



CentOS Linux

System Administrator's Guide

Storage Management

Table of Contents

SECTION I. Standard Partitioning in CentOS	
1.1 Create new partition from a newly attached disk.....	
1.2 Create another partition from an existing disk	
1.3 Delete a partition from an existing disk.....	
1.4 Extend existing partition without LVM using 'grow-part' utility	
1.5 Extend existing partition without LVM using 'f-disk' utility	
SECTION II. Linear LVM Partitioning in CentOS	
2.1 Managing physical volumes (PV).....	
2.2 Managing volume groups (VG).....	
2.3 Managing logical volumes (LV).....	
Case I: Creating new LV(s) from scratch	
Case II: Extend an existing LV(s) by increasing capacity of existing partition of drive (PV)	
Case III: Extend an existing LV(s) by adding another drive to the machine	
Case IV: Extend an existing LV(s) by reducing another LV of the same volume group.....	
SECTION III. Stripped LVM Partitioning in CentOS.....	
3.1 Creating a stripped LV	
3.2 Extending a stripped LV	

1. Standard Partitioning

The standard partitioning scheme typically refers to the use of traditional disk partitioning methods, such as using the MBR (Master Boot Record) or GPT (GUID Partition Table) partitioning schemes. These schemes divide the disk into multiple partitions to organize and manage the storage space.

1.1 Below are the steps to create a new partition from a newly attached disk drive:

1. First, check the available disks on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0      0   60G  0 disk
├─sda1               8:1      0    1G  0 part /boot
└─sda2               8:2      0   59G  0 part
   ├─centos_vm-root 253:0      0  38.3G  0 lvm  /
   ├─centos_vm-swap 253:1      0    2G  0 lvm  [SWAP]
   └─centos_vm-home 253:2      0  18.7G  0 lvm  /home
sr0                 11:0      1 1024M  0 rom
```

2. Listed below, actual hard-disk “sda” is partition into sda(1) & sda(2), the sda(2) is further divided into different LV(s) using LVM system. This the default LVM created by OS while installation.

```
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0      0   60G  0 disk
├─sda1               8:1      0    1G  0 part /boot
└─sda2               8:2      0   59G  0 part
   ├─centos_vm-root 253:0      0  38.3G  0 lvm  /
   ├─centos_vm-swap 253:1      0    2G  0 lvm  [SWAP]
   └─centos_vm-home 253:2      0  18.7G  0 lvm  /home
sr0                 11:0      1 1024M  0 rom
```

<-- Actual Hard Disk (sda)

<-- (sda) is partitioned into sda(1),sda(2)

<-- sda(2) is further partitioned into LVM(s)

3. Let's add the new hard-drive. I'm going to add 5 GB disk to my machine.
4. After adding new disk, list the available disk on your machine. The results will now show the newly added hard-drive.
5. If the new drive is not visible in available disks, you have to rescan all the “SCSI” hosts to make it visible.

echo "- - -" | tee /sys/class/scsi_host/host*/scan

```
[root@sysadmin ~]# echo "- - -" | tee /sys/class/scsi_host/host*/scan
- - -
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0      0   60G  0 disk
├─sda1               8:1      0    1G  0 part /boot
└─sda2               8:2      0   59G  0 part
   ├─centos_vm-root 253:0      0  38.3G  0 lvm  /
   ├─centos_vm-swap 253:1      0    2G  0 lvm  [SWAP]
   └─centos_vm-home 253:2      0  18.7G  0 lvm  /home
sdb                  8:16      0    5G  0 disk
sr0                 11:0      1 1024M  0 rom
```

6. Alternatively, you can use the “rescan-scsi-bus.sh” script contained in “sg3_utils” package to scan all the hosts.

yum install sg3_utils

rescan-scsi-bus.sh

7. By default, “fdisk” utility build the new drive using “DOS” partitioning scheme. Before proceeding with partitioning the disk, change the partition table of newly attached disk to “GPT”.

```
[root@sysadmin ~]# fdisk /dev/sdb
Welcome to fdisk (util-linux 2.23.2).

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
Building a new DOS disklabel with disk identifier 0x8dd337b5.

Command (m for help): |
```

Press “g” to change the partition.

```
Command (m for help): g
Building a new GPT disklabel (GUID: 3052B452-8972-48B2-A130-EC008B9B2BF4)
```

Press “w” to save the changes.

```
Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.
```

```
[root@sysadmin ~]# blkid /dev/sdb
/dev/sdb: PTTYPE="gpt"
```

8. Create a partition from a newly attached disk, in this case “sdb” using “fdisk” utility.

fdisk /dev/sdb

```
[root@sysadmin ~]# fdisk /dev/sdb
Welcome to fdisk (util-linux 2.23.2).

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
Building a new DOS disklabel with disk identifier 0x8dd337b5.

Command (m for help): |
```

Press ‘n’ to add a new partition to the selected disk.

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

Proceed with default ‘p’ option, now next select partition number (1-4), go ahead with default first sector value. Now, it prompts for the last sector value, the whole drive (5 GB) will be partitioned, if you don’t specify the last sector size. In this case, I’m partitioning with only “2 GB” out of total “5 GB”.

```
Command (m for help): n
Partition type:
   p   primary (0 primary, 0 extended, 4 free)
   e   extended
Select (default p): p
Partition number (1-4, default 1): 1
First sector (2048-10485759, default 2048):
Using default value 2048
Last sector, +sectors or +size{K,M,G} (2048-10485759, default 10485759): +2G
Partition 1 of type Linux and of size 2 GiB is set
```

Press “p” to print available partitions for the selected drive (sdb).

```

Command (m for help): p

Disk /dev/sdb: 5368 MB, 5368709120 bytes, 10485760 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk label type: dos
Disk identifier: 0x33762e31

   Device Boot      Start         End      Blocks   Id  System
/dev/sdb1           2048        4196351       2097152    83   Linux

```

By default, the drive partitioned to a “Linux” filesystem type. However, there is still a need to format a partition to a filesystem type “ext4,xfs”.

Press ‘w’ to save for the changes.

```

Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.

```

9. Verify the the new created partition for “sdb” disk using “lsblk” command.

```

[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0    0   60G  0 disk
├─sda1                             8:1    0    1G  0 part /boot
├─sda2                             8:2    0   59G  0 part
│   ├─centos_vm-root               253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap               253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home               253:2    0  18.7G  0 lvm  /home
sdb                                 8:16    0    5G  0 disk
├─sdb1                             8:17    0    2G  0 part
sr0                                11:0    1 1024M  0 rom

```

10. Now format “sdb1” with the appropriate filesystem. I’m formatting with “xfs”.

mkfs.xfs -L sysadmin_fs /dev/sdb1

```

[root@sysadmin ~]# mkfs.xfs -L sysadmin_fs /dev/sdb1
meta-data=/dev/sdb1            isize=512    agcount=4, agsize=131072 blks
=                               sectsz=512   attr=2, projid32bit=1
=                               crc=1      finobt=0, sparse=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=512   sunit=0 blks, lazy-count=1
realtime  =none               extsz=4096   blocks=0, rtextents=0

```

11. Validate the formatted FS using “blkid” command.

blkid /dev/sdb1

```

[root@sysadmin ~]# blkid /dev/sdb1
/dev/sdb1: LABEL="sysadmin_fs" UUID="72c64ae8-b7bf-4b97-9a8d-6728e6ff3969" TYPE="xfs"
PARTUUID="7cd853af-6b68-4b80-87c3-ca591804756c"

```

12. Let’s mount “sdb1” to a specific mount location.

13. You can mount partition on any location, here I’m going to create a custom directory and mount the partition on that custom mount point.

mkdir -p /sysadmin_mountpoint

mount /dev/sdb1 /sysadmin_mountpoint

```

[root@sysadmin ~]# mkdir -p /sysadmin_mountpoint
[root@sysadmin ~]# mount /dev/sdb1 /sysadmin_mountpoint

```

14. Verify the mount using “df -h” command.

