Red Hat Enterprise Linux 8

Configuring and managing logical volumes

A guide to the configuration and management of LVM logical volumes

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Legal Notice

Abstract

This documentation collection provides instructions on how to manage LVM logical volumes on Red Hat Enterprise Linux 8.

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MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see our CTO Chris Wright's message.

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CHAPTER 1. LOGICAL VOLUMES

Volume management creates a layer of abstraction over physical storage, allowing you to create logical storage volumes. This provides much greater flexibility in a number of ways than using physical storage directly. In addition, the hardware storage configuration is hidden from the software so it can be resized and moved without stopping applications or unmounting file systems. This can reduce operational costs.

Logical volumes provide the following advantages over using physical storage directly:

- Flexible capacity
  When using logical volumes, file systems can extend across multiple disks, since you can aggregate disks and partitions into a single logical volume.
- Resizeable storage pools
  You can extend logical volumes or reduce logical volumes in size with simple software commands, without reformatting and repartitioning the underlying disk devices.
- Online data relocation
  To deploy newer, faster, or more resilient storage subsystems, you can move data while your system is active. Data can be rearranged on disks while the disks are in use. For example, you can empty a hot-swappable disk before removing it.
- Convenient device naming
  Logical storage volumes can be managed in user-defined and custom named groups.
- Disk striping
  You can create a logical volume that stripes data across two or more disks. This can dramatically increase throughput.
- Mirroring volumes
  Logical volumes provide a convenient way to configure a mirror for your data.
- Volume snapshots
  Using logical volumes, you can take device snapshots for consistent backups or to test the effect of changes without affecting the real data.
- Thin volumes
  Logical volumes can be thinly provisioned. This allows you to create logical volumes that are larger than the available extents.
- Cache volumes
  A cache logical volume uses a small logical volume consisting of fast block devices (such as SSD drives) to improve the performance of a larger and slower logical volume by storing the frequently used blocks on the smaller, faster logical volume.

1.1. LVM ARCHITECTURE

The following are the components of LVM:

Physical volume

A physical volume (PV) is a partition or whole disk designated for LVM use. For more information, see Managing LVM physical volumes.

Volume group

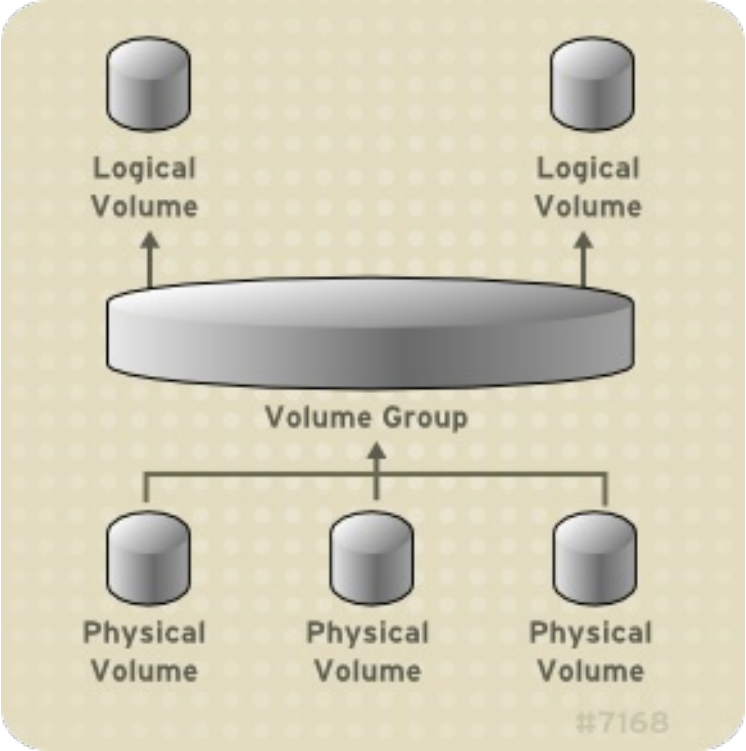
A volume group (VG) is a collection of physical volumes (PVs), which creates a pool of disk space out of which logical volumes can be allocated. For more information, see Managing LVM volume groups.

Logical volume

A logical volume represents a mountable storage device. For more information, see Managing LVM logical volumes.

The following Figure 1.1, "LVM logical volume components" illustrates the components of LVM:

Figure 1.1. LVM logical volume components



1.2. PHYSICAL VOLUMES

The underlying physical storage unit of an LVM logical volume is a block device such as a partition or whole disk. To use the device for an LVM logical volume, the device must be initialized as a physical volume (PV). Initializing a block device as a physical volume places a label near the start of the device.

By default, the LVM label is placed in the second 512-byte sector. You can override this default by placing the label on any of the first 4 sectors when you create the physical volume. This allows LVM volumes to co-exist with other users of these sectors, if necessary.

An LVM label provides correct identification and device ordering for a physical device, since devices can come up in any order when the system is booted. An LVM label remains persistent across reboots and throughout a cluster.

The LVM label identifies the device as an LVM physical volume. It contains a random unique identifier (the UUID) for the physical volume. It also stores the size of the block device in bytes, and it records where the LVM metadata will be stored on the device.

The LVM metadata contains the configuration details of the LVM volume groups on your system. By default, an identical copy of the metadata is maintained in every metadata area in every physical volume within the volume group. LVM metadata is small and stored as ASCII.

Currently LVM allows you to store 0, 1 or 2 identical copies of its metadata on each physical volume. The default is 1 copy. Once you configure the number of metadata copies on the physical volume, you cannot

change that number at a later time. The first copy is stored at the start of the device, shortly after the label. If there is a second copy, it is placed at the end of the device. If you accidentally overwrite the area at the beginning of your disk by writing to a different disk than you intend, a second copy of the metadata at the end of the device will allow you to recover the metadata.

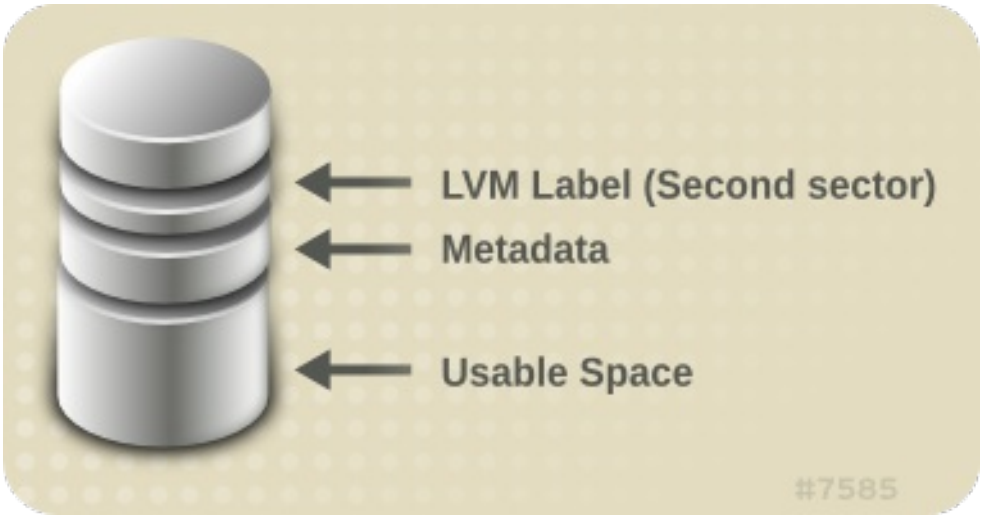
1.2.1. LVM physical volume layout

Figure 1.2, "Physical volume layout" shows the layout of an LVM physical volume. The LVM label is on the second sector, followed by the metadata area, followed by the usable space on the device.

NOTE

In the Linux kernel (and throughout this document), sectors are considered to be 512 bytes in size.

Figure 1.2. Physical volume layout



1.2.2. Multiple partitions on a disk

LVM allows you to create physical volumes out of disk partitions. Red Hat recommends 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.

- 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.

Although it is not recommended, there may be specific circumstances when you will need to divide a disk into separate LVM physical volumes. For example, on a system with few disks it may be necessary to move data around partitions when you are migrating an existing system to LVM volumes. Additionally, if you have a very large disk and want to have more than one volume group for administrative purposes then it is necessary to partition the disk. If you do have a disk with more than one partition and both of those partitions are in the same volume group, take care to specify which partitions are to be included in a logical volume when creating striped volumes.

Note that although LVM supports using a non-partitioned disk as physical volume (PV), it is recommended to create a single, whole-disk partition for the following reasons:

- Creating a PV without a partition can be problematic in a mixed operating system environment. Other operating systems may interpret the device as free, and overwrite the PV label at the beginning of the drive.
- Creating PVs on multiple partitions of the same device can result in loss of performance or redundancy. For example, it might place striped or RAID1 layouts on different partitions that actually exist on the same device.

1.3. VOLUME GROUPS

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 extents. An extent is the smallest unit of space that can be allocated. Within a physical volume, extents are referred to as physical extents.

A logical volume is allocated into logical extents of the same size as the physical extents. The extent size is thus the same for all logical volumes in the volume group. The volume group maps the logical extents to physical extents.

1.4. LVM LOGICAL VOLUMES

In LVM, a volume group is divided up into logical volumes. An administrator can grow or shrink logical volumes without destroying data, unlike standard disk partitions. If the physical volumes in a volume group are on separate drives or RAID arrays, then administrators can also spread a logical volume across the storage devices.

You can lose data if you shrink a logical volume to a smaller capacity than the data on the volume requires. To ensure maximum flexibility, create logical volumes to meet your current needs, and leave excess storage capacity unallocated. You can safely extend logical volumes to use unallocated space, depending on your needs.

IMPORTANT

On AMD, Intel, ARM systems, and IBM Power Systems servers, the boot loader cannot read LVM volumes. You must make a standard, non-LVM disk partition for your /boot partition. On IBM Z, the zipl boot loader supports /boot on LVM logical volumes with linear mapping. By default, the installation process always creates the / and swap partitions within LVM volumes, with a separate /boot partition on a physical volume.

The following sections describe the different types of logical volumes.

