Data is first written in LE1 disk1, followed by LE2 disk2, followed by LE3 disk3, the again back to disk-1, LE4 and so on

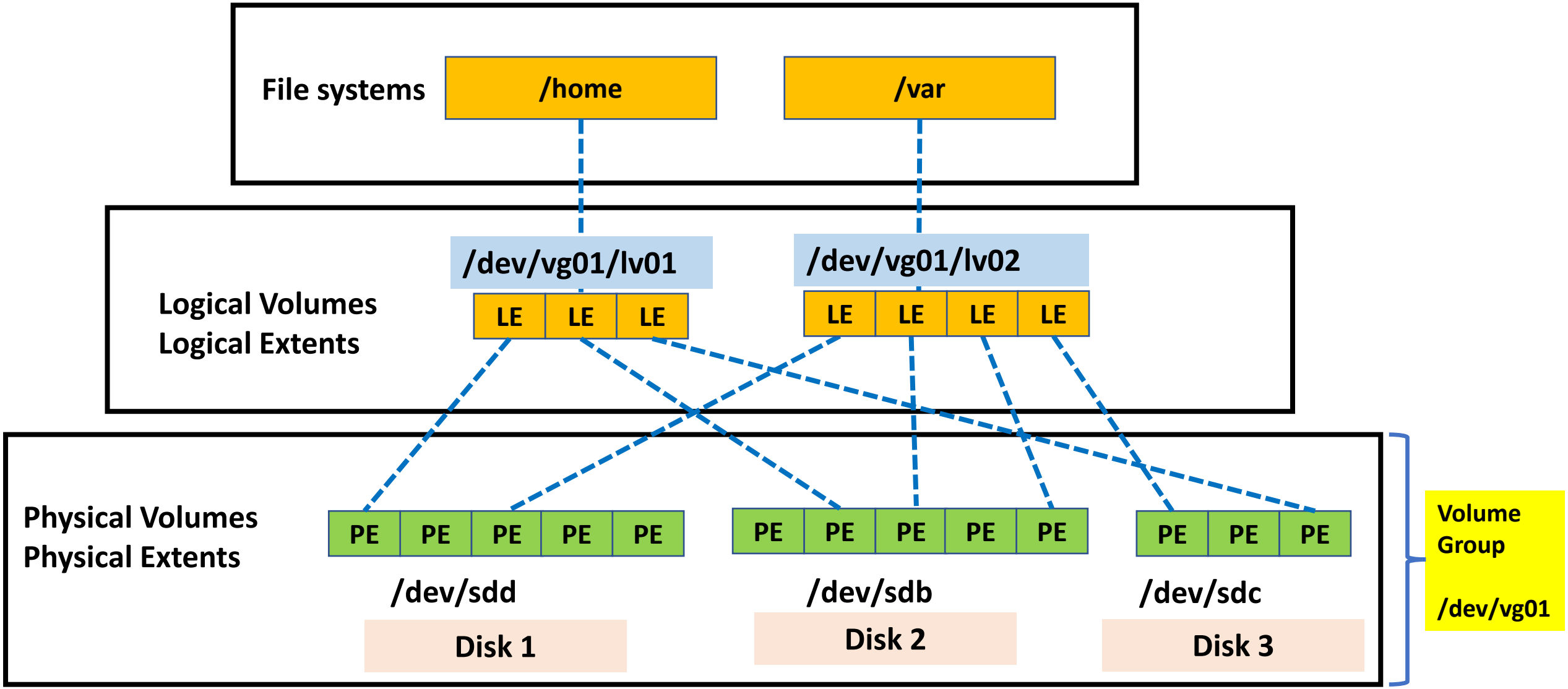


Types of Logical Volumes

- A ***Mirrored volume*** aggregates space from two or more Logical extents into one logical volume.
- The logical extents will be from PE from different disks within the VG.
- Example:
  - We can take different extents shown from different disks to create a linear logical volume as shown in the diagram.
  - Each LE is made up of two PE's
  - Data is first written in LE1 disk1, followed by LE2 disk2, followed by LE3 disk3, the again back to disk-1, LE4 and so on