```
[root@sysadmin ~]# df -h
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        475M   0  475M   0% /dev
tmpfs           487M   0  487M   0% /dev/shm
tmpfs           487M  7.7M  479M   2% /run
tmpfs           487M   0  487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root 39G   1.6G   37G   5% /
/dev/mapper/centos_vm-home 19G   33M   19G   1% /home
/dev/sda1       1014M  169M   846M  17% /boot
tmpfs           98M    0    98M   0% /run/user/0
/dev/sdb1       2.0G   33M   2.0G   2% /sysadmin_mountpoint
```

15. To automatically mount the above the partition or drive on the specific mount location, we have to make configuration changes to the “/etc/fstab” file. The “fstab” file in Linux is used to define and configure the filesystems (partitions) that are automatically mounted during the system boot process.
16. Let’s edit the file using “vi/nano” editor and the add following line.

vi /etc/fstab

/dev/sdb1 /sysadmin_mountpoint xfs defaults 1 2

```
/dev/mapper/centos_vm-root / xfs defaults 0 0
UUID=02738ca7-6b46-4fb2-b4c3-093352dd8b6f /boot xfs defaults 0 0
/dev/mapper/centos_vm-home /home xfs defaults 0 0
/dev/mapper/centos_vm-swap swap swap defaults 0 0
/dev/sdb1 /sysadmin_mountpoint xfs defaults 1 2
```

“**/dev/sdb1**”: This is the device or partition that will be mounted. In this case, it refers to the device file /dev/sdb1.

“**/sysadmin_mountpoint**”: This is the mount point, which is the directory where the filesystem will be attached. In this example, the filesystem will be mounted at the directory /sysadmin_mountpoint.

“**xfs**”: This specifies the filesystem type. In this case, it is XFS, which is a high-performance filesystem commonly used in Linux.

“**defaults**”: This field specifies the mount options for the filesystem. The "defaults" option implies a standard set of mount options, including allowing read and write access, enabling atime (access time) updates, and using default file permissions.

“**1**”: This field determines whether the filesystem should be backed up by the dump utility. A value of 1 indicates that the filesystem will be backed up.

“**2**”: This field specifies the order in which filesystems are checked during the boot process by the fsck (filesystem check) utility. A value of 2 means that the filesystem will be checked after the root filesystem but before other filesystems with a value of 0.

Note: It’s a best practice to always specify a filesystem in the “fstab” with their “UUIDs” because “/dev/sdb1” for example can change to “/dev/sdc1” after a system reboot which the “fstab” file will not be able to read the supposed populated filesystem.

1.2 Below are the steps to create another partition from existing drive using “parted” utility:

1. First, check the available disks and partitions on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0    0   60G  0 disk
├─sda1                8:1    0    1G  0 part /boot
├─sda2                8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb                  8:16    0   15G  0 disk
└─sdb1                8:17    0   12G  0 part
sr0                 11:0    1 1024M  0 rom
```

2. Above shown, you can see the drive “sdb” has (15 GB) total space, and a partition of (12 GB) is already created. We’re now going to create another partition of available (3 GB) space.
3. Let’s create another partition using “parted”.

parted /dev/sdb

```
[root@sysadmin ~]# parted /dev/sdb
GNU Parted 3.1
Using /dev/sdb
Welcome to GNU Parted! Type 'help' to view a list of commands.
(parted) |
```

Type ‘print’ to print the available partitions for drive “sdb”.

```
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdb: 16.1GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File system  Name  Flags
  1      1049kB  12.9GB  12.9GB  ext4          
```

Proceed for creating a new partition. Type ‘mkpart’ to create a new partition.

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

Proceed with naming the new partition, you can leave it blank as well, next provide file system type, I’m opting for “ext4”. Provide the start & end sector values for creating a partition.

```
(parted) mkpart
Partition name?  []?
File system type?  [ext2]? ext4
Start? 12.9GB
End? 16.1GB
```

Type ‘print’ to make sure that partitioning has been done for drive “sdb”.

```
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdb: 16.1GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File system  Name  Flags
  1      1049kB  12.9GB  12.9GB  ext4
  2      12.9GB  16.1GB  3221MB  
```

Type 'quit' to exit from parted utility.

4. Confirm using "lsblk" command.

```
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0    0   60G  0 disk
├─sda1               8:1    0    1G  0 part /boot
├─sda2               8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm /home
└─sdb                8:16    0   15G  0 disk
   ├─sdb1            8:17    0   12G  0 part
   └─sdb2            8:18    0    3G  0 part
sr0                 11:0    1 1024M  0 rom
```

5. Now format "sdb2" with the appropriate filesystem. I'm formatting with "ext4".

```
mkfs.ext4 -L sysadmin_fs /dev/sdb2
```

6. Verify using "blkid" command

```
blkid /dev/sdb2
```

```
[root@sysadmin ~]# blkid /dev/sdb2
/dev/sdb2: LABEL="sysadmin_fs2" UUID="f793dd40-0892-4aae-9e7c-bc93484006bb" TYPE="ext4"
PARTUUID="99747e8a-23cc-4453-863c-039cdcb1bd42"
```

7. Let's mount "sdb2" to a specific mount location.

8. You can mount partition on any location, here I'm going to create a custom directory and mount the partition on that custom mount point.

```
mkdir -p /sysadmin_mountpoint2
```

```
mount /dev/sdb1 /sysadmin_mountpoint
```

9. Verify the mount using "df -h" command.

```
[root@sysadmin ~]# df -h
Filesystem            Size  Used Avail Use% Mounted on
devtmpfs              475M   0   475M   0% /dev
tmpfs                 487M   0   487M   0% /dev/shm
tmpfs                 487M  7.7M   479M   2% /run
tmpfs                 487M   0   487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root 39G  2.3G   36G   6% /
/dev/mapper/centos_vm-home 19G   33M   19G   1% /home
/dev/sda1             1014M  169M   846M  17% /boot
tmpfs                 98M   0    98M   0% /run/user/0
/dev/sdb1             12G   41M   12G   1% /sysadmin_mountpoint
/dev/sdb2             2.9G   9.0M   2.8G   1% /sysadmin_mountpoint2
```

10. To automatically mount the above the partition or drive on the specific mount location. You can follow the above steps to make entry in "fstab" file.

1.3 Below are the steps to delete partition from existing drive using “parted” utility:

1. First, check the available disks and partitions on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                  8:0    0   60G  0 disk
├─sda1                8:1    0    1G  0 part /boot
├─sda2                8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0 38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0 18.7G  0 lvm  /home
sdb                  8:16    0   15G  0 disk
├─sdb1                8:17    0   12G  0 part
└─sdb2                8:18    0    3G  0 part
sr0                 11:0    1 1024M  0 rom
```

2. Above shown, you can see the drive “sdb” has two partitions sdb(1),sdb(2). I’m going to delete sdb(2) using parted.
3. Please be careful while deleting the partitions as , this process can make your machine(s) corrupt.
4. Un-mount the partition before deleting it.
umount /dev/sdb2
5. Let’s delete partition sdb(2) using “parted”.

parted /dev/sdb

```
[root@sysadmin ~]# parted /dev/sdb
GNU Parted 3.1
Using /dev/sdb
Welcome to GNU Parted! Type 'help' to view a list of commands.
(parted) |
```

Type ‘print’ to print the available partitions for drive “sdb”.

```
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdb: 16.1GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File system  Name  Flags
 1      1049kB  12.9GB  12.9GB  ext4         sdb1
 2      12.9GB  16.1GB  3221MB  ext4         sdb2
```

Proceed for deleting partition sdb(2). Type ‘rm <partition-number>’ to delete a new partition.

```
(parted) rm 2
(parted) |
```

Type ‘print’ to print the available partitions for drive “sdb”.

```
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdb: 16.1GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File system  Name  Flags
 1      1049kB  12.9GB  12.9GB  ext4         sdb1
```

Type ‘quit’ to exit from parted utility.

6. Confirm using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0      0   60G  0 disk
├─sda1                             8:1      0    1G  0 part /boot
└─sda2                             8:2      0   59G  0 part
   ├─centos_vm-root                 253:0    0  38.3G  0 lvm  /
   ├─centos_vm-swap                 253:1    0    2G  0 lvm  [SWAP]
   └─centos_vm-home                 253:2    0  18.7G  0 lvm  /home
sdb                                 8:16     0   15G  0 disk
└─sdb1                             8:17     0   12G  0 part /sysadmin_mountpoint
sr0                                11:0     1 1024M  0 rom
```

7. You can see above, partition sdb(2) has been removed.

Note: Make sure to take backup before removing any partition. It is recommended to always perform this action using “parted utility” as this can be somewhat safer compared to other tools. Other tools, can make your OS stuck at next boot after deleting a partition.

1.4 Below are the steps to extend an existing partition without LVM using “growpart” utility: (Recommended)

1. First, check the available disks and partitions on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda          8:0    0   60G  0 disk
├─sda1       8:1    0    1G  0 part /boot
├─sda2       8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm /home
└─sdb        8:16    0   10G  0 disk
   └─sdb1     8:17    0    5G  0 part /sysadmin_mountpoint
sr0         11:0    1 1024M  0 rom
```

2. Now increase the size of your drive from backend, and rescan the SCSI hosts using the steps given above. Here I've already done these steps, we have “sdb” drive of total size (10 GB). I'm going to increase the size of partition “sdb1” from (5 GB) to (10 GB) using growpart utility.
3. First make sure the growpart-utils are installed on your machine.

yum install cloud-utils-growpart gdisk

4. Let's increase the size of “sdb1” to (10 GB).

growpart /dev/sdb 1

```
[root@sysadmin ~]# growpart /dev/sdb 1
CHANGED: partition=1 start=2048 old: size=10485760 end=10487808 new: size=20967424 end=20969472
```

5. You need to use the “resize2fs or xfs_growfs” command to resize the filesystem after extending a partition to ensure that the filesystem recognizes and utilizes the additional space. Since in this case, partition “sdb1” FS was “xfs” so I use “xfs_growfs” for resizing. For ext(s) file systems, use “resize2fs”

xfs_growfs /dev/sdb1

```
[root@sysadmin ~]# xfs_growfs /dev/sdb1
meta-data=/dev/sdb1            isize=512    agcount=4, agsize=327680 blks
=                               sectsz=512   attr=2, projid32bit=1
=                               crc=1       finobt=0 spinodes=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            bsize=4096   blocks=2560, version=2
=                               sectsz=512   sunit=0 blks, lazy-count=1
realtime =none                extsz=4096   blocks=0, rtextents=0
data blocks changed from 1310720 to 2620928
```

6. Verify using “df -h” command.