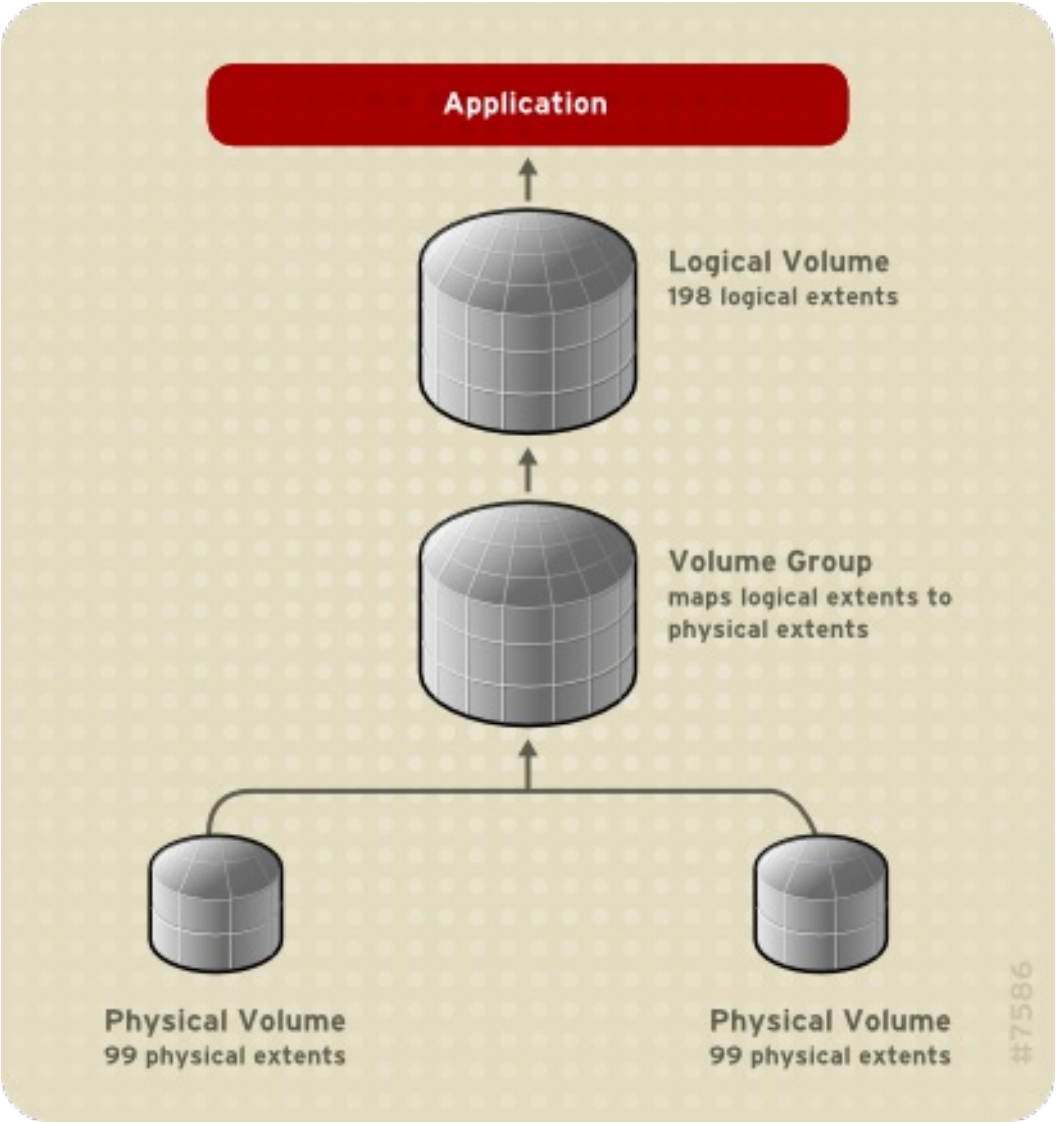
1.4.1. Linear Volumes

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.

Creating a linear volume assigns a range of physical extents to an area of a logical volume in order. For example, as shown in Figure 1.3, “Extent Mapping” logical extents 1 to 99 could map to one physical

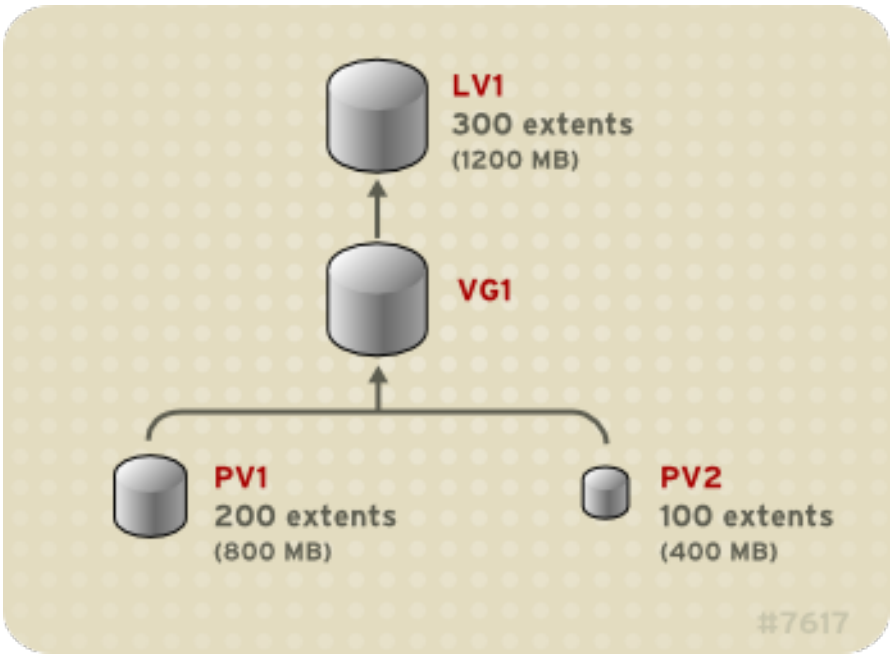
volume and logical extents 100 to 198 could map to a second physical volume. From the point of view of the application, there is one device that is 198 extents in size.

Figure 1.3. Extent Mapping



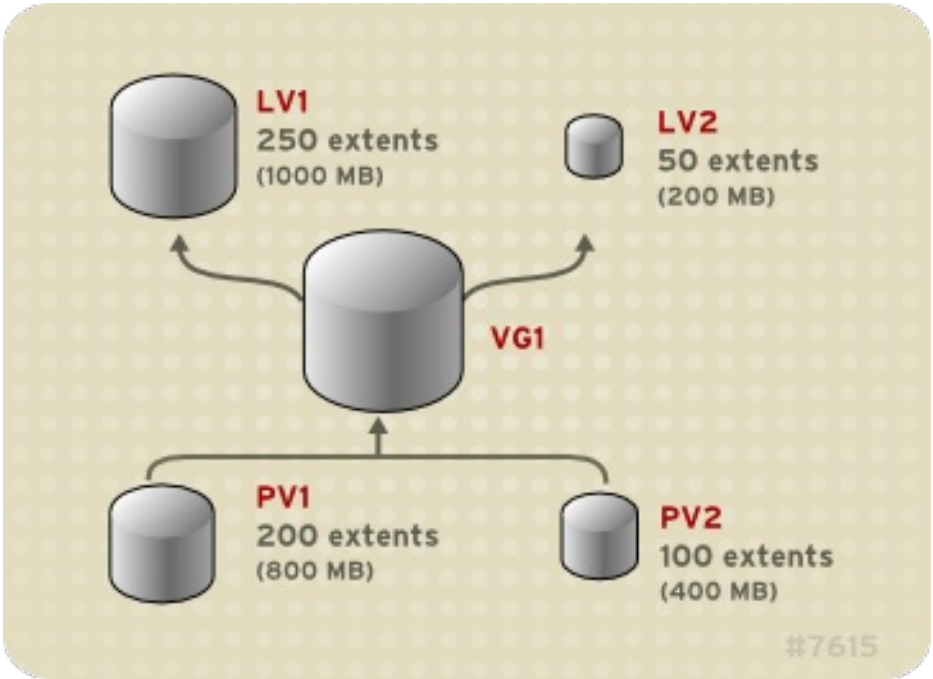
The physical volumes that make up a logical volume do not have to be the same size. Figure 1.4, "Linear volume with unequal physical volumes" shows volume group **VG1** with a physical extent size of 4MB. This volume group includes 2 physical volumes named **PV1** and **PV2**. The physical volumes are divided into 4MB units, since that is the extent size. In this example, **PV1** is 200 extents in size (800MB) and **PV2** is 100 extents in size (400MB). You can create a linear volume any size between 1 and 300 extents (4MB to 1200MB). In this example, the linear volume named **LV1** is 300 extents in size.

Figure 1.4. Linear volume with unequal physical volumes



You can configure more than one linear logical volume of whatever size you require from the pool of physical extents. Figure 1.5, "Multiple logical volumes" shows the same volume group as in Figure 1.4, "Linear volume with unequal physical volumes", but in this case two logical volumes have been carved out of the volume group: **LV1**, which is 250 extents in size (1000MB) and **LV2** which is 50 extents in size (200MB).

Figure 1.5. Multiple logical volumes



1.4.2. Striped Logical Volumes

When you write data to an LVM logical volume, the file system lays the data out across the underlying physical volumes. You can control the way the data is written to the physical volumes by creating a striped logical volume. For large sequential reads and writes, this can improve the efficiency of the data I/O.

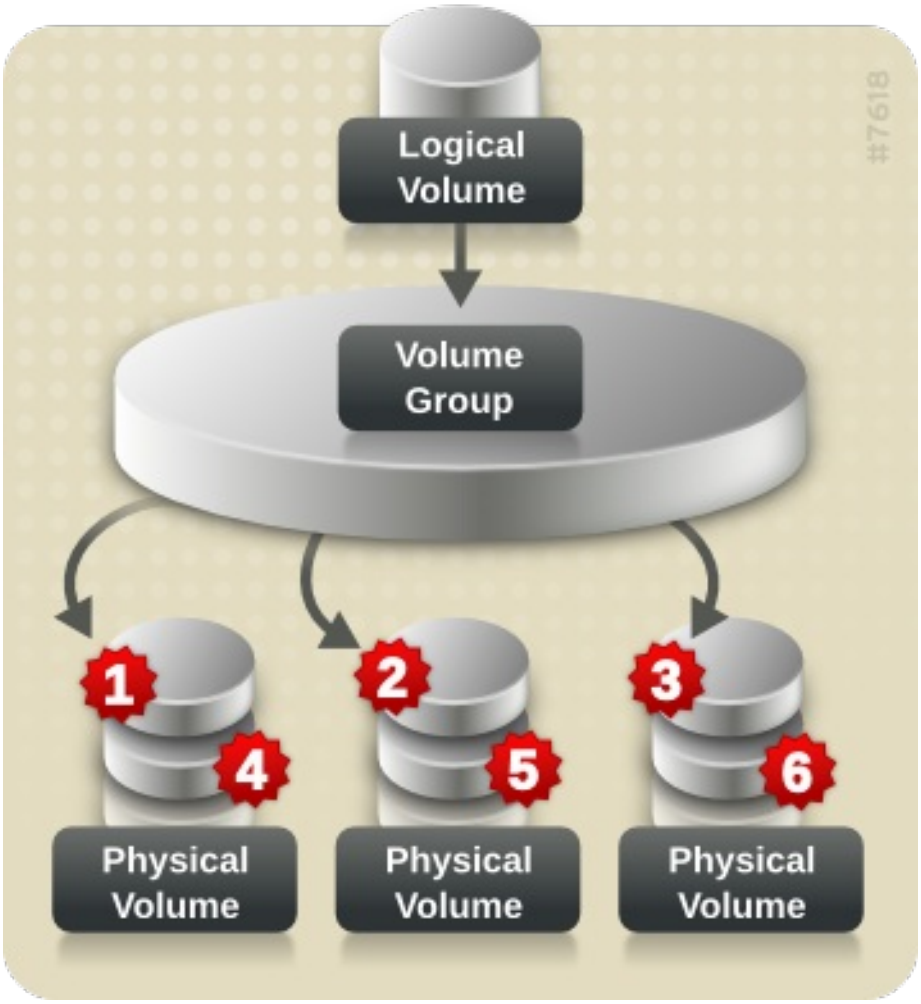
Striping enhances performance by writing data to a predetermined number of physical volumes in round-robin fashion. With striping, I/O can be done in parallel. In some situations, this can result in near-linear performance gain for each additional physical volume in the stripe.

The following illustration shows data being striped across three physical volumes. In this figure:

- the first stripe of data is written to the first physical volume
- the second stripe of data is written to the second physical volume
- the third stripe of data is written to the third physical volume
- the fourth stripe of data is written to the first physical volume

In a striped logical volume, the size of the stripe cannot exceed the size of an extent.

Figure 1.6. Striping data across three PVs



Striped logical volumes can be extended by concatenating another set of devices onto the end of the first set. In order to extend a striped logical volume, however, there must be enough free space on the set of 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.

1.4.3. RAID logical volumes

LVM supports RAID levels 0, 1, 4, 5, 6, and 10.

An LVM RAID volume has the following characteristics:

- RAID logical volumes created and managed by LVM leverage the Multiple Devices (MD) kernel drivers.
- You can temporarily split RAID1 images from the array and merge them back into the array later.
- LVM RAID volumes support snapshots.

Clusters

RAID logical volumes are not cluster-aware.

Although you can create and activate RAID logical volumes exclusively on one machine, you cannot activate them simultaneously on more than one machine.

Subvolumes

When you create a RAID logical volume, LVM creates a metadata subvolume that is one extent in size for every data or parity subvolume in the array.

For example, creating a 2-way RAID1 array results in two metadata subvolumes (**lv_rmeta_0** and **lv_rmeta_1**) and two data subvolumes (**lv_rimage_0** and **lv_rimage_1**). Similarly, creating a 3-way stripe (plus 1 implicit parity device) RAID4 results in 4 metadata subvolumes (**lv_rmeta_0**, **lv_rmeta_1**, **lv_rmeta_2**, and **lv_rmeta_3**) and 4 data subvolumes (**lv_rimage_0**, **lv_rimage_1**, **lv_rimage_2**, and **lv_rimage_3**).