LVM Component Relationships



lvmscandisk, pvs, pvcreate, pvdisplay

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- lvmscandisk
  - To scan the system and identify disks connected to the machine.
  - It also detects if any PV. VG. LV exists on the system
- pvs
  - scan physical volume available on the machines
  - It checks to see if a private region is defined for the physical disk/partition
- pvcreate
  - Create the public and private region on disk or a partition of disk.
  - Syntax: pvcreate “name of the device (disk or partition)”
  - Example:
    - pvcreate /dev/sdb
    - pvcreate /dev/sdb2
- pvdisplay
  - Display the details for pv’s available on the machine

lvmscandisk, pvs, pvcreate, pvdisplay

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```
root@Sipl-183:~
[root@Sipl-183 ~]#
[root@Sipl-183 ~]# pvcreate /dev/sdb1 /dev/sdb
sdb    sdb1   sdb2   sdb3
[root@Sipl-183 ~]# pvcreate /dev/sdb1 /dev/sdb2
[root@Sipl-183 ~]# pvcreate /dev/sdb1 /dev/sdb2
  Physical volume "/dev/sdb1" successfully created.
  Physical volume "/dev/sdb2" successfully created.
[root@Sipl-183 ~]# pvs
  PV         VG Fmt  Attr PSize   PFree
  /dev/sda2  rl lvm2 a--  <27.95g  4.00m
  /dev/sdb1     lvm2 ---   10.00g 10.00g
  /dev/sdb2     lvm2 ---   10.00g 10.00g
```