```
[root@sysadmin ~]# df -h
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        475M   0   475M   0% /dev
tmpfs           487M   0   487M   0% /dev/shm
tmpfs           487M  7.7M  479M   2% /run
tmpfs           487M   0   487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root 39G   2.3G   36G    6% /
/dev/mapper/centos_vm-home 19G   33M   19G    1% /home
/dev/sda1       1014M  169M  846M   17% /boot
tmpfs           98M    0    98M    0% /run/user/0
/dev/sdb1       10G   773M   9.3G    8% /sysadmin_mountpoint
```

1.5 Below are the steps to extend an existing partition without LVM using fdisk utility:

1. First, check the available disks and partitions on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0    0   60G  0 disk
├─sda1                             8:1    0    1G  0 part /boot
├─sda2                             8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb                                 8:16    0    5G  0 disk
└─sdb1                             8:17    0    2G  0 part /sysadmin_mountpoint
sr0                                11:0    1 1024M  0 rom
```

2. Here we have “sdb” drive of total size (5 GB).

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0    0   60G  0 disk
├─sda1                             8:1    0    1G  0 part /boot
├─sda2                             8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb                                 8:16    0    5G  0 disk
└─sdb1                             8:17    0    2G  0 part /sysadmin_mountpoint
sr0                                11:0    1 1024M  0 rom
```

3. I’m going to enhance the hard drive size of my machine from backend. To do this, maybe you have to power off your machine.
4. You can see the drive size has been increased from (5 GB) to (10 GB).

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0    0   60G  0 disk
├─sda1                             8:1    0    1G  0 part /boot
├─sda2                             8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb                                 8:16    0   10G  0 disk
└─sdb1                             8:17    0    2G  0 part /sysadmin_mountpoint
sr0                                11:0    1 1024M  0 rom
```

5. You can also see the consumed space for sdb1.

```
[root@sysadmin sysadmin_mountpoint]# df -h .
Filesystem      Size  Used Avail Use% Mounted on
/dev/sdb1       2.0G  773M  1.3G  38% /sysadmin_mountpoint
```

6. Un-mount the partition

umount /sysadmin_mountpoint

```
[root@sysadmin /]# umount /sysadmin_mountpoint
[root@sysadmin /]# df -h
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        475M    0  475M   0% /dev
tmpfs           487M    0  487M   0% /dev/shm
tmpfs           487M  7.6M  479M   2% /run
tmpfs           487M    0  487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root 39G   1.8G   37G   5% /
/dev/mapper/centos_vm-home 19G   33M   19G   1% /home
/dev/sda1       1014M  169M  846M  17% /boot
tmpfs           98M    0   98M   0% /run/user/0
```

7. Make sure to backup the data before extending a standard partition.
8. Extend the partition “sdb1” of disk “sdb” using “fdisk” utility.

fdisk /dev/sdb

```
[root@sysadmin ~]# fdisk /dev/sdb
Welcome to fdisk (util-linux 2.23.2).

Changes will remain in memory only, until you decide to write them.
Be careful before using the write command.

Command (m for help): |
```

Press 'p' to print the available partitions for drive "sdb".

```
Command (m for help): p

Disk /dev/sdb: 10.7 GB, 10737418240 bytes, 20971520 sectors
Units = sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disk label type: dos
Disk identifier: 0x00000000

   Device Boot      Start         End      Blocks   Id  System
/dev/sdb1             1      10485759      5242879+   ee   GPT

Command (m for help): |
```

Press 'd' to delete the partition, if multiple partitions available, identify the partition number and then specify it while deleting.

```
Command (m for help): d
Selected partition 1
Partition 1 is deleted

Command (m for help): |
```

Proceed for creating a new partition with new allocated space. Press 'n' to create a new partition.

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

Proceed with default 'p' option, now next select partition number (1-4), go ahead with default first sector value. Now, it prompts for the last sector value, the whole drive (10 GB) will be partitioned, if you don't specify the last sector size. In this case, I'm partitioning with only "7 GB" out of total "10 GB" available.

```
Command (m for help): n
Partition type:
   p   primary (0 primary, 0 extended, 4 free)
   e   extended
Select (default p):
Using default response p
Partition number (1-4, default 1): 1
First sector (2048-20971519, default 2048):
Using default value 2048
Last sector, +sectors or +size{K,M,G} (2048-20971519, default 20971519): +7G
Partition 1 of type Linux and of size 7 GiB is set
```

Press 'w' to save the changes made to disk.

```
Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.
```

9. Now mount the extended partition on the same mount point.

mount /dev/sdb1 /sysadmin_mountpoint

10. You need to use the “resize2fs or xfs_growfs” command to resize the filesystem after extending a partition to ensure that the filesystem recognizes and utilizes the additional space. Since in this case, partition “sdb1” FS was “xfs” so I use “xfs_growfs” for resizing. For ext(s) file systems, use “resize2fs”

xfs_growfs /dev/sdb1

```
[root@sysadmin ~]# xfs_growfs /dev/sdb1
meta-data=/dev/sdb1             isize=512    agcount=4, agsize=131072 blks
      =                       sectsz=512   attr=2, projid32bit=1
      =                       crc=1        finobt=0 spinodes=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            bsize=4096   blocks=2560, version=2
      =                       sectsz=512   sunit=0 blks, lazy-count=1
realtime  =none                extsz=4096   blocks=0, rtextents=0
data blocks changed from 524288 to 1835008
```

11. Verify the extended space using the “df -h” command.

```
[root@sysadmin ~]# df -h
Filesystem      Size  Used Avail Use% Mounted on
devtmpfs        475M   0  475M   0% /dev
tmpfs           487M   0  487M   0% /dev/shm
tmpfs           487M  7.7M  479M   2% /run
tmpfs           487M   0  487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root 39G  1.8G  37G   5% /
/dev/mapper/centos_vm-home 19G   33M  19G   1% /home
/dev/sda1       1014M  169M  846M  17% /boot
tmpfs           98M   0   98M   0% /run/user/0
/dev/sdb1       7.0G  773M  6.3G  11% /sysadmin_mountpoint
```

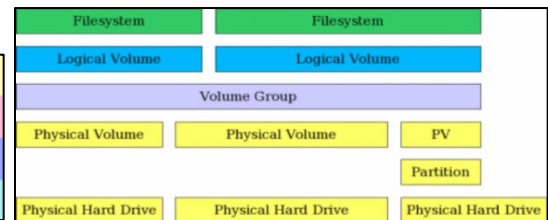
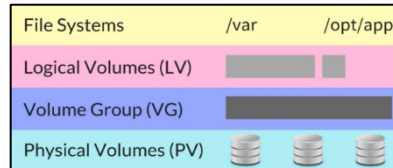
12. Above, it is noticed that the “sdb(1)” space has been extended from (5 GB) to (10 GB).

2. Linear LVM Partitioning

LVM stands for Logical Volume Management. This is an alternative method of managing storage systems than the traditional partition-based one. In LVM, instead of creating partitions, you create logical volumes, and then you can just as easily mount those volumes in your filesystem as you'd a disk partition. The main advantage of LVM is how easy it is to resize a logical volume or volume group. It abstracts away all the ugly parts (partitions, raw disks) and leaves us with a central storage pool to work with.

There are three main components to LVM:

1. Physical Volumes
2. Volume Groups
3. Logical Volumes
4. Physical Extents
5. Logical Extents



Physical Volumes:

Physical volumes are the raw materials or building blocks that are used to achieve the abstraction that is logical volumes. In simpler words, physical volumes are the logical unit of an LVM system. Physical volume(s) are created from block devices. A block device could be LUNS created from the storage array, the physical hard drive or even a partition on a disk. Creating and initializing a physical volume are the same thing. Both mean you're just preparing the building blocks (i.e., partitions, disks) for further operations.

Volume Groups:

Volume groups are collections of physical volumes. It is the next level of abstraction in LVM. Volume groups are the storage pool that combines the storage capacity of multiple raw storage devices.

Logical Groups:

A logical volume is like a partition, but instead of sitting on top of a raw disk, it sits on top of a volume group. You can format a logical volume with whichever filesystem you want. Mount it anywhere in the filesystem you want.

Physical Extents:

Physical extent represents a fixed-size block of storage in LVM. It refers to a contiguous portion of a physical disk or a RAID array that is allocated for use by LVM. The size of a physical extent is determined during the creation of a Volume Group (VG) in LVM. All physical extents within a Volume Group have the same size, and this size is typically set to a power of two, such as 4MB or 8MB.