Integrity

You can lose data when a RAID device fails or when soft corruption occurs. Soft corruption in data storage implies that the data retrieved from a storage device is different from the data written to that device. Adding integrity to a RAID LV helps mitigate or prevent soft corruption. To learn more about soft corruption and how to add integrity to a RAID LV, see Section 10.6, “Using DM integrity with RAID LV”.

1.4.4. Thinly-provisioned logical volumes (thin volumes)

Logical volumes can be thinly provisioned. This allows you to create logical volumes that are larger than the available extents. Using thin provisioning, you can manage a storage pool of free space, known as a thin pool, which can be allocated to an arbitrary number of devices when needed by applications. You can then create devices that can be bound to the thin pool for later allocation when an application actually writes to the logical volume. The thin pool can be expanded dynamically when needed for cost-effective allocation of storage space.

NOTE

Thin volumes are not supported across the nodes in a cluster. The thin pool and all its thin volumes must be exclusively activated on only one cluster node.

By using thin provisioning, a storage administrator can overcommit the physical storage, often avoiding the need to purchase additional storage. For example, if ten users each request a 100GB file system for their application, the storage administrator can create what appears to be a 100GB file system for each user but which is backed by less actual storage that is used only when needed.

NOTE

When using thin provisioning, it is important that the storage administrator monitor the storage pool and add more capacity if it starts to become full.

To make sure that all available space can be used, LVM supports data discard. This allows for re-use of the space that was formerly used by a discarded file or other block range.

For information on creating thin volumes, see Creating thinly-provisioned logical volumes .

Thin volumes provide support for a new implementation of copy-on-write (COW) snapshot logical volumes, which allow many virtual devices to share the same data in the thin pool. For information on thin snapshot volumes, see Thinly-provisioned snapshot volumes .

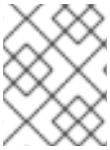
1.4.5. Snapshot Volumes

The LVM snapshot feature provides the ability to create virtual images of a device at a particular instant without causing a service interruption. When a change is made to the original device (the origin) after a snapshot is taken, the snapshot feature makes a copy of the changed data area as it was prior to the change so that it can reconstruct the state of the device.

NOTE

LVM supports thinly-provisioned snapshots.

Because a snapshot copies only the data areas that change after the snapshot is created, the snapshot feature requires a minimal amount of storage. For example, with a rarely updated origin, 3-5 % of the origin's capacity is sufficient to maintain the snapshot.



NOTE

Snapshot copies of a file system are virtual copies, not an actual media backup for a file system. Snapshots do not provide a substitute for a backup procedure.

The size of the snapshot governs the amount of space set aside for storing the changes to the origin volume. For example, if you made a snapshot and then completely overwrote the origin the snapshot would have to be at least as big as the origin volume to hold the changes. You need to dimension a snapshot according to the expected level of change. So for example a short-lived snapshot of a read-mostly volume, such as /**usr**, would need less space than a long-lived snapshot of a volume that sees a greater number of writes, such as /**home**.

If a snapshot runs full, the snapshot becomes invalid, since it can no longer track changes on the origin volume. You should regularly monitor the size of the snapshot. Snapshots are fully resizable, however, so if you have the storage capacity you can increase the size of the snapshot volume to prevent it from getting dropped. Conversely, if you find that the snapshot volume is larger than you need, you can reduce the size of the volume to free up space that is needed by other logical volumes.

When you create a snapshot file system, full read and write access to the origin stays possible. If a chunk on a snapshot is changed, that chunk is marked and never gets copied from the original volume.

There are several uses for the snapshot feature:

- Most typically, a snapshot is taken when you need to perform a backup on a logical volume without halting the live system that is continuously updating the data.

- You can execute the **fsck** command on a snapshot file system to check the file system integrity and determine whether the original file system requires file system repair.

- Because the snapshot is read/write, you can test applications against production data by taking a snapshot and running tests against the snapshot, leaving the real data untouched.

- You can create LVM volumes for use with Red Hat Virtualization. LVM snapshots can be used to create snapshots of virtual guest images. These snapshots can provide a convenient way to modify existing guests or create new guests with minimal additional storage.

You can use the **--merge** option of the **lvconvert** command to merge a snapshot into its origin volume. One use for this feature is to perform system rollback if you have lost data or files or otherwise need to restore your system to a previous state. After you merge the snapshot volume, the resulting logical volume will have the origin volume's name, minor number, and UUID and the merged snapshot is removed.

1.4.6. Thinly-provisioned snapshot volumes

Red Hat Enterprise Linux provides support for thinly-provisioned snapshot volumes. Thin snapshot volumes allow many virtual devices to be stored on the same data volume. This simplifies administration and allows for the sharing of data between snapshot volumes.

As for all LVM snapshot volumes, as well as all thin volumes, thin snapshot volumes are not supported across the nodes in a cluster. The snapshot volume must be exclusively activated on only one cluster node.

Thin snapshot volumes provide the following benefits:

- A thin snapshot volume can reduce disk usage when there are multiple snapshots of the same origin volume.

- If there are multiple snapshots of the same origin, then a write to the origin will cause one COW operation to preserve the data. Increasing the number of snapshots of the origin should yield no major slowdown.

- Thin snapshot volumes can be used as a logical volume origin for another snapshot. This allows for an arbitrary depth of recursive snapshots (snapshots of snapshots of snapshots...).

- A snapshot of a thin logical volume also creates a thin logical volume. This consumes no data space until a COW operation is required, or until the snapshot itself is written.

- A thin snapshot volume does not need to be activated with its origin, so a user may have only the origin active while there are many inactive snapshot volumes of the origin.

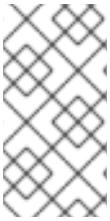
- When you delete the origin of a thinly-provisioned snapshot volume, each snapshot of that origin volume becomes an independent thinly-provisioned volume. This means that instead of merging a snapshot with its origin volume, you may choose to delete the origin volume and then create a new thinly-provisioned snapshot using that independent volume as the origin volume for the new snapshot.

Although there are many advantages to using thin snapshot volumes, there are some use cases for which the older LVM snapshot volume feature may be more appropriate to your needs:

- You cannot change the chunk size of a thin pool. If the thin pool has a large chunk size (for example, 1MB) and you require a short-living snapshot for which a chunk size that large is not efficient, you may elect to use the older snapshot feature.

- You cannot limit the size of a thin snapshot volume; the snapshot will use all of the space in the thin pool, if necessary. This may not be appropriate for your needs.

In general, you should consider the specific requirements of your site when deciding which snapshot format to use.



NOTE

When using thin provisioning, it is important that the storage administrator monitor the storage pool and add more capacity if it starts to become full. For information on configuring and displaying information on thinly-provisioned snapshot volumes, see Creating thinly-provisioned snapshot volumes .

1.4.7. Cache Volumes

LVM supports the use of fast block devices (such as SSD drives) as write-back or write-through caches for larger slower block devices. Users can create cache logical volumes to improve the performance of their existing logical volumes or create new cache logical volumes composed of a small and fast device coupled with a large and slow device.

CHAPTER 2. MANAGING LOCAL STORAGE USING RHEL SYSTEM ROLES

To manage LVM and local file systems (FS) using Ansible, you can use the **storage** role, which is one of the RHEL System Roles available in RHEL 8.

Using the **storage** role enables you to automate administration of file systems on disks and logical volumes on multiple machines and across all versions of RHEL starting with RHEL 7.7.

For more information about RHEL System Roles and how to apply them, see Introduction to RHEL System Roles.

2.1. INTRODUCTION TO THE STORAGE ROLE

The **storage** role can manage:

- File systems on disks which have not been partitioned
- Complete LVM volume groups including their logical volumes and file systems

With the **storage** role you can perform the following tasks:

- Create a file system
- Remove a file system
- Mount a file system
- Unmount a file system
- Create LVM volume groups
- Remove LVM volume groups
- Create logical volumes
- Remove logical volumes
- Create RAID volumes
- Remove RAID volumes
- Create LVM pools with RAID
- Remove LVM pools with RAID

2.2. PARAMETERS THAT IDENTIFY A STORAGE DEVICE IN THE STORAGE SYSTEM ROLE

Your **storage** role configuration affects only the file systems, volumes, and pools that you list in the following variables.

storage_volumes

List of file systems on all unpartitioned disks to be managed.
Partitions are currently unsupported.

storage_pools

List of pools to be managed.
Currently the only supported pool type is LVM. With LVM, pools represent volume groups (VGs). Under each pool there is a list of volumes to be managed by the role. With LVM, each volume corresponds to a logical volume (LV) with a file system.

2.3. EXAMPLE ANSIBLE PLAYBOOK TO CREATE AN XFS FILE SYSTEM ON A BLOCK DEVICE

This section provides an example Ansible playbook. This playbook applies the **storage** role to create an XFS file system on a block device using the default parameters.

WARNING

The **storage** role can create a file system only on an unpartitioned, whole disk or a logical volume (LV). It cannot create the file system on a partition.

Example 2.1. A playbook that creates XFS on /dev/sdb

```
---
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - sdb
        fs_type: xfs
  roles:
    - rhel-system-roles.storage
```

- The volume name (***barefs*** in the example) is currently arbitrary. The **storage** role identifies the volume by the disk device listed under the **disks:** attribute.
- You can omit the **fs_type: xfs** line because XFS is the default file system in RHEL 8.
- To create the file system on an LV, provide the LVM setup under the **disks:** attribute, including the enclosing volume group. For details, see Example Ansible playbook to manage logical volumes.
  Do not provide the path to the LV device.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.4. EXAMPLE ANSIBLE PLAYBOOK TO PERSISTENTLY MOUNT A FILE SYSTEM

This section provides an example Ansible playbook. This playbook applies the **storage** role to immediately and persistently mount an XFS file system.

Example 2.2. A playbook that mounts a file system on /dev/sdb to /mnt/data

```
---
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - sdb
        fs_type: xfs
        mount_point: /mnt/data
  roles:
    - rhel-system-roles.storage
```

- This playbook adds the file system to the **/etc/fstab** file, and mounts the file system immediately.
- If the file system on the **/dev/sdb** device or the mount point directory do not exist, the playbook creates them.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.5. EXAMPLE ANSIBLE PLAYBOOK TO MANAGE LOGICAL VOLUMES

This section provides an example Ansible playbook. This playbook applies the **storage** role to create an LVM logical volume in a volume group.

Example 2.3. A playbook that creates a mylv logical volume in the myvg volume group

```
- hosts: all
  vars:
    storage_pools:
      - name: myvg
        disks:
          - sda
          - sdb
          - sdc
        volumes:
          - name: mylv
            size: 2G
            fs_type: ext4
            mount_point: /mnt
  roles:
    - rhel-system-roles.storage
```

- The **myvg** volume group consists of the following disks:
  - **/dev/sda**
  - **/dev/sdb**
  - **/dev/sdc**
- If the **myvg** volume group already exists, the playbook adds the logical volume to the volume group.
- If the **myvg** volume group does not exist, the playbook creates it.
- The playbook creates an Ext4 file system on the **mylv** logical volume, and persistently mounts the file system at **/mnt**.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.6. EXAMPLE ANSIBLE PLAYBOOK TO ENABLE ONLINE BLOCK DISCARD

This section provides an example Ansible playbook. This playbook applies the **storage** role to mount an XFS file system with online block discard enabled.

Example 2.4. A playbook that enables online block discard on /mnt/data/

```
---
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - sdb
        fs_type: xfs
        mount_point: /mnt/data
        mount_options: discard
  roles:
    - rhel-system-roles.storage
```

Additional resources

- Example Ansible playbook to persistently mount a file system
- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.7. EXAMPLE ANSIBLE PLAYBOOK TO CREATE AND MOUNT AN EXT4 FILE SYSTEM

This section provides an example Ansible playbook. This playbook applies the **storage** role to create and mount an Ext4 file system.