```
root@Sipl-183:~
[root@Sipl-183 ~]# pvdisplay /dev/sdb1 /dev/sdb2
  "/dev/sdb1" is a new physical volume of "10.00 GiB"
  --- NEW Physical volume ---
  PV Name               /dev/sdb1
  VG Name
  PV Size               10.00 GiB
  Allocatable           NO
  PE Size               0
  Total PE              0
  Free PE               0
  Allocated PE          0
  PV UUID               sAYHGt-WiZz-WUSL-2f8f-cEhK-sfSL-eN1pSj
```

vgs, vgcreate , vgdisplay

- vgs
  - To scan the system and identify volume groups available on the machine
  - To achieve this the system reads the “private area” in all physical volumes
- vgcreate
  - Create a volume group using one or more physical volumes (PV).
  - Syntax: vgcreate “Vg name” “ one or more PV names”
  - Example:
    - vgcreate test_vg /dev/sdb1 /dev/sdd
    - Vgcreate vg00 /dev/sdb1
- vgdisplay
  - Display the details for volume group available on the machine

VGS / VGCREATE / VGDISPLAY

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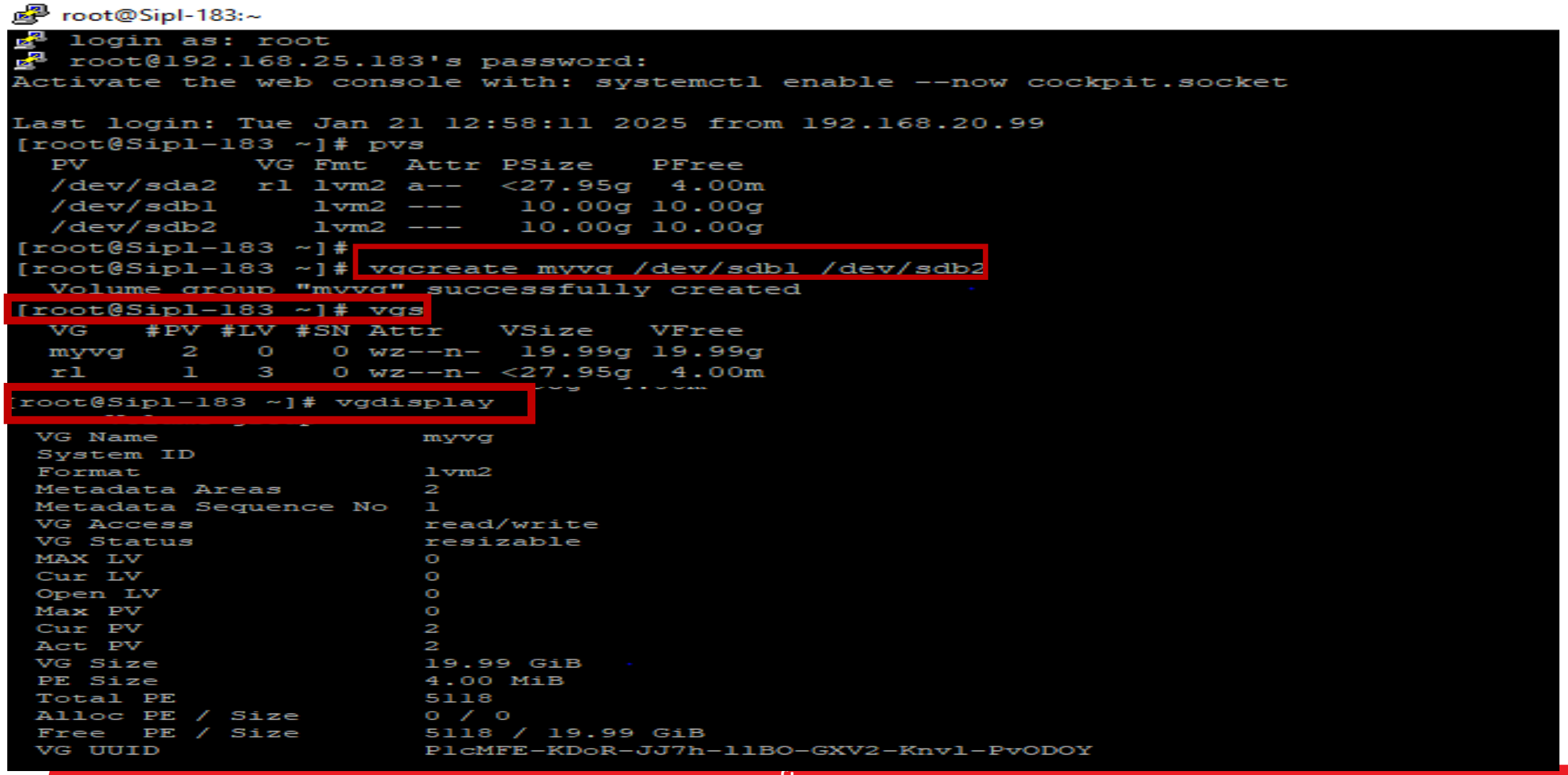

Important options while creating VG

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Option	Meaning
-s	Physical Extent Size
-p	Maximum number of physical volumes
-l	Maximum number of logical volumes
-alloc	allocation policy (either contiguous, anywhere, or cling)

LVS / LVCREATE / LVDISPLAY/LVSCAN

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- lvs
  - To scan the system and identify volume groups available on the machine
  - To achieve this the system reads the “private area” in all physical volumes
- lvcreate
  - Create linear volume
    - lvcreate -L 5G -n lvol01 vg00
  - Create a stripped volume
    - lvcreate -L 5G -I 4096 -i 2 -n stripped-Vol vg00
  - Create mirrored volume
    - lvcreate -L 4G -i 2 -n mirr-vol vg00
- lvgdisplay
  - Display the details for logical volumes available on the machine

LVS / LVCREATE / LVDISPLAY

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```
  Cannot process volume group vg00
[root@localhost ~]# vgs vg00
  VG    #PV #LV #SN Attr   VSize  VFree
  vg00    2   0   0 wz--n- 19.99g 19.99g
[root@localhost ~]#
[root@localhost ~]# lvcreate -L 5G -n lvol01 vg00
  Logical volume "lvol01" created.
[root@localhost ~]# lvcreate -L 5G -I 4096 -i 3 -n stripped-Vol vg00
  Rounding size 5.00 GiB (1280 extents) up to stripe boundary size 5.00 GiB (128
1 extents).
  Number of stripes (3) must not exceed number of physical volumes (2)
[root@localhost ~]# echo $?
5
[root@localhost ~]# lvcreate -L 5G -I 4096 -i 2 -n stripped-Vol vg00
  Logical volume "stripped-Vol" created.
[root@localhost ~]# lvcreate -L 4G  -i 2 -n mirr-vol vg00
  Using default stripesize 64.00 KiB.
  Logical volume "mirr-vol" created.
[root@localhost ~]# lvs
  LV           VG   Attr       LSize Pool Origin Data%  Meta%  Move Log Cpy%Sync
 Convert
  lvol01       vg00 -wi-a----- 5.00g

  mirr-vol     vg00 -wi-a----- 4.00g

  stripped-Vol vg00 -wi-a----- 5.00g

[root@localhost ~]#
```