When you create logical volumes (LVs) within a Volume Group, they are divided into smaller units called logical extents, which are mapped to physical extents on the underlying physical storage devices.

Logical Extents:

A logical extent represents a portion of a logical volume (LV) in LVM. It is an abstraction that allows LVM to manage the allocation and mapping of logical volumes to physical extents. The size of a logical extent is the same as the size of a physical extent in the associated Volume Group.

Logical extents are grouped together to form logical volumes, which can be formatted with a file system and mounted as a regular storage device within the operating system. The logical extents of a logical volume do not have to be contiguous on the physical storage; they can be spread across multiple physical devices, allowing for flexibility and management of storage resources.

2.1 Managing Physical Volumes (PV):

1. First, check the available disks on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME            MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda              8:0    0   60G  0 disk
├─sda1           8:1    0    1G  0 part /boot
├─sda2           8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb             8:16    0   15G  0 disk
sdc             8:32    0   20G  0 disk
sr0            11:0    1 1024M  0 rom
```

2. Here, we have two physical drives “sdb” and “sdc” available right now. For now, we are going to create one PV from “sdb” drive.

pvcreate /dev/sdb

```
[root@sysadmin ~]# pvcreate /dev/sdb
Physical volume "/dev/sdb" successfully created.
[root@sysadmin ~]#
```

3. You can verify created PV using “pvs” command.

```
[root@sysadmin ~]# pvs
PV          VG      Fmt Attr PSize  PFree
/dev/sda2   centos_vm lvm2 a-- <59.00g 4.00m
/dev/sdb    lvm2  ---   15.00g 15.00g
```

4. Now we'll be partition “sdc” into sdc(1) & sdc(2). You can use above steps to create a partition using fdisk or any other tool.

```
[root@sysadmin ~]# lsblk
NAME            MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda              8:0    0   60G  0 disk
├─sda1           8:1    0    1G  0 part /boot
├─sda2           8:2    0   59G  0 part
│   ├─centos_vm-root 253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap 253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home 253:2    0  18.7G  0 lvm  /home
sdb             8:16    0   15G  0 disk
sdc             8:32    0   20G  0 disk
├─sdc1          8:33    0   10G  0 part
└─sdc2          8:34    0    5G  0 part
sr0            11:0    1 1024M  0 rom
```

5. Here above we have created sdc(1) of (10 GB) & sdc(2) of (5 GB) out of total (20 GB) space available.
6. Create two PV(s) from these newly created partitions.

pvcreate /dev/sdc1 /dev/sdc2


```
[root@sysadmin ~]# pvcreate /dev/sdc1 /dev/sdc2
Physical volume "/dev/sdc1" successfully created.
Physical volume "/dev/sdc2" successfully created.
```

- You can verify available physical volumes using “pvs” command.

```
[root@sysadmin ~]# pvs
PV          VG          Fmt  Attr  PSize   PFree
/dev/sda2   centos_vm  lvm2 a--   <59.00g  4.00m
/dev/sdb           lvm2 ---   15.00g  15.00g
/dev/sdc1           lvm2 ---   10.00g  10.00g
/dev/sdc2           lvm2 ---    5.00g   5.00g
```

- You can also remove a PV using “pvremove” command.

```
[root@sysadmin ~]# pvremove /dev/sdc2
Labels on physical volume "/dev/sdc2" successfully wiped.
```

- You can verify available physical volumes using “pvs” command.

```
[root@sysadmin ~]# pvs
PV          VG          Fmt  Attr  PSize   PFree
/dev/sda2   centos_vm  lvm2 a--   <59.00g  4.00m
/dev/sdb           lvm2 ---   15.00g  15.00g
/dev/sdc1           lvm2 ---   10.00g  10.00g
```

- Here, you can see sdc(2) has been removed.

2.2 Managing Volume Groups (VG):

- Let’s create a volume group from two PV(s) (sdb,sdc1)

vgcreate <vg-name> <pv-1> <pv-2>

```
[root@sysadmin ~]# vgcreate sysadmin_VG_1 /dev/sdb /dev/sdc1
Volume group "sysadmin_VG_1" successfully created
```

- You can list all the volume groups using “vgs” command.

```
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize   VFree
centos_vm    1  3  0 wz--n- <59.00g  4.00m
sysadmin_VG_1 2  0  0 wz--n-  24.99g  24.99g
```

- You can also extend the existing volume group with a new PV. I’m adding “sdc(2)” to our existing volume group we just created “sysadmin_VG_1”

vgextend <vg-name> <pv-1> <pv-2>

```
[root@sysadmin ~]# vgextend sysadmin_VG_1 /dev/sdc2
Volume group "sysadmin_VG_1" successfully extended
```

- List all the volume groups to verify extended VG, using “vgs” command.

```
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize   VFree
centos_vm    1  3  0 wz--n- <59.00g  4.00m
sysadmin_VG_1 3  0  0 wz--n- <29.99g <29.99g
```

- Here above, you can see volume group “sysadmin_VG_1” has been extended successfully.

- You can also reduce a volume group using “vgreduce” command

vgreduce <vg-name> <pv-1> <pv-2>

```
[root@sysadmin ~]# vgreduce sysadmin_VG_1 /dev/sdc2
Removed "/dev/sdc2" from volume group "sysadmin_VG_1"
```

- List all the volume groups to verify reduced VG, using “vgs” command.

```
[root@sysadmin ~]# vgs
VG                #PV #LV #SN Attr   VSize   VFree
centos_vm         1   3   0 wz--n- <59.00g 4.00m
sysadmin_VG_1     2   0   0 wz--n- 24.99g 24.99g
```

8. The whole volume group can be removed using “vgremove” command
vgremove <vg-name>

2.3 Managing Logical Volumes (LV):

Case I: Creating new LV from Scratch

1. Let's create a logical volume from VG. I'm creating LV of size 8 GB on our VG “sysadmin_VG_1”
lvcreate -L <size> -n <lv-name> <vg-name>

```
[root@sysadmin ~]# lvcreate -L 8GB -n sysadmin_LV_1 sysadmin_VG_1
Logical volume "sysadmin_LV_1" created.
```

2. You can list all the volume groups using “vgs” command.

```
VG                #PV #LV #SN Attr   VSize   VFree
centos_vm         1   3   0 wz--n- <59.00g 4.00m
sysadmin_VG_1     2   1   0 wz--n- 24.99g 16.99g
```

3. Verify the created LV using “lvs” command.

```
[root@sysadmin ~]# lvs
LV                VG                Attr      LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
home              centos_vm         -wi-ao---- <18.70g
root              centos_vm         -wi-ao---- <38.30g
swap              centos_vm         -wi-ao---- 2.00g
sysadmin_LV_1     sysadmin_VG_1    -wi-a----- 8.00g
```

4. Format the newly created LVM.

mkfs.ext4 /dev/<vg-name>/<lv-name>

```
[root@sysadmin ~]# mkfs.ext4 /dev/sysadmin_VG_1/sysadmin_LV_1
mke2fs 1.42.9 (28-Dec-2013)
Filesystem label=
OS type: Linux
Block size=4096 (log=2)
Fragment size=4096 (log=2)
Stride=0 blocks, Stripe width=0 blocks
524288 inodes, 2097152 blocks
104857 blocks (5.00%) reserved for the super user
First data block=0
Maximum filesystem blocks=2147483648
64 block groups
32768 blocks per group, 32768 fragments per group
8192 inodes per group
Superblock backups stored on blocks:
    32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632

Allocating group tables: done
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done
```

5. You can verify FS type using “blkid” command

```
[root@sysadmin ~]# blkid /dev/sysadmin_VG_1/sysadmin_LV_1
/dev/sysadmin_VG_1/sysadmin_LV_1: UUID="03d3c368-054d-4356-a68a-790eb4d05f24" TYPE="ext4"
```

6. Mount the LV on the any location
mount <lv-name> <mount-location>
7. Verify using “df -h” command

```
[root@sysadmin ~]# df -h
```

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	475M	0	475M	0%	/dev
tmpfs	487M	0	487M	0%	/dev/shm
tmpfs	487M	7.7M	479M	2%	/run
tmpfs	487M	0	487M	0%	/sys/fs/cgroup
/dev/mapper/centos_vm-root	39G	1.6G	37G	5%	/
/dev/sda1	1014M	169M	846M	17%	/boot
/dev/mapper/centos_vm-home	19G	33M	19G	1%	/home
tmpfs	98M	0	98M	0%	/run/user/0
/dev/mapper/sysadmin_VG_1-sysadmin_LV_1	7.8G	36M	7.3G	1%	/sysadmin_mountpoint

Case II: Extend an existing LV by increasing capacity of an existing partition of a drive (PV):

1. First verify the LV that needs to be extended is part of which volume group using “lvs”.