Example 2.5. A playbook that creates Ext4 on /dev/sdb and mounts it at /mnt/data

```
---
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - sdb
        fs_type: ext4
        fs_label: label-name
        mount_point: /mnt/data
  roles:
    - rhel-system-roles.storage
```

- The playbook creates the file system on the **/dev/sdb** disk.
- The playbook persistently mounts the file system at the ***/mnt/data*** directory.
- The label of the file system is ***label-name***.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.8. EXAMPLE ANSIBLE PLAYBOOK TO CREATE AND MOUNT AN EXT3 FILE SYSTEM

This section provides an example Ansible playbook. This playbook applies the **storage** role to create and mount an Ext3 file system.

Example 2.6. A playbook that creates Ext3 on /dev/sdb and mounts it at /mnt/data

```
---
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - sdb
        fs_type: ext3
        fs_label: label-name
        mount_point: /mnt/data
  roles:
    - rhel-system-roles.storage
```

- The playbook creates the file system on the **/dev/sdb** disk.

- The playbook persistently mounts the file system at the ***/mnt/data*** directory.
- The label of the file system is ***label-name***.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.9. EXAMPLE ANSIBLE PLAYBOOK TO RESIZE AN EXISTING EXT4 OR EXT3 FILE SYSTEM USING THE STORAGE RHEL SYSTEM ROLE

This section provides an example Ansible playbook. This playbook applies the **storage** role to resize an existing Ext4 or Ext3 file system on a block device.

Example 2.7. A playbook that set up a single volume on a disk

```
---
- name: Create a disk device mounted on /opt/barefs
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - /dev/sdb
  size: 12 GiB
        fs_type: ext4
        mount_point: /opt/barefs
  roles:
    - rhel-system-roles.storage
```

- If the volume in the previous example already exists, to resize the volume, you need to run the same playbook, just with a different value for the parameter **size**. For example:

Example 2.8. A playbook that resizes ext4 on /dev/sdb

```
---
- name: Create a disk device mounted on /opt/barefs
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
          - /dev/sdb
  size: 10 GiB
        fs_type: ext4
        mount_point: /opt/barefs
  roles:
    - rhel-system-roles.storage
```

- The volume name (barefs in the example) is currently arbitrary. The storage role identifies the volume by the disk device listed under the disks: attribute.

NOTE

Using the **Resizing** action in other file systems can destroy the data on the device you are working on.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.10. EXAMPLE ANSIBLE PLAYBOOK TO RESIZE AN EXISTING FILE SYSTEM ON LVM USING THE STORAGE RHEL SYSTEM ROLE

This section provides an example Ansible playbook. This playbook applies the storage RHEL System Role to resize an LVM logical volume with a file system.

WARNING

Using the **Resizing** action in other file systems can destroy the data on the device you are working on.

Example 2.9. A playbook that resizes existing mylv1 and myvl2 logical volumes in the myvg volume group

```
---

- hosts: all
  vars:
   storage_pools:
     - name: myvg
       disks:
         - /dev/sda
         - /dev/sdb
         - /dev/sdc
       volumes:
          - name: mylv1
            size: 10 GiB
            fs_type: ext4
            mount_point: /opt/mount1
          - name: mylv2
            size: 50 GiB
            fs_type: ext4
            mount_point: /opt/mount2
```

```
- name: Create LVM pool over three disks
  incude_role:
    name: rhel-system-roles.storage
```

- This playbook resizes the following existing file systems:
  - The Ext4 file system on the **mylv1** volume, which is mounted at **/opt/mount1**, resizes to 10 GiB.
  - The Ext4 file system on the **mylv2** volume, which is mounted at **/opt/mount2**, resizes to 50 GiB.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.11. EXAMPLE ANSIBLE PLAYBOOK TO CREATE A SWAP PARTITION USING THE STORAGE RHEL SYSTEM ROLE

This section provides an example Ansible playbook. This playbook applies the **storage** role to create a swap partition, if it does not exist, or to modify the swap partition, if it already exist, on a block device using the default parameters.

Example 2.10. A playbook that creates or modify an existing XFS on /dev/sdb

```
---
- name: Create a disk device with swap
- hosts: all
  vars:
    storage_volumes:
      - name: swap_fs
        type: disk
        disks:
          - /dev/sdb
 size: 15 GiB
        fs_type: swap
  roles:
    - rhel-system-roles.storage
```

- The volume name (***swap_fs*** in the example) is currently arbitrary. The **storage** role identifies the volume by the disk device listed under the **disks:** attribute.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.12. CONFIGURING A RAID VOLUME USING THE STORAGE SYSTEM ROLE

With the **storage** System Role, you can configure a RAID volume on RHEL using Red Hat Ansible Automation Platform. In this section you will learn how to set up an Ansible playbook with the available parameters to configure a RAID volume to suit your requirements.

Prerequisites

- You have Red Hat Ansible Engine installed on the system from which you want to run the playbook.

NOTE

You do not have to have Red Hat Ansible Automation Platform installed on the systems on which you want to deploy the **storage** solution.

- You have the **rhel-system-roles** package installed on the system from which you want to run the playbook.
- You have an inventory file detailing the systems on which you want to deploy a RAID volume using the **storage** System Role.

Procedure

1. Create a new ***playbook.yml*** file with the following content:

```
- hosts: all
  vars:
    storage_safe_mode: false
    storage_volumes:
      - name: data
        type: raid
        disks: [sdd, sde, sdf, sdg]
        raid_level: raid0
        raid_chunk_size: 32 KiB
        mount_point: /mnt/data
        state: present
  roles:
    - name: rhel-system-roles.storage
```

WARNING

Device names can change in certain circumstances; for example, when you add a new disk to a system. Therefore, to prevent data loss, we do not recommend using specific disk names in the playbook.

2. Optional. Verify playbook syntax.

```
# ansible-playbook --syntax-check playbook.yml
```

3. Run the playbook on your inventory file:

```
# ansible-playbook -i inventory.file /path/to/file/playbook.yml
```

Additional resources

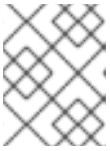
- Managing RAID.
- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.13. CONFIGURING AN LVM POOL WITH RAID USING THE STORAGE SYSTEM ROLE

With the **storage** System Role, you can configure an LVM pool with RAID on RHEL using Red Hat Ansible Automation Platform. In this section you will learn how to set up an Ansible playbook with the available parameters to configure an LVM pool with RAID.

Prerequisites

- You have Red Hat Ansible Engine installed on the system from which you want to run the playbook.



NOTE

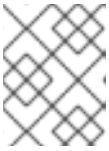
You do not have to have Red Hat Ansible Automation Platform installed on the systems on which you want to deploy the **storage** solution.

- You have the **rhel-system-roles** package installed on the system from which you want to run the playbook.
- You have an inventory file detailing the systems on which you want to configure an LVM pool with RAID using the **storage** System Role.

Procedure

1. Create a new ***playbook.yml*** file with the following content:

```
- hosts: all
  vars:
    storage_safe_mode: false
    storage_pools:
      - name: my_pool
        type: lvm
        disks: [sdh, sdi]
        raid_level: raid1
        volumes:
          - name: my_pool
            size: "1 GiB"
            mount_point: "/mnt/app/shared"
            fs_type: xfs
            state: present
  roles:
    - name: rhel-system-roles.storage
```



NOTE

To create an LVM pool with RAID, you must specify the RAID type using the **raid_level** parameter.

2. Optional. Verify playbook syntax.

```
# ansible-playbook --syntax-check playbook.yml
```

3. Run the playbook on your inventory file:

```
# ansible-playbook -i inventory.file /path/to/file/playbook.yml
```

Additional resources

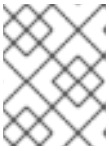
- Managing RAID.
- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

2.14. CREATING A LUKS ENCRYPTED VOLUME USING THE STORAGE ROLE

You can use the **storage** role to create and configure a volume encrypted with LUKS by running an Ansible playbook.

Prerequisites

- You have Red Hat Ansible Engine installed on the system from which you want to run the playbook.



NOTE

You do not have to have Red Hat Ansible Automation Platform installed on the systems on which you want to create the volume.

- You have the **rhel-system-roles** package installed on the Ansible controller.
- You have an inventory file detailing the systems on which you want to deploy a LUKS encrypted volume using the storage System Role.

Procedure

1. Create a new ***playbook.yml*** file with the following content:

```
- hosts: all
  vars:
    storage_volumes:
      - name: barefs
        type: disk
        disks:
         - sdb
        fs_type: xfs
        fs_label: label-name
```

```
      mount_point: /mnt/data
      encryption: true
      encryption_password: your-password
  roles:
   - rhel-system-roles.storage
```

2. Optional: Verify playbook syntax:

```
# ansible-playbook --syntax-check playbook.yml
```

3. Run the playbook on your inventory file:

```
# ansible-playbook -i inventory.file /path/to/file/playbook.yml
```

Additional resources

- Encrypting block devices using LUKS
- **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file

2.15. ADDITIONAL RESOURCES

- **/usr/share/doc/rhel-system-roles/storage/**
- **/usr/share/ansible/roles/rhel-system-roles.storage/**

CHAPTER 3. DEPLOYING LVM

The following procedures represent the basic configuration for LVM logical volumes on a freshly installed operating system.

3.1. CREATING LVM PHYSICAL VOLUME

This procedure describes how to create and label LVM physical volumes (PVs).

In this procedure, replace the */dev/vdb1*, */dev/vdb2*, and */dev/vdb3* with the available storage devices in your system.

Prerequisites

- The **lvm2** package is installed.

Procedure

1. Create multiple physical volumes by using the space-delimited device names as arguments to the **pvcreate** command:

```
# pvcreate /dev/vdb1 /dev/vdb2 /dev/vdb3
  Physical volume "/dev/vdb1" successfully created.
  Physical volume "/dev/vdb2" successfully created.
  Physical volume "/dev/vdb3" successfully created.
```

   This places a label on */dev/vdb1*, */dev/vdb2*, and */dev/vdb3*, marking them as physical volumes belonging to LVM.

2. View the created physical volumes by using any one of the following commands as per your requirement:

   a. The **pvdisplay** command, which provides a verbose multi-line output for each physical volume. It displays physical properties, such as size, extents, volume group, and other options in a fixed format:

```
# pvdisplay
--- NEW Physical volume ---
  PV Name               /dev/vdb1
  VG Name
  PV Size               1.00 GiB
[..]
--- NEW Physical volume ---
  PV Name               /dev/vdb2
  VG Name
  PV Size               1.00 GiB
[..]
--- NEW Physical volume ---
  PV Name               /dev/vdb3
  VG Name
  PV Size               1.00 GiB
[..]
```

b. The **pvs** command provides physical volume information in a configurable form, displaying one line per physical volume:

```
# pvs
  PV         VG  Fmt  Attr  PSize     PFree
/dev/vdb1        lvm2        1020.00m  0
/dev/vdb2        lvm2        1020.00m  0
/dev/vdb3        lvm2        1020.00m  0
```

c. The **pvscan** command scans all supported LVM block devices in the system for physical volumes. You can define a filter in the **lvm.conf** file so that this command avoids scanning specific physical volumes:

```
# pvscan
  PV /dev/vdb1                lvm2 [1.00 GiB]
  PV /dev/vdb2                lvm2 [1.00 GiB]
  PV /dev/vdb3                lvm2 [1.00 GiB]
```

Additional resources

- **pvcreate(8)**, **pvdisplay(8)**, **pvs(8)**, and **pvscan(8)** man pages

3.2. CREATING LVM VOLUME GROUP

This procedure describes how to create an LVM volume group (VG) *myvg*, by using the */dev/vdb1* and */dev/vdb2* physical volumes.

Prerequisites

- The **lvm2** package is installed.
- One or more physical volumes are created. For more information on creating physical volumes, see Creating LVM physical volume.

Procedure

1. Create a volume group:

```
# vgcreate myvg /dev/vdb1 /dev/vdb2
 Volume group "myvg" successfully created.
```

This creates a VG with the name of *myvg*. The PVs */dev/vdb1* and */dev/vdb2* are the base storage level for the *myvg* VG .