LVS / LVCREATE / LVDISPLAY

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```
[root@localhost ~]# clear
[root@localhost ~]# lvdisplay
  --- Logical volume ---
  LV Path                /dev/vg00/lvol01
  LV Name                lvol01
  VG Name                vg00
  LV UUID                6iL1wo-16cz-mzku-0J1E-YutC-IDWW-ksCaHC
  LV Write Access        read/write
  LV Creation host, time localhost, 2020-04-05 16:26:29 +0530
  LV Status              available
  # open                 0
  LV Size                5.00 GiB
  Current LE             1280
  Segments               1
  Allocation             inherit
```

LVSCAN / MKFS / MOUNT

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- lvscan
  - Show the list of volumes available
- mkfs
  - Create file system on the logical volume
    - mkfs /dev/vg00/lvol01
- Mount file system
  - Mkdir /u09
  - Mount /dev/vg00/lvol1 /u09

Important options while creating LV

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Option	Meaning
-l	Stripe size
-m	Number of mirrors
-n	Name of the logical volume
-L	Size of the logical volume (M for MB, G for GB)
-s	Snapshot
--type	Type of RAID

LVSCAN / MKFS

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root@Sipl-183:~

```
[root@Sipl-183 ~]# lvscan
  ACTIVE            '/dev/rl/root' [9.31 GiB] inherit
  ACTIVE            '/dev/rl/swap' [13.97 GiB] inherit
  ACTIVE            '/dev/rl/var' [<4.66 GiB] inherit
[root@Sipl-183 ~]# vgs
  VG    #PV #LV #SN Attr   VSize   VFree
  myvg    2   0   0 wz--n-  19.99g 19.99g
  rl      1   3   0 wz--n- <27.95g  4.00m
[root@Sipl-183 ~]# lvcreate -L 15G -n /dev/myvg/LVM1
  Logical volume "LVM1" created.
[root@Sipl-183 ~]# lvscan
  ACTIVE            '/dev/myvg/LVM1' [15.00 GiB] inherit
  ACTIVE            '/dev/rl/root' [9.31 GiB] inherit
  ACTIVE            '/dev/rl/swap' [13.97 GiB] inherit
  ACTIVE            '/dev/rl/var' [<4.66 GiB] inherit
[root@Sipl-183 ~]# mkfs.ext4 /dev/myvg/LVM1
mke2fs 1.46.5 (30-Dec-2021)
Creating filesystem with 3932160 4k blocks and 983040 inodes
Filesystem UUID: f951e40d-9e4f-464a-8638-e06dfd5f7ee7
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208

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

LVSCAN / LVEXTEND /RESIZE2FS for Filesystem resizing

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- Lvscan
  - Show the list of logical volumes available
    - Lvscan /dev/myvg/LVM1
- Lvextend
  - To extend logical volumes
    - Lvextend –L 18G /dev/myvg/LVM1
- Resize2fs
  - To resize filesystem of extended logical volume.
    - resize2fs /dev/myvg/LVM1

- ***NOTE*** *:- resize2fs command is specifically used for resizing ext2, ext3, and ext4 filesystems. For XFS filesystems, the appropriate command to resize the filesystem is xfs_growfs.*

LVSCAN / LVEXTEND /RESIZE2FS for Filesystem resizing

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root@Sipl-183:~

```
[root@Sipl-183 ~]# lvs /dev/myvg/LVM1
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 15.00g
[root@Sipl-183 ~]# lvextend -L 18G /dev/myvg/LVM1
  Size of logical volume myvg/LVM1 changed from 15.00 GiB (3840 extents) to 18.00 GiB (4608 extents).
  Logical volume myvg/LVM1 successfully resized.
[root@Sipl-183 ~]# resize2fs /dev/myvg/LVM1
resize2fs 1.46.5 (30-Dec-2021)
Resizing the filesystem on /dev/myvg/LVM1 to 4718592 (4k) blocks.
The filesystem on /dev/myvg/LVM1 is now 4718592 (4k) blocks long.

[root@Sipl-183 ~]# lvs /dev/myvg/LVM1
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 18.00g
[root@Sipl-183 ~]#
```