```
[root@sysadmin ~]# lvs
```

LV	VG	Attr	LSize	Pool	Origin	Data%	Meta%	Move	Log	Cpy%	Sync	Convert
home	centos_vm	-wi-ao----	<18.70g									
root	centos_vm	-wi-ao----	<38.30g									
swap	centos_vm	-wi-ao----	2.00g									
sysadmin_LV_1	sysadmin_VG_1	-wi-ao----	24.99g									

2. I want to increase the space of “sysadmin_LV_1” which is a part of volume group “sysadmin_VG_1”.
3. Let’s check, if “sysadmin_VG_1” volume group has free space available using “vgs” & “pvs” command.

```
[root@sysadmin ~]# vgs
```

VG	#PV	#LV	#SN	Attr	VSize	VFree
centos_vm	1	3	0	wz--n-	<59.00g	4.00m
sysadmin_VG_1	2	1	0	wz--n-	24.99g	0

```
[root@sysadmin ~]# pvs
```

PV	VG	Fmt	Attr	PSize	PFree
/dev/sda2	centos_vm	lvm2	a--	<59.00g	4.00m
/dev/sdb	sysadmin_VG_1	lvm2	a--	<15.00g	0
/dev/sdc1	sysadmin_VG_1	lvm2	a--	<10.00g	0
/dev/sdc2		lvm2	---	5.00g	5.00g

4. Here above you can see that our VG has no space left. We have to increase the space of any PV (drive/partition) that is a part of our VG. Above “sdb” or “sdc1” both are part of our VG “sysadmin_VG_1”. I’m extending the space of “sdc” from backend.
5. I have increased the space of “sdc” from (20 GB) to (30 GB). Let’s verify using “lsblk” command.

```
[root@sysadmin ~]# lsblk
```

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINT
sda	8:0	0	60G	0	disk	
└─sda1	8:1	0	1G	0	part	/boot
└─sda2	8:2	0	59G	0	part	
└─┬─centos_vm-root	253:0	0	38.3G	0	lvm	/
└─┬─centos_vm-swap	253:1	0	2G	0	lvm	[SWAP]
└─└─centos_vm-home	253:3	0	18.7G	0	lvm	/home
sdb	8:16	0	15G	0	disk	
└─sysadmin_VG_1-sysadmin_LV_1	253:2	0	25G	0	lvm	
sdc	8:32	0	40G	0	disk	
└─sdc1	8:33	0	10G	0	part	
└─┬─sysadmin_VG_1-sysadmin_LV_1	253:2	0	25G	0	lvm	
└─└─sdc2	8:34	0	20G	0	part	
sr0	11:0	1	1024M	0	rom	

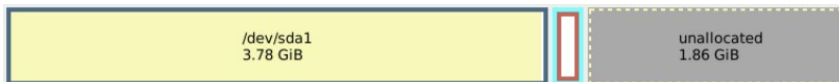
If the changes is not reflect, follow the step 5 of SECTION 1.1, to rescan all the SCSI hosts.

6. Since partition “sdc(1)” is part of Volume Group “sysadmin_VG_1”. So, we have to extend this partition first to make the free space available to VG. I’m using “grow-part” utility for this purpose.

growpart /dev/sdc 1

```
[root@sysadmin ~]# growpart /dev/sdc 1
NOCHANGE: partition 1 is size 20971520. it cannot be grown
```

7. Above listed error, I’m unable to increase the size sdc(1) even though I’ve increased my drive (sdc) space. This is because, the unallocated space resides at the end of drive. In our case right after partition “sdc(2)”. To increase “sdc1” (PV) we have to delete “sdc2” to make the unallocated space available right after “sdc1” or we can attach a new disk drive and create PV from it, make that PV a part of our VG “sysadmin_VG_1”. This whole picture is better illustrated below:



8. In this case, since I have no any data on my sdc(2) partition. I’m going to delete it or I can make a PV from it also. But, proceeding with deletion using parted.

```
[root@sysadmin ~]# parted /dev/sdc
GNU Parted 3.1
Using /dev/sdc
Welcome to GNU Parted! Type 'help' to view a list of commands.
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdc: 42.9GB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number  Start   End     Size    Type     File system  Flags
 1      1049kB  10.7GB  10.7GB  primary
 2      10.7GB  32.2GB  21.5GB  primary

(parted) rm 2
(parted) print
Model: VMware, VMware Virtual S (scsi)
Disk /dev/sdc: 42.9GB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number  Start   End     Size    Type     File system  Flags
 1      1049kB  10.7GB  10.7GB  primary
```

9. Verify using “lsblk” command

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                  8:0    0   60G  0 disk
├─sda1                              8:1    0    1G  0 part /boot
├─sda2                              8:2    0   59G  0 part
│   ├─centos_vm-root                253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap                253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home                253:3    0  18.7G  0 lvm  /home
sdb                                  8:16    0   15G  0 disk
└─sysadmin_VG_1-sysadmin_LV_1      253:2    0    25G  0 lvm
sdc                                  8:32    0   40G  0 disk
├─sdc1                              8:33    0    10G  0 part
└─sysadmin_VG_1-sysadmin_LV_1      253:2    0    25G  0 lvm
sr0                                  11:0    1 1024M  0 rom
```

10. Now extend “sdc1” using growpart utility.

```
[root@sysadmin ~]# growpart /dev/sdc 1
CHANGED: partition=1 start=2048 old: size=20971520 end=20973568 new: size=83883999 end=83886047
```

11. List all the disks and partitions again.

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0      0  60G  0 disk
├─sda1                             8:1      0   1G  0 part /boot
├─sda2                             8:2      0   59G  0 part
│   ├─centos_vm-root               253:0    0  38.3G  0 lvm /
│   ├─centos_vm-swap               253:1    0    2G  0 lvm [SWAP]
│   └─centos_vm-home               253:3    0  18.7G  0 lvm /home
└─sdb                             8:16     0   15G  0 disk
   └─sysadmin_VG_1-sysadmin_LV_1  253:2    0   25G  0 lvm
sdc                                 8:32     0  40G  0 disk
├─sdc1                             8:33     0  40G  0 part
└─sysadmin_VG_1-sysadmin_LV_1  253:2    0   25G  0 lvm
sr0                                11:0     1 1024M  0 rom
```

12. Now, we have to resize our PV (sdc1) to make the free space available.

pvresize /dev/sdc1

```
[root@sysadmin ~]# pvresize /dev/sdc1
Physical volume "/dev/sdc1" changed
1 physical volume(s) resized or updated / 0 physical volume(s) not resized
```

13. Confirm the new free space using “pvs” command.

```
[root@sysadmin ~]# pvs
PV          VG          Fmt Attr PSize  PFree
/dev/sda2   centos_vm   lvm2 a--  <59.00g  4.00m
/dev/sdb    sysadmin_VG_1 lvm2 a--  <15.00g   0
/dev/sdc1   sysadmin_VG_1 lvm2 a--  <40.00g 30.00g
```

14. Here, it is confirmed that free space has been available.

15. Let's confirm the same available to VG.

```
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize  VFree
centos_vm   1   3   0 wz--n-  <59.00g  4.00m
sysadmin_VG_1 2   1   0 wz--n-  54.99g 30.00g
```

16. Proceed for extending the size of LV of “sysadmin_VG_1”

lvresize -L <+|-><size> <vg-name>/<lv-name>

17. Let's first confirm our current LV size.

```
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0      0  60G  0 disk
├─sda1                             8:1      0   1G  0 part /boot
├─sda2                             8:2      0   59G  0 part
│   ├─centos_vm-root               253:0    0  38.3G  0 lvm /
│   ├─centos_vm-swap               253:1    0    2G  0 lvm [SWAP]
│   └─centos_vm-home               253:3    0  18.7G  0 lvm /home
└─sdb                             8:16     0   15G  0 disk
   └─sysadmin_VG_1-sysadmin_LV_1  253:2    0   25G  0 lvm
sdc                                 8:32     0  40G  0 disk
├─sdc1                             8:33     0  40G  0 part
└─sysadmin_VG_1-sysadmin_LV_1  253:2    0   25G  0 lvm
sr0                                11:0     1 1024M  0 rom
```

18. Current LV size is 25 GB. Let's extend it to 55 GB.

```
[root@sysadmin ~]# lvresize -L +30GB sysadmin_VG_1/sysadmin_LV_1
Size of logical volume sysadmin_VG_1/sysadmin_LV_1 changed from 24.99 GiB (6398 extents) to 54.99 GiB (14078 extents).
Logical volume sysadmin_VG_1/sysadmin_LV_1 successfully resized.
```

19. You need to use the resize the filesystem after extending a LVM to ensure that the filesystem recognizes and utilizes the additional space. For LVM, “resize2fs” will be used.

resize2fs /dev/<vg-name>/<lv-name>

```
[root@sysadmin ~]# resize2fs /dev/sysadmin_VG_1/sysadmin_LV_1
resize2fs 1.42.9 (28-Dec-2013)
Filesystem at /dev/sysadmin_VG_1/sysadmin_LV_1 is mounted on /sysadmin_mountpoint; on-line resizing required
old_desc_blocks = 4, new_desc_blocks = 7
The filesystem on /dev/sysadmin_VG_1/sysadmin_LV_1 is now 14415872 blocks long.
```

20. Verify using “df -h”

```
[root@sysadmin ~]# df -h
```

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	475M	0	475M	0%	/dev
tmpfs	487M	0	487M	0%	/dev/shm
tmpfs	487M	7.7M	479M	2%	/run
tmpfs	487M	0	487M	0%	/sys/fs/cgroup
/dev/mapper/centos_vm-root	39G	1.6G	37G	5%	/
/dev/mapper/centos_vm-home	19G	33M	19G	1%	/home
/dev/sda1	1014M	169M	846M	17%	/boot
tmpfs	98M	0	98M	0%	/run/user/0
/dev/mapper/sysadmin_VG_1-sysadmin_LV_1	55G	52M	52G	1%	/sysadmin_mountpoint

Case III: Extend an existing LV by adding another drive to a machine:

1. First verify the LV that needs to be extended is part of which volume group using “lvs”.