2. View the created volume groups by using any one of the following commands as per your requirement:

a. The **vgs** command provides volume group information in a configurable form, displaying one line per volume groups:

```
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  myvg   4   1   0 wz--n-   3.98g 1008.00m
```

b. The **vgdisplay** command displays volume group properties such as size, extents, number of physical volumes, and other options in a fixed form. The following example shows the output of the **vgdisplay** command for the volume group *myvg*. If you do not specify a volume group, all existing volume groups are displayed:

```
# vgdisplay myvg _ --- Volume group --- VG Name _myvg
  System ID
  Format               lvm2
  Metadata Areas       4
  Metadata Sequence No  6
  VG Access            read/write
[..]
```

c. The **vgscan** command scans all supported LVM block devices in the system for volume group:

```
# vgscan
  Found volume group "myvg" using metadata type lvm2
```

3. Optional: Increase a volume group's capacity by adding one or more free physical volumes:

```
# vgextend myvg /dev/vdb3
Physical volume "/dev/vdb3" successfully created.
Volume group "myvg" successfully extended
```

Additional resources

- **pvcreate(8)**, **vgextend(8)**, **vgdisplay(8)**, **vgs(8)**, and **vgscan(8)** man pages

3.3. CREATING LVM LOGICAL VOLUME

This procedure describes how to create *mylv* LVM logical volume (LV) from the *myvg* volume group, which is created by using the */dev/vdb1*, */dev/vdb2*, and */dev/vdb3* physical volumes.

Prerequisites

- The **lvm2** package is installed.
- The volume group is created. For more information, see Creating LVM volume group.

Procedure

1. Create a logical volume:

```
# lvcreate -n mylv -L 500M myvg
```

Use the **-n** option to set the LV name to *mylv*, and the **-L** option to set the size of LV in units of Mb, but it is possible to use any other units. The LV type is linear by default, but the user can specify the desired type by using the **--type** option.

IMPORTANT

The command fails if the VG does not have a sufficient number of free physical extents for the requested size and type.

2. View the created logical volumes by using any one of the following commands as per your requirement:

   a. The **lvs** command provides logical volume information in a configurable form, displaying one line per logical volume:

```
# lvs
  LV   VG   Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
 mylv myvg -wi-ao----   500.00m
```

   b. The **lvdisplay** command displays logical volume properties, such as size, layout, and mapping in a fixed format:

```
# lvdisplay -v /dev/myvg/mylv
  --- Logical volume ---
  LV Path                /dev/myvg/mylv
  LV Name                mylv
  VG Name                myvg
  LV UUID                YTnAk6-kMlT-c4pG-HBFZ-Bx7t-ePMk-7YjhaM
  LV Write Access        read/write
[..]
```

   c. The **lvscan** command scans for all logical volumes in the system and lists them:

```
# lvscan
 ACTIVE                 '/dev/myvg/mylv' [500.00 MiB] inherit
```

3. Create a file system on the logical volume. The following command creates an **xfs** file system on the logical volume:

```
# mkfs.xfs /dev/myvg/mylv
meta-data=/dev/myvg/mylv       isize=512    agcount=4, agsize=32000 blks
         =                     sectsz=512   attr=2, projid32bit=1
         =                     crc=1        finobt=1, sparse=1, rmapbt=0
         =                     reflink=1
data     =                       bsize=4096   blocks=128000, imaxpct=25
         =                     sunit=0      swidth=0 blks
naming   =version 2                bsize=4096   ascii-ci=0, ftype=1
log      =internal log           bsize=4096   blocks=1368, version=2
         =                     sectsz=512   sunit=0 blks, lazy-count=1
realtime =none                     extsz=4096   blocks=0, rtextents=0
Discarding blocks...Done.
```

4. Mount the logical volume and report the file system disk space usage:

```
# mount /dev/myvg/mylv /mnt

# df -h
```

```
Filesystem                1K-blocks  Used  Available Use% Mounted on
/dev/mapper/myvg-mylv     506528     29388 477140    6%   /mnt
```

Additional resources

- **lvcreate(8)**, **lvdisplay(8)**, **lvs(8)**, **lvscan(8)**, and **mkfs.xfs(8)** man pages

CHAPTER 4. CONFIGURING LVM LOGICAL VOLUMES

The following procedures provide examples of basic LVM administration tasks.

4.1. USING CLI COMMANDS

The following sections describe some general operational features of LVM CLI commands.

Specifying units in a command line argument

When sizes are required in a command line argument, units can always be specified explicitly. If you do not specify a unit, then a default is assumed, usually KB or MB. LVM CLI commands do not accept fractions.

When specifying units in a command line argument, LVM is case-insensitive; specifying M or m is equivalent, for example, and powers of 2 (multiples of 1024) are used. However, when specifying the **--units** argument in a command, lower-case indicates that units are in multiples of 1024 while upper-case indicates that units are in multiples of 1000.

Specifying volume groups and logical volumes

Note the following when specifying volume groups or logical volumes in an LVM CLI command.

- Where commands take volume group or logical volume names as arguments, the full path name is optional. A logical volume called **lvol0** in a volume group called **vg0** can be specified as **vg0/lvol0**.
- Where a list of volume groups is required but is left empty, a list of all volume groups will be substituted.
- Where a list of logical volumes is required but a volume group is given, a list of all the logical volumes in that volume group will be substituted. For example, the **lvdisplay vg0** command will display all the logical volumes in volume group **vg0**.

Increasing output verbosity

All LVM commands accept a **-v** argument, which can be entered multiple times to increase the output verbosity. The following examples shows the default output of the **lvcreate** command.

```
# lvcreate -L 50MB new_vg
  Rounding up size to full physical extent 52.00 MB
  Logical volume "lvol0" created
```

The following command shows the output of the **lvcreate** command with the **-v** argument.

```
# lvcreate -v -L 50MB new_vg
  Rounding up size to full physical extent 52.00 MB
    Archiving volume group "new_vg" metadata (seqno 1).
    Creating logical volume lvol0
    Creating volume group backup "/etc/lvm/backup/new_vg" (seqno 2).
    Activating logical volume new_vg/lvol0.
    activation/volume_list configuration setting not defined: Checking only host tags for new_vg/lvol0.
    Creating new_vg-lvol0
    Loading table for new_vg-lvol0 (253:0).
    Resuming new_vg-lvol0 (253:0).
    Wiping known signatures on logical volume "new_vg/lvol0"
    Initializing 4.00 KiB of logical volume "new_vg/lvol0" with value 0.
  Logical volume "lvol0" created
```

-

The **-vv**, **-vvv** and the **-vvvv** arguments display increasingly more details about the command execution. The **-vvvv** argument provides the maximum amount of information at this time. The following example shows the first few lines of output for the **lvcreate** command with the **-vvvv** argument specified.

```
# lvcreate -vvvv -L 50MB new_vg
#lvmcmdline.c:913         Processing: lvcreate -vvvv -L 50MB new_vg
#lvmcmdline.c:916         O_DIRECT will be used
#config/config.c:864      Setting global/locking_type to 1
#locking/locking.c:138      File-based locking selected.
#config/config.c:841      Setting global/locking_dir to /var/lock/lvm
#activate/activate.c:358       Getting target version for linear
#ioctl/libdm-iface.c:1569        dm version   OF   [16384]
#ioctl/libdm-iface.c:1569        dm versions   OF   [16384]
#activate/activate.c:358       Getting target version for striped
#ioctl/libdm-iface.c:1569        dm versions   OF   [16384]
#config/config.c:864      Setting activation/mirror_region_size to 512
...
```

Displaying help for LVM CLI commands

You can display help for any of the LVM CLI commands with the **--help** argument of the command.

```
# commandname --help
```

To display the man page for a command, execute the **man** command:

```
# man commandname
```

The **man lvm** command provides general online information about LVM.

4.2. CREATING AN LVM LOGICAL VOLUME ON THREE DISKS

This example procedure creates an LVM logical volume called **mylv** that consists of the disks at **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

1. To use disks in a volume group, label them as LVM physical volumes with the **pvcreate** command.

WARNING

This command destroys any data on **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

```
# pvcreate /dev/sda1 /dev/sdb1 /dev/sdc1
  Physical volume "/dev/sda1" successfully created
  Physical volume "/dev/sdb1" successfully created
  Physical volume "/dev/sdc1" successfully created
```

2. Create the a volume group that consists of the LVM physical volumes you have created. The following command creates the volume group **myvg**.

```
# vgcreate myvg /dev/sda1 /dev/sdb1 /dev/sdc1
  Volume group "myvg" successfully created
```

You can use the **vgs** command to display the attributes of the new volume group.

```
# vgs
  VG   #PV #LV #SN Attr   VSize  VFree
  myvg   3   0   0 wz--n- 51.45G 51.45G
```

3. Create the logical volume from the volume group you have created. The following command creates the logical volume **mylv** from the volume group **myvg**. This example creates a logical volume that uses 2 gigabytes of the volume group.

```
# lvcreate -L 2G -n mylv myvg
  Logical volume "mylv" created
```

4. Create a file system on the logical volume. The following command creates an **ext4** file system on the logical volume.

```
# mkfs.ext4 /dev/myvg/mylv
mke2fs 1.44.3 (10-July-2018)
Creating filesystem with 524288 4k blocks and 131072 inodes
Filesystem UUID: 616da032-8a48-4cd7-8705-bd94b7a1c8c4
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

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

The following commands mount the logical volume and report the file system disk space usage.

```
# mount /dev/myvg/mylv /mnt
# df
Filesystem              1K-blocks     Used  Available Use% Mounted on
/dev/mapper/myvg-mylv    1998672     6144    1871288   1% /mnt
```

4.3. CREATING A RAID0 (STRIPED) LOGICAL VOLUME

A RAID0 logical volume spreads logical volume data across multiple data subvolumes in units of stripe size.

The format for the command to create a RAID0 volume is as follows.

```
lvcreate --type raid0[_meta] --stripes Stripes --stripesize StripeSize VolumeGroup
[PhysicalVolumePath ...]
```

Table 4.1. RAID0 Command Creation parameters

Parameter	Description
--type raid0[_meta]	Specifying **raid0** creates a RAID0 volume without metadata volumes. Specifying **raid0_meta** creates a RAID0 volume with metadata volumes. Because RAID0 is non-resilient, it does not have to store any mirrored data blocks as RAID1/10 or calculate and store any parity blocks as RAID4/5/6 do. Hence, it does not need metadata volumes to keep state about resynchronization progress of mirrored or parity blocks. Metadata volumes become mandatory on a conversion from RAID0 to RAID4/5/6/10, however, and specifying **raid0_meta** preallocates those metadata volumes to prevent a respective allocation failure.
--stripes *Stripes*	Specifies the number of devices to spread the logical volume across.
--stripesize *StripeSize*	Specifies the size of each stripe in kilobytes. This is the amount of data that is written to one device before moving to the next device.
VolumeGroup	Specifies the volume group to use.
PhysicalVolumePath ...	Specifies the devices to use. If this is not specified, LVM will choose the number of devices specified by the *Stripes* option, one for each stripe.

This example procedure creates an LVM RAID0 logical volume called **mylv** that stripes data across the disks at **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

1. Label the disks you will use in the volume group as LVM physical volumes with the **pvcreate** command.

WARNING

This command destroys any data on **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

```
# pvcreate /dev/sda1 /dev/sdb1 /dev/sdc1
  Physical volume "/dev/sda1" successfully created
  Physical volume "/dev/sdb1" successfully created
  Physical volume "/dev/sdc1" successfully created
```

2. Create the volume group **myvg**. The following command creates the volume group **myvg**.

```
# vgcreate myvg /dev/sda1 /dev/sdb1 /dev/sdc1
  Volume group "myvg" successfully created
```

You can use the **vgs** command to display the attributes of the new volume group.

```
# vgs
  VG   #PV #LV #SN Attr   VSize  VFree
  myvg   3   0   0 wz--n- 51.45G 51.45G
```

3. Create a RAID0 logical volume from the volume group you have created. The following command creates the RAID0 volume **mylv** from the volume group **myvg**. This example creates a logical volume that is 2 gigabytes in size, with three stripes and a stripe size of 4 kilobytes.