LVSCAN / LVREDUCE /RESIZE2FS for Filesystem resizing

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- While reducing LVM we must reduce first filesystem then LVM.
- lvscan
  - Show the list of logical volumes available
    - Lvscan /dev/myvg/LVM1
- E2fsck
  - To check filesystem
    - e2fsck /dev/myvg/LVM1
- Resize2fs
  - To resize filesystem of reduce logical volume.
    - resize2fs /dev/myvg/LVM1 10 (size we want re-assign)
- Lvreduce
  - To reduce logical volume.
    - Lvreduce –L 10G /dev/sda/LVM1

- ***Note :-*** *ext2, ext3, and ext4 filesystems support the ability to be reduced in size, whereas XFS filesystems do not support shrinking*

LVSCAN / LVREDUCE /RESIZE2FS for Filesystem resizing

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root@Sipl-183:~

```
[root@Sipl-183 ~]# lvs /dev/myvg/LVM1
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 18.00g
[root@Sipl-183 ~]# e2fsck /dev/myvg/LVM1
e2fsck 1.46.5 (30-Dec-2021)
/dev/myvg/LVM1: clean, 11/1179648 files, 101703/4718592 blocks
[root@Sipl-183 ~]# resize2fs /dev/myvg/LVM1 10G
resize2fs 1.46.5 (30-Dec-2021)
Resizing the filesystem on /dev/myvg/LVM1 to 2621440 (4k) blocks.
The filesystem on /dev/myvg/LVM1 is now 2621440 (4k) blocks long.

[root@Sipl-183 ~]# lvreduce -L 10G /dev/myvg/LVM1
  File system ext4 found on myvg/LVM1.
  File system size (10.00 GiB) is equal to the requested size (10.00 GiB).
  File system reduce is not needed, skipping.
  Size of logical volume myvg/LVM1 changed from 18.00 GiB (4608 extents) to 10.00 GiB (2560 extents).
  Logical volume myvg/LVM1 successfully resized.
[root@Sipl-183 ~]# lvs /dev/myvg/LVM1
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 10.00g
[root@Sipl-183 ~]#
```

LVSCAN/SNAPSHOT of LVM /LVMERGE to Rollback

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- While creating Snapshot your Lvm and Snapshot should on same VG.
- lvscan
  - Show the list of logical volumes available
    - Lvscan /dev/myvg/LVM1
- Lvcreate
  - To create Snapshot
    - Lvcreate –L 10G –s –n /dev/myvg/LVM1snap /dev/myvg/LVM1
- Lvconvert --merg
  - To Rollback the snapshot
    - Lvconvert --merg /dev/myvg/LVM1snap (Name of SNAPSHOT)

LVSCAN/SNAPSHOT of LVM /LVMERGE to Rollback

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root@Sipl-183:~

```
[root@Sipl-183 ~]# lvs /dev/myvg/LVM1
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 18.00g
[root@Sipl-183 ~]# lvcreate -L 10G -s -n /dev/myvg/LVMsnap /dev/myvg/LVM1
  Logical volume "LVMsnap" created.
[root@Sipl-183 ~]# lvs
  LV      VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1    myvg owi-a-s--- 18.00g
  LVMsnap myvg swi-a-s--- 10.00g      LVM1   0.00
  root    rl   -wi-ao----  9.31g
  swap    rl   -wi-ao---- 13.97g
  var     rl   -wi-ao---- <4.66g
[root@Sipl-183 ~]# lvconvert --merge /dev/myvg/LVMsnap
  Merging of volume myvg/LVMsnap started.
  myvg/LVM1: Merged: 100.00%
[root@Sipl-183 ~]# lvs
  LV   VG   Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  LVM1 myvg -wi-a----- 18.00g
  root rl   -wi-ao----  9.31g
  swap rl   -wi-ao---- 13.97g
  var  rl   -wi-ao---- <4.66g
[root@Sipl-183 ~]#
```

Summary of commands

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Physical Volume	Volume Group	Logical Volume	Others
pvs	vgs	lvs	dmesg
pvdisplay	vgdisplay	lvdisplay	fdisk
pvcreate	vgcreate	lvcreate	mkfs
pvremove	vgremove	lvremove	mount
pvextend	vgextend	lvextend	umount
	vgreduce	Lvresize	blkid
	vgchange	Lvconvert	fuser
	vgcfgbackup		lsof
	vgcfgrestore		lsblk

Practical's

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- Create different types of raid volumes
- Create filesystems on these raid volumes
- Add the filesystem to config file so that when the machine starts, the filesystems are mounted (i.e. are accessible)
- Reduce Physical Volume from Volume Group.