```
[root@sysadmin ~]# lvs
```

LV	VG	Attr	LSize	Pool	Origin	Data%	Meta%	Move	Log	Cpy%	Sync	Convert
home	centos_vm	-wi-ao----	<18.70g									
root	centos_vm	-wi-ao----	<38.30g									
swap	centos_vm	-wi-ao----	2.00g									
sysadmin_LV_1	sysadmin_VG_1	-wi-ao----	54.99g									

2. I want to increase the space of “sysadmin_LV_1” which is a part of volume group “sysadmin_VG_1”.
3. Let’s check, if “sysadmin_VG_1” volume group has free space available using “vgs” & “pvs” command.

```
[root@sysadmin ~]# vgs
```

VG	#PV	#LV	#SN	Attr	VSize	VFree
centos_vm	1	3	0	wz--n-	<59.00g	4.00m
sysadmin_VG_1	2	1	0	wz--n-	54.99g	0

```
[root@sysadmin ~]# pvs
```

PV	VG	Fmt	Attr	PSize	PFree
/dev/sda2	centos_vm	lvm2	a--	<59.00g	4.00m
/dev/sdb	sysadmin_VG_1	lvm2	a--	<15.00g	0
/dev/sdc1	sysadmin_VG_1	lvm2	a--	<40.00g	0

4. Here above you can see that our VG has no space left. We have to attach another hard drive to our machine.
5. Below you can see that I have attached disk “sdd” of space (5 GB).

```
[root@sysadmin ~]# lsblk
```

NAME	MAJ:MIN	RM	SIZE	RO	TYPE	MOUNTPOINT
sda	8:0	0	60G	0	disk	
├─sda1	8:1	0	1G	0	part	/boot
└─sda2	8:2	0	59G	0	part	
├─centos_vm-root	253:0	0	38.3G	0	lvm	/
├─centos_vm-swap	253:1	0	2G	0	lvm	[SWAP]
└─centos_vm-home	253:3	0	18.7G	0	lvm	/home
sdb	8:16	0	15G	0	disk	
└─sysadmin_VG_1-sysadmin_LV_1	253:2	0	55G	0	lvm	/sysadmin_mountpoint
sdc	8:32	0	40G	0	disk	
├─sdc1	8:33	0	40G	0	part	
└─sysadmin_VG_1-sysadmin_LV_1	253:2	0	55G	0	lvm	/sysadmin_mountpoint
sdd	8:48	0	5G	0	disk	
sr0	11:0	1	1024M	0	rom	

If the changes is not reflect, follow the step 5 of SECTION 1.1, to rescan all the SCSI hosts.

6. Let’s create a PV from this newly attached drive.

pvcreate /dev/sdd

```
[root@sysadmin ~]# pvcreate /dev/sdd
```

Physical volume "/dev/sdd" successfully created.

```
[root@sysadmin ~]#
```

7. List all the PV(s) to confirm.

```
[root@sysadmin ~]# pvs
PV          VG          Fmt Attr PSize  PFree
/dev/sda2   centos_vm    lvm2 a--  <59.00g 4.00m
/dev/sdb    sysadmin_VG_1 lvm2 a--  <15.00g  0
/dev/sdc1   sysadmin_VG_1 lvm2 a--  <40.00g  0
/dev/sdd                    lvm2 ---   5.00g 5.00g
```

8. Now extend the VG “sysadmin_VG_1” using the newly created PV (sdd)

vgextend sysadmin_VG_1 /dev/sdd

9. Confirm by listing the available VG(s) and check the free space.

```
[root@sysadmin ~]# vgextend sysadmin_VG_1 /dev/sdd
Volume group "sysadmin_VG_1" successfully extended
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize  VFree
centos_vm    1  3  0 wz--n-  <59.00g 4.00m
sysadmin_VG_1 3  1  0 wz--n-  <59.99g <5.00g
```

21. Proceed for extending the size of LV of “sysadmin_VG_1”

lvresize -L <+|-><size> <vg-name>/<lv-name>

22. Let's first confirm our current LV size.

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                  8:0    0   60G  0 disk
├─sda1                              8:1    0    1G  0 part /boot
├─sda2                              8:2    0   59G  0 part
│   ├─centos_vm-root                253:0    0  38.3G  0 lvm  /
│   ├─centos_vm-swap                253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home                253:3    0  18.7G  0 lvm  /home
sdb                                  8:16    0   15G  0 disk
└─sysadmin_VG_1-sysadmin_LV_1      253:2    0   55G  0 lvm  /sysadmin_mountpoint
sdc                                  8:32    0   40G  0 disk
├─sdc1                              8:33    0   40G  0 part
└─sysadmin_VG_1-sysadmin_LV_1      253:2    0   55G  0 lvm  /sysadmin_mountpoint
sdd                                  8:48    0    5G  0 disk
sr0                                  11:0    1 1024M  0 rom
```

23. Current LV size is 55 GB. Let's extend it to 60 GB.

```
[root@sysadmin ~]# lvresize -L +4.9GB sysadmin_VG_1/sysadmin_LV_1
Rounding size to boundary extents: 4.90 GiB.
Size of logical volume sysadmin_VG_1/sysadmin_LV_1 changed from 54.99 GiB (14078 extents) to 59.89 GiB (15333 extents).
Logical volume sysadmin_VG_1/sysadmin_LV_1 successfully resized.
```

24. You need to use the resize the filesystem after extending a LVM to ensure that the filesystem recognizes and utilizes the additional space. For xfs LVM, “xfs_growfs” will be used. For ext4 LVM, “resize2fs” will be used.

resize2fs /dev/<vg-name>/<lv-name>

```
[root@sysadmin ~]# resize2fs /dev/sysadmin_VG_1/sysadmin_LV_1
resize2fs 1.42.9 (28-Dec-2013)
Filesystem at /dev/sysadmin_VG_1/sysadmin_LV_1 is mounted on /sysadmin_mountpoint; on-line resizing required
old_desc_blocks = 7, new_desc_blocks = 8
The filesystem on /dev/sysadmin_VG_1/sysadmin_LV_1 is now 15700992 blocks long.
```

25. Verify using “df -h”

```
[root@sysadmin ~]# df -h
Filesystem                                Size  Used Avail Use% Mounted on
devtmpfs                                  475M    0   475M    0% /dev
tmpfs                                      487M    0   487M    0% /dev/shm
tmpfs                                      487M  7.7M  479M    2% /run
tmpfs                                      487M    0   487M    0% /sys/fs/cgroup
/dev/mapper/centos_vm-root                 39G   1.6G   37G    5% /
/dev/mapper/centos_vm-home                 19G   33M   19G    1% /home
/dev/sda1                                  1014M  169M  846M   17% /boot
tmpfs                                       98M    0   98M    0% /run/user/0
/dev/mapper/sysadmin_VG_1-sysadmin_LV_1    59G   52M   57G    1% /sysadmin_mountpoint
```

Case IV: Extend an existing LV by reducing another LV of the same VG:

Reduction:

1. First verify the LV that needs to be reduced is part of which volume group using “lvs”.

```
[root@sysadmin ~]# lvs
LV          VG          Attr      LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
home        centos_vm    -wi-ao---- <18.70g
root        centos_vm    -wi-ao---- <38.30g
swap        centos_vm    -wi-ao---- 2.00g
sysadmin_LV_1 sysadmin_VG_1 -wi-a----- 49.89g
sysadmin_LV_2 sysadmin_VG_1 -wi-a----- 10.00g
```

2. I want to decrease the space of “sysadmin_LV_2” which is a part of volume group “sysadmin_VG_1”.
3. Let’s check, if “sysadmin_VG_1” volume group has free space available using “vgs” command.

```
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize   VFree
centos_vm    1  3  0 wz--n- <59.00g 4.00m
sysadmin_VG_1 3  2  0 wz--n- <59.99g 96.00m
```