```
# lvcreate --type raid0 -L 2G --stripes 3 --stripesize 4 -n mylv myvg
  Rounding size 2.00 GiB (512 extents) up to stripe boundary size 2.00 GiB(513 extents).
  Logical volume "mylv" created.
```

4. Create a file system on the RAID0 logical volume. The following command creates an **ext4** file system on the logical volume.

```
# mkfs.ext4 /dev/myvg/mylv
mke2fs 1.44.3 (10-July-2018)
Creating filesystem with 525312 4k blocks and 131376 inodes
Filesystem UUID: 9d4c0704-6028-450a-8b0a-8875358c0511
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

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

The following commands mount the logical volume and report the file system disk space usage.

```
# mount /dev/myvg/mylv /mnt
# df
Filesystem            1K-blocks     Used  Available Use% Mounted on
/dev/mapper/myvg-mylv    2002684     6168    1875072   1% /mnt
```

4.4. RENAMING LVM LOGICAL VOLUMES

This procedure describes how to rename an existing logical volume *mylv* to *mylv1*.

Procedure

1. If the logical volume is currently mounted, unmount the volume:

```
# umount /mnt
```

Replace */mnt* with the mount point.

2. If the logical volume exists in a clustered environment, deactivate the logical volume on all nodes where it is active. Use the following command on each such node:

```
# lvchange --activate n myvg/mylv
```

3. Rename an existing logical volume:

```
# lvrename myvg mylv mylv1
Logical volume "mylv" successfully renamed to "mylv1"
```

You can also rename the logical volume by specifying the full paths to the devices:

```
# lvrename /dev/myvg/mylv /dev/myvg/mylv1
```

Additional resources

- **lvrename(8)** man page

4.5. REMOVING A DISK FROM A LOGICAL VOLUME

This procedure describes how to remove a disk from an existing logical volume, either to replace the disk or to use the disk as part of a different volume.

In order to remove a disk, you must first move the extents on the LVM physical volume to a different disk or set of disks.

Procedure

1. View the used and free space of physical volumes when using the LV:

```
# pvs -o+pv_used
  PV         VG    Fmt    Attr   PSize      PFree     Used
 /dev/vdb1 myvg  lvm2   a--    1020.00m    0        1020.00m
 /dev/vdb2 myvg  lvm2   a--    1020.00m    0        1020.00m
 /dev/vdb3 myvg  lvm2   a--    1020.00m   1008.00m   12.00m
```

2. Move the data to other physical volume:

   a. If there are enough free extents on the other physical volumes in the existing volume group, use the following command to move the data:

```
# pvmove /dev/vdb3
  /dev/vdb3: Moved: 2.0%
 ...
  /dev/vdb3: Moved: 79.2%
 ...
  /dev/vdb3: Moved: 100.0%
```

   b. If there are no enough free extents on the other physical volumes in the existing volume group, use the following commands to add a new physical volume, extend the volume group using the newly created physical volume, and move the data to this physical volume:

```
# pvcreate /dev/vdb4
  Physical volume "/dev/vdb4" successfully created

# vgextend myvg /dev/vdb4
```

```
  Volume group "myvg" successfully extended

# pvmove /dev/vdb3 /dev/vdb4
  /dev/vdb3: Moved: 33.33%
  /dev/vdb3: Moved: 100.00%
```

3. Remove the physical volume:

```
# vgreduce myvg /dev/vdb3
Removed "/dev/vdb3" from volume group "myvg"
```

If a logical volume contains a physical volume that fails, you cannot use that logical volume. To remove missing physical volumes from a volume group, you can use the **--removemissing** parameter of the **vgreduce** command, if there are no logical volumes that are allocated on the missing physical volumes:

```
# vgreduce --removemissing myvg
```

Additional resources

- **pvmove(8)**, **vgextend(8)**, **vereduce(8)**, and **pvs(8)** man pages

4.6. CONFIGURING PERSISTENT DEVICE NUMBERS

Major and minor device numbers are allocated dynamically at module load. Some applications work best if the block device is always activated with the same device (major and minor) number. You can specify these with the **lvcreate** and the **lvchange** commands by using the following arguments:

```
--persistent y --major major --minor minor
```

Use a large minor number to be sure that it has not already been allocated to another device dynamically.

If you are exporting a file system using NFS, specifying the **fsid** parameter in the exports file may avoid the need to set a persistent device number within LVM.

4.7. SPECIFYING LVM EXTENT SIZE

When physical volumes are used to create a volume group, its disk space is divided into 4MB extents, by default. This extent is the minimum amount by which the logical volume may be increased or decreased in size. Large numbers of extents will have no impact on I/O performance of the logical volume.

You can specify the extent size with the **-s** option to the **vgcreate** command if the default extent size is not suitable. You can put limits on the number of physical or logical volumes the volume group can have by using the **-p** and **-l** arguments of the **vgcreate** command.

4.8. MANAGING LVM LOGICAL VOLUMES USING RHEL SYSTEM ROLES

This section describes how to apply the **storage** role to perform the following tasks:

- Create an LVM logical volume in a volume group consisting of multiple disks.

- Create an ext4 file system with a given label on the logical volume.
- Persistently mount the ext4 file system.

Prerequisites

- An Ansible playbook including the **storage** role

For information on how to apply an Ansible playbook, see Applying a role.

4.8.1. Example Ansible playbook to manage logical volumes

This section provides an example Ansible playbook. This playbook applies the **storage** role to create an LVM logical volume in a volume group.

Example 4.1. A playbook that creates a mylv logical volume in the myvg volume group

```
- hosts: all
  vars:
    storage_pools:
      - name: myvg
        disks:
          - sda
          - sdb
          - sdc
        volumes:
          - name: mylv
            size: 2G
            fs_type: ext4
            mount_point: /mnt
  roles:
    - rhel-system-roles.storage
```

- The **myvg** volume group consists of the following disks:
  - **/dev/sda**
  - **/dev/sdb**
  - **/dev/sdc**
- If the **myvg** volume group already exists, the playbook adds the logical volume to the volume group.
- If the **myvg** volume group does not exist, the playbook creates it.
- The playbook creates an Ext4 file system on the **mylv** logical volume, and persistently mounts the file system at **/mnt**.

Additional resources

- The **/usr/share/ansible/roles/rhel-system-roles.storage/README.md** file.

4.8.2. Additional resources

- For more information about the **storage** role, see Managing local storage using RHEL System Roles.

4.9. REMOVING LVM LOGICAL VOLUMES

This procedure describes how to remove an existing logical volume */dev/myvg/mylv1* from the volume group *myvg*.

Procedure

1. If the logical volume is currently mounted, unmount the volume:

```
# umount /mnt
```

2. If the logical volume exists in a clustered environment, deactivate the logical volume on all nodes where it is active. Use the following command on each such node:

```
# lvchange --activate n vg-name/lv-name
```

3. Remove the logical volume using the **lvremove** utility:

```
# lvremove /dev/myvg/mylv1

Do you really want to remove active logical volume "mylv1"? [y/n]: y
Logical volume "mylv1" successfully removed
```

NOTE

In this case, the logical volume has not been deactivated. If you explicitly deactivated the logical volume before removing it, you would not see the prompt verifying whether you want to remove an active logical volume.

Additional resources

- **lvremove(8)** man page

CHAPTER 5. MODIFYING THE SIZE OF A LOGICAL VOLUME

After you have created a logical volume, you can modify the size of the volume.

5.1. GROWING A LOGICAL VOLUME AND FILE SYSTEM

This procedure describes how to extend the logical volume and grow a file system on the same logical volume.

To increase the size of a logical volume, use the **lvextend** command. When you extend the logical volume, you can indicate how much you want to extend the volume, or how large you want it to be after you extend it.

Prerequisites

1. You have an existing logical volume (LV) with a file system on it. Determine the file system type by using the **df -Th** command.
   For more information on creating LV and a file system, see Creating LVM logical volume.

2. You have sufficient space in the volume group to grow your LV and file system. Use the **vgs -o name,vgfree** command to determine the available space.

Procedure

1. Optional: If the volume group has insufficient space to grow your LV, then add a new physical volume to the volume group by using the following command:

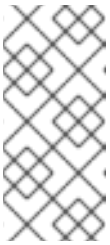
   ```
   # vgextend myvg /dev/vdb3
   Physical volume "/dev/vdb3" successfully created.
   Volume group "myvg" successfully extended
   ```

   For more information, see Creating LVM volume group.

2. Now that the volume group is large enough, execute any one of the following steps as per your requirement:

   a. To extend the LV with the provided size, use the following command:

   ```
   # lvextend -L 3G /dev/myvg/mylv
   Size of logical volume myvg/mylv changed from 2.00 GiB (512 extents) to 3.00 GiB (768 extents).
   Logical volume myvg/mylv successfully resized.
   ```



NOTE

You can use the **-r** option of the **lvextend** command to extend the logical volume and resize the underlying file system with a single command:

```
# lvextend -r -L 3G /dev/myvg/mylv
```

WARNING

You can also extend the logical volume using the **lvresize** command with the same arguments, but this command does not guarantee against accidental shrinkage.

b. To extend the *mylv* logical volume to fill all of the unallocated space in the *myvg* volume group, use the following command:

```
# lvextend -l +100%FREE /dev/myvg/mylv
 Size of logical volume myvg/mylv changed from 10.00 GiB (2560 extents) to 6.35 TiB (1665465 extents).
 Logical volume myvg/mylv successfully resized.
```

As with the **lvcreate** command, you can use the **-l** argument of the **lvextend** command to specify the number of extents by which to increase the size of the logical volume. You can also use this argument to specify a percentage of the volume group, or a percentage of the remaining free space in the volume group.

3. If you are not using the **r** option with the **lvextend** command to extend the LV and resize the file system with a single command, then resize the file system on the logical volume by using the following command:

```
xfs_growfs /mnt/mnt1/
meta-data=/dev/mapper/myvg-mylv  isize=512    agcount=4, agsize=65536 blks
         =                       sectsz=512   attr=2, projid32bit=1
         =                       crc=1        finobt=1, sparse=1, rmapbt=0
         =                       reflink=1
data     =                       bsize=4096   blocks=262144, 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
data blocks changed from 262144 to 524288
```

NOTE

Without the **-D** option, **xfs_growfs** grows the file system to the maximum size supported by the underlying device. For more information, see Increasing the size of an XFS file system.

For resizing an ext4 file system, see Resizing an ext4 file system .

Verification

- Verify if the file system is growing by using the following command:

```
# df -Th
```

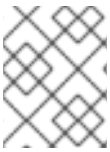
```
Filesystem           Type      Size  Used Avail Use% Mounted on
devtmpfs             devtmpfs  1.9G     0  1.9G   0% /dev
tmpfs                tmpfs     1.9G     0  1.9G   0% /dev/shm
tmpfs                tmpfs     1.9G  8.6M  1.9G   1% /run
tmpfs                tmpfs     1.9G     0  1.9G   0% /sys/fs/cgroup
/dev/mapper/rhel-root xfs        45G  3.7G   42G   9% /
/dev/vda1            xfs      1014M  369M  646M  37% /boot
tmpfs                tmpfs     374M     0  374M   0% /run/user/0
/dev/mapper/myvg-mylv xfs       2.0G   47M  2.0G   3% /mnt/mnt1
```

Additional resources

- **vgextend(8)**, **lvextend(8)**, and **xfs_growfs(8)** man pages

5.2. SHRINKING LOGICAL VOLUMES

You can reduce the size of a logical volume with the **lvreduce** command.



NOTE

Shrinking is not supported on a GFS2 or XFS file system, so you cannot reduce the size of a logical volume that contains a GFS2 or XFS file system.

If the logical volume you are reducing contains a file system, to prevent data loss you must ensure that the file system is not using the space in the logical volume that is being reduced. For this reason, it is recommended that you use the **--resizefs** option of the **lvreduce** command when the logical volume contains a file system.

When you use this option, the **lvreduce** command attempts to reduce the file system before shrinking the logical volume. If shrinking the file system fails, as can occur if the file system is full or the file system does not support shrinking, then the **lvreduce** command will fail and not attempt to shrink the logical volume.

WARNING

In most cases, the **lvreduce** command warns about possible data loss and asks for a confirmation. However, you should not rely on these confirmation prompts to prevent data loss because in some cases you will not see these prompts, such as when the logical volume is inactive or the **--resizefs** option is not used.

Note that using the **--test** option of the **lvreduce** command does not indicate where the operation is safe, as this option does not check the file system or test the file system resize.

Procedure

- To shrink the *mylv* logical volume in *myvg* volume group to 64 megabytes, use the following command:

```
# lvreduce --resizefs -L 64M myvg/mylv
fsck from util-linux 2.37.2
/dev/mapper/myvg-mylv: clean, 11/25688 files, 4800/102400 blocks
resize2fs 1.46.2 (28-Feb-2021)
Resizing the filesystem on /dev/mapper/myvg-mylv to 65536 (1k) blocks.
The filesystem on /dev/mapper/myvg-mylv is now 65536 (1k) blocks long.

Size of logical volume myvg/mylv changed from 100.00 MiB (25 extents) to 64.00 MiB (16 extents).
 Logical volume myvg/mylv successfully resized.
```

In this example, *mylv* contains a file system, which this command resizes together with the logical volume.

- Specifying the **-** sign before the resize value indicates that the value will be subtracted from the logical volume's actual size. To shrink a logical volume to an absolute size of 64 megabytes, use the following command:

```
# lvreduce --resizefs -L -64M myvg/mylv
```

Additional resources

- **lvreduce(8)** man page

5.3. EXTENDING A STRIPED LOGICAL VOLUME

In order to increase the size of a 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 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.

For example, consider a volume group **vg** that consists of two underlying physical volumes, as displayed with the following **vgs** command.

```
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  vg     2   0   0 wz--n- 271.31G 271.31G
```

You can create a stripe using the entire amount of space in the volume group.

```
# lvcreate -n stripe1 -L 271.31G -i 2 vg
  Using default stripesize 64.00 KB
  Rounding up size to full physical extent 271.31 GB
  Logical volume "stripe1" created
# lvs -a -o +devices
  LV      VG   Attr   LSize   Origin Snap%  Move Log Copy%  Devices
  stripe1 vg   -wi-a- 271.31G                             /dev/sda1(0),/dev/sdb1(0)
```

Note that the volume group now has no more free space.

```
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  vg     2   1   0 wz--n- 271.31G    0
```

The following command adds another physical volume to the volume group, which then has 135 gigabytes of additional space.

```
# vgextend vg /dev/sdc1
  Volume group "vg" successfully extended
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  vg     3   1   0 wz--n- 406.97G 135.66G
```

At this point you cannot extend the striped logical volume to the full size of the volume group, because two underlying devices are needed in order to stripe the data.

```
# lvextend vg/stripe1 -L 406G
  Using stripesize of last segment 64.00 KB
  Extending logical volume stripe1 to 406.00 GB
  Insufficient suitable allocatable extents for logical volume stripe1: 34480
more required
```

To extend the striped logical volume, add another physical volume and then extend the logical volume. In this example, having added two physical volumes to the volume group we can extend the logical volume to the full size of the volume group.

```
# vgextend vg /dev/sdd1
  Volume group "vg" successfully extended
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  vg     4   1   0 wz--n- 542.62G 271.31G
# lvextend vg/stripe1 -L 542G
  Using stripesize of last segment 64.00 KB
  Extending logical volume stripe1 to 542.00 GB
  Logical volume stripe1 successfully resized
```

If you do not have enough underlying physical devices to extend the striped logical volume, it is possible to extend the volume anyway if it does not matter that the extension is not striped, which may result in uneven performance. When adding space to the logical volume, the default operation is to use the same striping parameters of the last segment of the existing logical volume, but you can override those parameters. The following example extends the existing striped logical volume to use the remaining free space after the initial **lvextend** command fails.

```
# lvextend vg/stripe1 -L 406G
  Using stripesize of last segment 64.00 KB
  Extending logical volume stripe1 to 406.00 GB
  Insufficient suitable allocatable extents for logical volume stripe1: 34480
more required
# lvextend -i1 -l+100%FREE vg/stripe1
```

CHAPTER 6. MANAGING LVM VOLUME GROUPS

A volume group (VG) is a collection of physical volumes (PVs), which creates a pool of disk space out of which logical volumes (LVs) can be allocated.

Within a volume group, the disk space available for allocation is divided into units of a fixed-size called extents. An extent is the smallest unit of space that can be allocated. Within a physical volume, extents are referred to as physical extents.

A logical volume is allocated into logical extents of the same size as the physical extents. The extent size is thus the same for all logical volumes in the volume group. The volume group maps the logical extents to physical extents.

6.1. CREATING LVM VOLUME GROUP

This procedure describes how to create an LVM volume group (VG) *myvg*, by using the */dev/vdb1* and */dev/vdb2* physical volumes.

Prerequisites

- The **lvm2** package is installed.
- One or more physical volumes are created. For more information on creating physical volumes, see Creating LVM physical volume.

Procedure

1. Create a volume group:

```
# vgcreate myvg /dev/vdb1 /dev/vdb2
 Volume group "myvg" successfully created.
```

   This creates a VG with the name of *myvg*. The PVs */dev/vdb1* and */dev/vdb2* are the base storage level for the *myvg* VG .

2. View the created volume groups by using any one of the following commands as per your requirement:

   a. The **vgs** command provides volume group information in a configurable form, displaying one line per volume groups:

```
# vgs
  VG   #PV #LV #SN Attr   VSize   VFree
  myvg   4   1   0 wz--n-   3.98g 1008.00m
```

   b. The **vgdisplay** command displays volume group properties such as size, extents, number of physical volumes, and other options in a fixed form. The following example shows the output of the **vgdisplay** command for the volume group *myvg*. If you do not specify a volume group, all existing volume groups are displayed:

```
# vgdisplay myvg _ --- Volume group --- VG Name _myvg
  System ID
  Format                lvm2
  Metadata Areas        4
```

```
  Metadata Sequence No  6
  VG Access             read/write
[..]
```

c. The **vgscan** command scans all supported LVM block devices in the system for volume group:

```
# vgscan
  Found volume group "myvg" using metadata type lvm2
```

3. Optional: Increase a volume group's capacity by adding one or more free physical volumes:

```
# vgextend myvg /dev/vdb3
Physical volume "/dev/vdb3" successfully created.
Volume group "myvg" successfully extended
```

Additional resources

- **pvcreate(8)**, **vgextend(8)**, **vgdisplay(8)**, **vgs(8)**, and **vgscan(8)** man pages

6.2. COMBINING LVM VOLUME GROUPS

To combine two volume groups into a single volume group, use the **vgmerge** command. You can merge an inactive "source" volume with an active or an inactive "destination" volume if the physical extent sizes of the volume are equal and the physical and logical volume summaries of both volume groups fit into the destination volume groups limits.

Procedure

- Merge the inactive volume group *databases* into the active or inactive volume group *myvg* giving verbose runtime information:

```
# vgmerge -v myvg databases
```

Additional resources

- **vgmerge(8)** man page

6.3. REMOVING PHYSICAL VOLUMES FROM A VOLUME GROUP

To remove unused physical volumes from a volume group, use the **vgreduce** command. The **vgreduce** command shrinks a volume group's capacity by removing one or more empty physical volumes. This frees those physical volumes to be used in different volume groups or to be removed from the system.

Procedure

1. If the physical volume is still being used, migrate the data to another physical volume from the same volume group :

```
# pvmove /dev/vdb3
  /dev/vdb3: Moved: 2.0%
  ...
```

```
  /dev/vdb3: Moved: 79.2%
  ...
  /dev/vdb3: Moved: 100.0%
```

2. If there are no enough free extents on the other physical volumes in the existing volume group:

   a. Create a new physical volume from */dev/vdb4*:

   ```
   # pvcreate /dev/vdb4
     Physical volume "/dev/vdb4" successfully created
   ```

   b. Add the newly created physical volume to the *myvg* volume group:

   ```
   # vgextend myvg /dev/vdb4
     Volume group "myvg" successfully extended
   ```

   c. Move the data from */dev/vdb3* to */dev/vdb4*:

   ```
   # pvmove /dev/vdb3 /dev/vdb4
     /dev/vdb3: Moved: 33.33%
     /dev/vdb3: Moved: 100.00%
   ```

3. Remove the physical volume */dev/vdb3* from the volume group:

```
# vgreduce myvg /dev/vdb3
Removed "/dev/vdb3" from volume group "myvg"
```

Verification

- Verify if the */dev/vdb3* physical volume is removed from the *myvg* volume group:

```
# pvs
  PV         VG    Fmt   Attr  PSize       PFree      Used
  /dev/vdb1  myvg  lvm2  a--   1020.00m    0          1020.00m
  /dev/vdb2  myvg  lvm2  a--   1020.00m    0          1020.00m
  /dev/vdb3        lvm2  a--   1020.00m  1008.00m    12.00m
```

Additional resources

- **vgreduce(8)**, **pvmove(8)**, and **pvs(8)** man pages

6.4. SPLITTING A LVM VOLUME GROUP

This procedure describes how to split the existing volume group. If there is enough unused space on the physical volumes, a new volume group can be created without adding new disks.

In the initial setup, the volume group *myvg* consists of */dev/vdb1*, */dev/vdb2*, and */dev/vdb3*. After completing this procedure, the volume group *myvg* will consist of */dev/vdb1* and */dev/vdb2*, and the second volume group, *yourvg*, will consist of */dev/vdb3*.

Prerequisites

- You have sufficient space in the volume group. Use the **vgscan** command to determine how much free space is currently available in the volume group.
- Depending on the free capacity in the existing physical volume, move all the used physical extents to other physical volume using the **pvmove** command. For more information, see Removing physical volumes from a volume group .

Procedure

1. Split the existing volume group *myvg* to the new volume group *yourvg*:

```
# vgsplit myvg yourvg /dev/vdb3
  Volume group "yourvg" successfully split from "myvg"
```

NOTE

If you have created a logical volume using the existing volume group, use the following command to deactivate the logical volume:

```
# lvchange -a n /dev/myvg/mylv
```

For more information on creating logical volumes, see Managing LVM logical volumes.

2. View the attributes of the two volume group:

```
# vgs
  VG     #PV #LV #SN Attr   VSize  VFree
  myvg     2   1   0 wz--n- 34.30G 10.80G
  yourvg   1   0   0 wz--n- 17.15G 17.15G
```

Verification

- Verify if the newly created volume group *yourvg* consists of */dev/vdb3* physical volume:

```
# pvs
  PV         VG     Fmt  Attr PSize    PFree    Used
  /dev/vdb1 myvg   lvm2 a--  1020.00m    0     1020.00m
  /dev/vdb2 myvg   lvm2 a--  1020.00m    0     1020.00m
  /dev/vdb3 yourvg lvm2 a--  1020.00m 1008.00m  12.00m
```

Additional resources

- **vgsplit(8)**, **vgs(8)**, and **pvs(8)** man pages

6.5. RENAMING LVM VOLUME GROUPS

This procedure renames an existing volume group *myvg* to *myvg1*.

Procedure

1. Deactivate the volume group. If it is a clustered volume group, deactivate the volume group on all nodes where it is active by using the following command on each such node:

```
# vgchange --activate n myvg
```

2. Rename an existing volume group:

```
# vgrename myvg myvg1
Volume group "myvg" successfully renamed to "myvg1"
```

You can also rename the volume group by specifying the full paths to the devices:

```
# vgrename /dev/myvg /dev/myvg1
```

Additional resources

- **vgrename(8)** man page

6.6. MOVING A VOLUME GROUP TO ANOTHER SYSTEM

You can move an entire LVM volume group to another system. It is recommended that you use the **vgexport** and **vgimport** commands when you do this.

NOTE

You can use the **--force** argument of the **vgimport** command. This allows you to import volume groups that are missing physical volumes and subsequently run the **vgreduce --removemissing** command.

The **vgexport** command makes an inactive volume group inaccessible to the system, which allows you to detach its physical volumes. The **vgimport** command makes a volume group accessible to a machine again after the **vgexport** command has made it inactive.