4. Here above you can see that our VG has almost no space left. What we are going to do is to decrease the space the “sysadmin_LV_2” and increase space of “sysadmin_LV_1” of the same VG.
5. First verify the all the drives and partitions.

```
[root@sysadmin ~]# lsblk
NAME                                MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda                                 8:0    0 60G  0 disk
├─sda1                             8:1    0   1G  0 part /boot
├─sda2                             8:2    0  59G  0 part
│   ├─centos_vm-root               253:0    0 38.3G  0 lvm  /
│   ├─centos_vm-swap               253:1    0    2G  0 lvm  [SWAP]
│   └─centos_vm-home               253:4    0 18.7G  0 lvm  /home
sdb                                 8:16    0   15G  0 disk
├─sysadmin_VG_1-sysadmin_LV_1     253:2    0 49.9G  0 lvm
sdc                                 8:32    0   40G  0 disk
├─sdc1                             8:33    0   40G  0 part
│   └─sysadmin_VG_1-sysadmin_LV_1 253:2    0 49.9G  0 lvm
│       └─sysadmin_VG_1-sysadmin_LV_2 253:3    0   10G  0 lvm
sdd                                 8:48    0    5G  0 disk
└─sysadmin_VG_1-sysadmin_LV_2     253:3    0   10G  0 lvm
sr0                                 11:0    1 1024M  0 rom
```

6. Here current size of “sysadmin_LV_2” is (10 GB). I’m reducing it to (5 GB). If the LVM is mounted make sure to unmount it first before actual reduction. In my case it is already unmounted.

```
[root@sysadmin ~]# lvs
LV          VG          Attr      LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
home        centos_vm    -wi-ao---- <18.70g
root        centos_vm    -wi-ao---- <38.30g
swap        centos_vm    -wi-ao---- 2.00g
sysadmin_LV_1 sysadmin_VG_1 -wi-a----- 49.89g
sysadmin_LV_2 sysadmin_VG_1 -wi-a----- 10.00g
```

7. Let’s check the FS for any errors. Depending on the filesystem type, you can use commands like “fsck.ext4” or “xfs_repair”

fsck.ext4 /dev/<vg-name>/<lv-name>

```
[root@sysadmin ~]# fsck.ext4 /dev/sysadmin_VG_1/sysadmin_LV_2
e2fsck 1.42.9 (28-Dec-2013)
/dev/sysadmin_VG_1/sysadmin_LV_2: clean, 11/655360 files, 83137/2621440 blocks
```

8. You need to use the resize the filesystem after extending a LVM to ensure that the filesystem recognizes and utilizes the additional space. For xfs LVM, “xfs_growfs” will be used. For ext4 LVM, “resize2fs” will be used.

resize2fs /dev/<vg-name>/<lv-name> <size in MB(s)>


```
[root@sysadmin ~]# resize2fs /dev/sysadmin_VG_1/sysadmin_LV_2 5012M
resize2fs 1.42.9 (28-Dec-2013)
Resizing the filesystem on /dev/sysadmin_VG_1/sysadmin_LV_2 to 1283072 (4k) blocks.
The filesystem on /dev/sysadmin_VG_1/sysadmin_LV_2 is now 1283072 blocks long.
```

9. Let's decrease the size of LV.

`lvresize -L <-><size> <vg-name>/<lv-name>`

```
[root@sysadmin ~]# lvresize -L -5GB sysadmin_VG_1/sysadmin_LV_2
WARNING: Reducing active logical volume to 5.00 GiB.
THIS MAY DESTROY YOUR DATA (filesystem etc.)
Do you really want to reduce sysadmin_VG_1/sysadmin_LV_2? [y/n]: y
Size of logical volume sysadmin_VG_1/sysadmin_LV_2 changed from 10.00 GiB (2560 extents) to 5.00 GiB (1280 extents).
Logical volume sysadmin_VG_1/sysadmin_LV_2 successfully resized.
```

10. Let's check, if "sysadmin_VG_1" volume group has free space available using "vgs" command.

```
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize  VFree
centos_vm   1   3   0 wz--n- <59.00g 4.00m
sysadmin_VG_1 3   2   0 wz--n- <59.99g 5.09g
```

11. Here above you can see that our VG has now 5 GB free space available. Let's allocate it to the "sysadmin_LV_1" of the same VG.

`lvresize -L <+><size> <vg-name>/<lv-name>`

```
[root@sysadmin ~]# lvresize -L +5.09GB sysadmin_VG_1/sysadmin_LV_1
Rounding size to boundary between physical extents: 5.09 GiB.
Size of logical volume sysadmin_VG_1/sysadmin_LV_1 changed from 49.89 GiB (12773 extents) to <54.99 GiB (14077 extents).
Logical volume sysadmin_VG_1/sysadmin_LV_1 successfully resized.
```

12. You need to use the resize the filesystem after extending a LVM to ensure that the filesystem recognizes and utilizes the additional space. For xfs LVM, "xfs_growfs" will be used. For ext4 LVM, "resize2fs" will be used. Perform diskcheck if needed.

`resize2fs /dev/<vg-name>/<lv-name>`

```
[root@sysadmin ~]# e2fsck -f /dev/sysadmin_VG_1/sysadmin_LV_1
e2fsck 1.42.9 (28-Dec-2013)
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/sysadmin_VG_1/sysadmin_LV_1: 11/3270400 files (0.0% non-contiguous), 251390/13079552 blocks
[root@sysadmin ~]#
[root@sysadmin ~]# resize2fs /dev/sysadmin_VG_1/sysadmin_LV_1
resize2fs 1.42.9 (28-Dec-2013)
Resizing the filesystem on /dev/sysadmin_VG_1/sysadmin_LV_1 to 14414848 (4k) blocks.
The filesystem on /dev/sysadmin_VG_1/sysadmin_LV_1 is now 14414848 blocks long.
```

13. Remount all the LVM(s)

14. Verify using "df -h"

```
[root@sysadmin ~]# df -h
Filesystem                                Size  Used Avail Use% Mounted on
devtmpfs                                  475M   0  475M   0% /dev
tmpfs                                      487M   0  487M   0% /dev/shm
tmpfs                                      487M  7.7M  479M   2% /run
tmpfs                                      487M   0  487M   0% /sys/fs/cgroup
/dev/mapper/centos_vm-root                 39G  1.6G   37G   5% /
/dev/sda1                                 1014M  169M   846M  17% /boot
/dev/mapper/centos_vm-home                 19G   33M   19G   1% /home
tmpfs                                      98M   0   98M   0% /run/user/0
/dev/mapper/sysadmin_VG_1-sysadmin_LV_1   55G   53M   52G   1% /sysadmin_mountpoint
/dev/mapper/sysadmin_VG_1-sysadmin_LV_2   4.8G   33M   4.5G   1% /sysadmin_mountpoint1
```

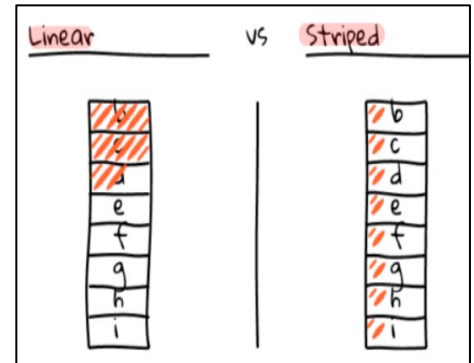
15. Above you can see that LVM_1 space has been increased from 50GB to 55GB and LVM_2 space has been decreased from 10GB to 5 GB

Note: Working with LVM reductions can result in data-loss or LVM corruption. It is always recommended to backups all the important data when reducing the LVM(s).

3. Stripped LVM Partitioning

A linear logical volume consists of a single physical volume or a concatenation of multiple physical volumes. It's the simplest form of logical volume in LVM, where the data is stored sequentially across the underlying physical volumes.

A striped logical volume, also known as a RAID-0 logical volume, distributes data across multiple physical volumes in a striped manner. The data is divided into chunks or stripes, which are then distributed evenly across the physical volumes. This provides improved performance by allowing simultaneous read and write operations across multiple disks.



The stripe size refers to the amount of data that is written to a single physical volume (PV) before moving on to the next one. It determines the size of each individual stripe within the striped LV.

3.1 Steps to create stripped LV from VG:

1. First, check the available disks on your machine using “lsblk” command.

```
[root@sysadmin ~]# lsblk
NAME        MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
sda           8:0    0   60G  0 disk
├─sda1         8:1    0    1G  0 part /boot
└─sda2         8:2    0   59G  0 part
   ├─centos_vm-root 253:0    0  38.3G  0 lvm /
   ├─centos_vm-swap 253:1    0    2G  0 lvm [SWAP]
   └─centos_vm-home 253:2    0  18.7G  0 lvm /home
sdb           8:16    0   10G  0 disk
sdc           8:32    0   10G  0 disk
sdd           8:48    0   20G  0 disk
sr0          11:0    1 1024M  0 rom
```

2. Here above, we have three disks “sdb,sdc,sdd” are available for use.
3. Let create physical volume from these drives and verify using “pvs” command.

pvs `pvcreate /dev/sd[b-d]`

```
[root@sysadmin ~]# pvcreate /dev/sd[b-d]
Physical volume "/dev/sdb" successfully created.
Physical volume "/dev/sdc" successfully created.
Physical volume "/dev/sdd" successfully created.
```

```
[root@sysadmin ~]# pvs
PV          VG          Fmt  Attr PSize  PFree
/dev/sda2   centos_vm  lvm2 a--  <59.00g  4.00m
/dev/sdb     lvm2      ---   10.00g  10.00g
/dev/sdc     lvm2      ---   10.00g  10.00g
/dev/sdd     lvm2      ---   20.00g  20.00g
```

4. Create volume group from these PV(s) and verify newly created VG using “vgs” command.

vgs `vgcreate sysadmin_VG_1 /dev/sd[b-d]`

```
[root@sysadmin ~]# vgcreate sysadmin_VG_1 /dev/sd[b-d]
Volume group "sysadmin_VG_1" successfully created
[root@sysadmin ~]# vgs
VG          #PV #LV #SN Attr   VSize  VFree
centos_vm    1  3  0 wz--n- <59.00g  4.00m
sysadmin_VG_1 3  0  0 wz--n- <39.99g <39.99g
```

5. Let's create striped LV from newly created VG "sysadmin_VG_1". The below command creates a LV of 27G from VG total space of 40 GB, with used stripes(drives) = 3, stipe-size = 1MB each.

lvcreate --stripes 3 --stripesize 1M -L 27G -n sysadmin_SLV_1 sysadmin_VG_1

```
[root@sysadmin ~]# lvcreate --stripes 3 --stripesize 1M -L 27G -n sysadmin_SLV_1 sysadmin_VG_1
Logical volume "sysadmin_SLV_1" created.
[root@sysadmin ~]# lvs
```

LV	VG	Attr	LSize	Pool	Origin	Data%	Meta%	Move	Log	Cpy%	Sync	Convert
home	centos_vm	-wi-ao----	<18.70g									
root	centos_vm	-wi-ao----	<38.30g									
swap	centos_vm	-wi-ao----	2.00g									
sysadmin_SLV_1	sysadmin_VG_1	-wi-a-----	27.00g									

6. You can check the devices and extents used by striped LV using "lvdisplay -v <lv-name>".

```
[root@sysadmin ~]# lvdisplay -m /dev/sysadmin_VG_1/sysadmin_SLV_1
--- Logical volume ---
LV Path                /dev/sysadmin_VG_1/sysadmin_SLV_1
LV Name                 sysadmin_SLV_1
VG Name                 sysadmin_VG_1
LV UUID                 N1Li08-7Haf-29Ue-lzw6-fmGE-Yns7-vZ4w1n
LV Write Access         read/write
LV Creation host, time sysadmin, 2023-06-03 04:40:35 +0500
LV Status                available
# open                  0
LV Size                 27.00 GiB
Current LE              6912
Segments                1
Allocation              inherit
Read ahead sectors      auto
- currently set to     12288
Block device            253:3

--- Segments ---
Logical extents 0 to 6911:
  Type                  striped
  Stripes                3
  Stripe size            1.00 MiB
  Stripe 0:
    Physical volume      /dev/sdb
    Physical extents     0 to 2303
  Stripe 1:
    Physical volume      /dev/sdc
    Physical extents     0 to 2303
  Stripe 2:
    Physical volume      /dev/sdd
    Physical extents     0 to 2303
```

7. Let's format the striped LV with ext4 FS.

mkfs.ext4 /dev/<vg-name>/<lv-name>

```
[root@sysadmin ~]# mkfs.ext4 /dev/sysadmin_VG_1/sysadmin_SLV_1
mke2fs 1.42.9 (28-Dec-2013)
Filesystem label=
OS type: Linux
Block size=4096 (log=2)
Fragment size=4096 (log=2)
Stride=256 blocks, Stripe width=768 blocks
1769472 inodes, 7077888 blocks
353894 blocks (5.00%) reserved for the super user
First data block=0
Maximum filesystem blocks=2155872256
216 block groups
32768 blocks per group, 32768 fragments per group
8192 inodes per group
Superblock backups stored on blocks:
    32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
    4096000

Allocating group tables: done
Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done
```

8. You can verify using blkid command.

```
[root@sysadmin ~]# blkid /dev/sysadmin_VG_1/sysadmin_SLV_1
/dev/sysadmin_VG_1/sysadmin_SLV_1: UUID="4531ae5e-d3cb-49b6-8a8a-b1345f6003c4" TYPE="ext4"
[root@sysadmin ~]#
```

9. We can also create linear LV along with striped LV on same VG.

lvcreate -L 12.988GB -n sysadmin_LLV_1 sysadmin_VG_1

```
[root@sysadmin ~]# lvcreate -L 12.988GB -n sysadmin_LLV_1 sysadmin_VG_1
Rounding up size to full physical extent <12.99 GiB
Logical volume "sysadmin_LLV_1" created.
```

10. Let's mount the striped LV created above to a mount location.

mount -t ext4 /dev/<vg-name>/<lv-name>

Filesystem	Size	Used	Avail	Use%	Mounted on
devtmpfs	475M	0	475M	0%	/dev
tmpfs	487M	0	487M	0%	/dev/shm
tmpfs	487M	7.7M	479M	2%	/run
tmpfs	487M	0	487M	0%	/sys/fs/cgroup
/dev/mapper/centos_vm-root	39G	1.6G	37G	5%	/
/dev/sda1	1014M	169M	846M	17%	/boot
/dev/mapper/centos_vm-home	19G	33M	19G	1%	/home
tmpfs	98M	0	98M	0%	/run/user/0
/dev/mapper/sysadmin_VG_1-sysadmin_SLV_1	27G	45M	26G	1%	/stripped_mount

3.2 Steps to extend a striped LV.

To increase the size of striped logical volume, there must be enough free space on the underlying physical volumes that make up the volume group to support the stripe. For example, if you have a two-way stripe that uses up an entire volume group, adding a single physical volume to the volume group will not enable you to extend the stripe. Instead, you must add at least two physical volumes to the volume group.

1. First, verify VG free space and list all the LVM using “lvs” command.

```
[root@sysadmin ~]# vgs
VG                #PV #LV #SN Attr   VSize  VFree
centos_vm         1   3   0 wz--n- <59.00g 4.00m
sysadmin_VG_1     3   1   0 wz--n- <39.99g <12.99g
[root@sysadmin ~]# lvs
LV                VG                Attr      LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
home              centos_vm         -wi-ao---- <18.70g
root              centos_vm         -wi-ao---- <38.30g
swap              centos_vm         -wi-ao---- 2.00g
sysadmin_SLV_1    sysadmin_VG_1     -wi-ao---- 27.00g
```

2. Let's try extending the striped LV.

lvextend /dev/<vg-name>/<lv-name> -L <size>

```
[root@sysadmin ~]# lvextend /dev/sysadmin_VG_1/sysadmin_SLV_1 -L +3GB
Using stripesize of last segment 1.00 MiB
Insufficient suitable allocatable extents for logical volume sysadmin_SLV_1: 3 more required
```

3. You can see above that, we can't able to extend. Based on required extents we need at-least two new physical disks.
4. Let's extend our VG by attaching another 2 PV(s) to our volume group. I have already attached a new physical disk (sde,sdf) of 30GB,5GB respectively to our machine.

pvcreate /dev/sd[e-g]

vgextend <vg-name> /dev/sd[e-g]

```
[root@sysadmin ~]# pvcreate /dev/sd[e-f]
Physical volume "/dev/sde" successfully created.
Physical volume "/dev/sdf" successfully created.
[root@sysadmin ~]# vgextend sysadmin_VG_1 /dev/sd[e-f]
Volume group "sysadmin_VG_1" successfully extended
```

5. Let's check the LV segments first.

lvdisplay -m /dev/sysadmin_VG_1/sysadmin_SLV_1 | tail -17

```
[root@sysadmin ~]# lvsdisplay -m /dev/sysadmin_VG_1/sysadmin_SLV_1 | tail -17

--- Segments ---
Logical extents 0 to 6911:
  Type                striped
  Stripes              3
  Stripe size          1.00 MiB
  Stripe 0:
    Physical volume    /dev/sdb
    Physical extents   0 to 2303
  Stripe 1:
    Physical volume    /dev/sdc
    Physical extents   0 to 2303
  Stripe 2:
    Physical volume    /dev/sdd
    Physical extents   0 to 2303
```

6. Now, try extending the striped LV again.

lvextend /dev/<vg-name>/<lv-name> -L +<size>

```
[root@sysadmin ~]# lvextend /dev/sysadmin_VG_1/sysadmin_SLV_1 -L +10G
Using stripesize of last segment 1.00 MiB
Rounding size (9472 extents) up to stripe boundary size for segment (9474 extents).
Size of logical volume sysadmin_VG_1/sysadmin_SLV_1 changed from 27.00 GiB (6912 extents) to <37.01 GiB (9474 extents)
Logical volume sysadmin_VG_1/sysadmin_SLV_1 successfully resized.
```

7. Now LV has been successfully extended.

Note: You can also reduce striped LV size, but since data resides on different PV(s), so it's not wise to reduce this LVM.