To move a volume group from one system to another, perform the following steps:

1. Make sure that no users are accessing files on the active volumes in the volume group, then unmount the logical volumes.

2. Use the **-a n** argument of the **vgchange** command to mark the volume group as inactive, which prevents any further activity on the volume group.

3. Use the **vgexport** command to export the volume group. This prevents it from being accessed by the system from which you are removing it.
After you export the volume group, the physical volume will show up as being in an exported volume group when you execute the **pvscan** command, as in the following example.

```
# pvscan
  PV /dev/sda1    is in exported VG myvg [17.15 GB / 7.15 GB free]
  PV /dev/sdc1    is in exported VG myvg [17.15 GB / 15.15 GB free]
  PV /dev/sdd1   is in exported VG myvg [17.15 GB / 15.15 GB free]
  ...
```

When the system is next shut down, you can unplug the disks that constitute the volume group and connect them to the new system.

4. When the disks are plugged into the new system, use the **vgimport** command to import the volume group, making it accessible to the new system.

5. Activate the volume group with the **-a y** argument of the **vgchange** command.

6. Mount the file system to make it available for use.

6.7. REMOVING LVM VOLUME GROUPS

This procedure describes how to remove an existing volume group.

Prerequisites

- The volume group contains no logical volumes. To remove logical volumes from a volume group, see Removing LVM logical volumes.

Procedure

1. If the volume group exists in a clustered environment, stop the **lockspace** of the volume group on all other nodes. Use the following command on all nodes except the node where you are performing the removing:

```
# vgchange --lockstop vg-name
```

Wait for the lock to stop.

2. Remove the volume group:

```
# vgremove vg-name
  Volume group "vg-name" successfully removed
```

Additional resources

- **vgremove(8)** man page

CHAPTER 7. MANAGING LVM PHYSICAL VOLUMES

There are a variety of commands and procedures you can use to manage LVM physical volumes.

7.1. SCANNING FOR BLOCK DEVICES TO USE AS PHYSICAL VOLUMES

You can scan for block devices that may be used as physical volumes with the **lvmdiskscan** command, as shown in the following example.

```
# lvmdiskscan
  /dev/ram0                 [       16.00 MB]
  /dev/sda                  [       17.15 GB]
  /dev/root                 [       13.69 GB]
  /dev/ram                  [       16.00 MB]
  /dev/sda1                 [       17.14 GB] LVM physical volume
  /dev/VolGroup00/LogVol01     [      512.00 MB]
  /dev/ram2                 [       16.00 MB]
  /dev/new_vg/lvol0            [       52.00 MB]
  /dev/ram3                 [       16.00 MB]
  /dev/pkl_new_vg/sparkie_lv   [        7.14 GB]
  /dev/ram4                 [       16.00 MB]
  /dev/ram5                 [       16.00 MB]
  /dev/ram6                 [       16.00 MB]
  /dev/ram7                 [       16.00 MB]
  /dev/ram8                 [       16.00 MB]
  /dev/ram9                 [       16.00 MB]
  /dev/ram10                [       16.00 MB]
  /dev/ram11                [       16.00 MB]
  /dev/ram12                [       16.00 MB]
  /dev/ram13                [       16.00 MB]
  /dev/ram14                [       16.00 MB]
  /dev/ram15                [       16.00 MB]
  /dev/sdb                  [       17.15 GB]
  /dev/sdb1                 [       17.14 GB] LVM physical volume
  /dev/sdc                  [       17.15 GB]
  /dev/sdc1                 [       17.14 GB] LVM physical volume
  /dev/sdd                  [       17.15 GB]
  /dev/sdd1                 [       17.14 GB] LVM physical volume
  7 disks
  17 partitions
  0 LVM physical volume whole disks
  4 LVM physical volumes
```

7.2. SETTING THE PARTITION TYPE FOR A PHYSICAL VOLUME

If you are using a whole disk device for your physical volume, the disk must have no partition table. For DOS disk partitions, the partition id should be set to 0x8e using the **fdisk** or **cfdisk** command or an equivalent. For whole disk devices only the partition table must be erased, which will effectively destroy all data on that disk. You can remove an existing partition table by zeroing the first sector with the following command:

```
# dd if=/dev/zero of=PhysicalVolume bs=512 count=1
```

7.3. RESIZING AN LVM PHYSICAL VOLUME

If you need to change the size of an underlying block device for any reason, use the **pvresize** command to update LVM with the new size. You can execute this command while LVM is using the physical volume.

7.4. REMOVING LVM PHYSICAL VOLUMES

If a device is no longer required for use by LVM, you can remove the LVM label by using the **pvremove** command. Executing the **pvremove** command zeroes the LVM metadata on an empty physical volume.

Procedure

1. Remove a physical volume:

```
# pvremove /dev/vdb3
Labels on physical volume "/dev/vdb3" successfully wiped.
```

2. View the existing physical volumes and verify if the required volume is removed:

```
# pvs
  PV         VG   Fmt   Attr   PSize     PFree
/dev/vdb1        lvm2          1020.00m   0
/dev/vdb2        lvm2          1020.00m   0
```

If the physical volume you want to remove is currently part of a volume group, you must remove it from the volume group with the **vgreduce** command. For more information, see Removing physical volumes from a volume group

Additional resources

- **pvremove(8)** man page

7.5. ADDING PHYSICAL VOLUMES TO A VOLUME GROUP

To add additional physical volumes to an existing volume group, use the **vgextend** command. The **vgextend** command increases a volume group's capacity by adding one or more free physical volumes.

The following command adds the physical volume **/dev/sdf1** to the volume group **vg1**.

```
# vgextend vg1 /dev/sdf1
```

7.6. REMOVING PHYSICAL VOLUMES FROM A VOLUME GROUP

To remove unused physical volumes from a volume group, use the **vgreduce** command. The **vgreduce** command shrinks a volume group's capacity by removing one or more empty physical volumes. This frees those physical volumes to be used in different volume groups or to be removed from the system.

Procedure

1. If the physical volume is still being used, migrate the data to another physical volume from the same volume group :

```
# pvmove /dev/vdb3
  /dev/vdb3: Moved: 2.0%
 ...
  /dev/vdb3: Moved: 79.2%
 ...
  /dev/vdb3: Moved: 100.0%
```

2. If there are no enough free extents on the other physical volumes in the existing volume group:

   a. Create a new physical volume from */dev/vdb4*:

   ```
   # pvcreate /dev/vdb4
     Physical volume "/dev/vdb4" successfully created
   ```

   b. Add the newly created physical volume to the *myvg* volume group:

   ```
   # vgextend myvg /dev/vdb4
     Volume group "myvg" successfully extended
   ```

   c. Move the data from */dev/vdb3* to */dev/vdb4*:

   ```
   # pvmove /dev/vdb3 /dev/vdb4
     /dev/vdb3: Moved: 33.33%
     /dev/vdb3: Moved: 100.00%
   ```

3. Remove the physical volume */dev/vdb3* from the volume group:

```
# vgreduce myvg /dev/vdb3
Removed "/dev/vdb3" from volume group "myvg"
```

Verification

- Verify if the */dev/vdb3* physical volume is removed from the *myvg* volume group:

```
# pvs
  PV         VG    Fmt   Attr  PSize       PFree      Used
  /dev/vdb1  myvg  lvm2  a--   1020.00m    0          1020.00m
  /dev/vdb2  myvg  lvm2  a--   1020.00m    0          1020.00m
  /dev/vdb3        lvm2  a--   1020.00m  1008.00m    12.00m
```

Additional resources

- **vgreduce(8)**, **pvmove(8)**, and **pvs(8)** man pages

CHAPTER 8. DISPLAYING LVM COMPONENTS

LVM provides a variety of ways to display the LVM components, as well as to customize the display. This sections summarizes the usage of the basic LVM display commands.

8.1. DISPLAYING LVM INFORMATION WITH THE LVM COMMAND

The **lvm** command provides several built-in options that you can use to display information about LVM support and configuration.

- **lvm devtypes**
  Displays the recognized built-in block device types
- **lvm formats**
  Displays recognized metadata formats.
- **lvm help**
  Displays LVM help text.
- **lvm segtypes**
  Displays recognized logical volume segment types.
- **lvm tags**
  Displays any tags defined on this host.
- **lvm version**
  Displays the current version information.

8.2. DISPLAYING PHYSICAL VOLUMES

There are three commands you can use to display properties of LVM physical volumes: **pvs**, **pvdisplay**, and **pvscan**.

The **pvs** command provides physical volume information in a configurable form, displaying one line per physical volume. The **pvs** command provides a great deal of format control, and is useful for scripting.

The **pvdisplay** command provides a verbose multi-line output for each physical volume. It displays physical properties (size, extents, volume group, and so on) in a fixed format.

The following example shows the output of the **pvdisplay** command for a single physical volume.

```
# pvdisplay
  --- Physical volume ---
  PV Name               /dev/sdc1
  VG Name               new_vg
  PV Size               17.14 GB / not usable 3.40 MB
  Allocatable           yes
  PE Size (KByte)       4096
  Total PE              4388
  Free PE               4375
  Allocated PE          13
  PV UUID               Joqlch-yWSj-kuEn-IdwM-01S9-XO8M-mcpsVe
```

The **pvscan** command scans all supported LVM block devices in the system for physical volumes.

The following command shows all physical devices found:

```
# pvscan
 PV /dev/sdb2   VG vg0   lvm2 [964.00 MB / 0   free]
 PV /dev/sdc1   VG vg0   lvm2 [964.00 MB / 428.00 MB free]
 PV /dev/sdc2            lvm2 [964.84 MB]
 Total: 3 [2.83 GB] / in use: 2 [1.88 GB] / in no VG: 1 [964.84 MB]
```

You can define a filter in the **lvm.conf** file so that this command will avoid scanning specific physical volumes.

8.3. DISPLAYING VOLUME GROUPS

There are two commands you can use to display properties of LVM volume groups: **vgs** and **vgdisplay**. The **vgscan** command, which scans all supported LVM block devices in the system for volume groups, can also be used to display the existing volume groups.

The **vgs** command provides volume group information in a configurable form, displaying one line per volume group. The **vgs** command provides a great deal of format control, and is useful for scripting.

The **vgdisplay** command displays volume group properties (such as size, extents, number of physical volumes, and so on) in a fixed form. The following example shows the output of the **vgdisplay** command for the volume group **new_vg**. If you do not specify a volume group, all existing volume groups are displayed.

```
# vgdisplay new_vg
  --- Volume group ---
  VG Name               new_vg
  System ID
  Format                lvm2
  Metadata Areas        3
  Metadata Sequence No  11
  VG Access             read/write
  VG Status             resizable
  MAX LV                0
  Cur LV                1
  Open LV               0
  Max PV                0
  Cur PV                3
  Act PV                3
  VG Size               51.42 GB
  PE Size               4.00 MB
  Total PE              13164
  Alloc PE / Size       13 / 52.00 MB
  Free  PE / Size       13151 / 51.37 GB
  VG UUID               jxQJ0a-ZKk0-OpMO-0118-nlwO-wwqd-fD5D32
```

The following example shows the output of the **vgscan** command.

```
# vgscan
Reading all physical volumes.  This may take a while...
Found volume group "new_vg" using metadata type lvm2
Found volume group "officevg" using metadata type lvm2
```

8.4. DISPLAYING LOGICAL VOLUMES

There are three commands you can use to display properties of LVM logical volumes: **lvs**, **lvdisplay**, and **lvscan**.

The **lvs** command provides logical volume information in a configurable form, displaying one line per logical volume. The **lvs** command provides a great deal of format control, and is useful for scripting.

The **lvdisplay** command displays logical volume properties (such as size, layout, and mapping) in a fixed format.

The following command shows the attributes of **lvol2** in **vg00**. If snapshot logical volumes have been created for this original logical volume, this command shows a list of all snapshot logical volumes and their status (active or inactive) as well.

```
# lvdisplay -v /dev/vg00/lvol2
```

The **lvscan** command scans for all logical volumes in the system and lists them, as in the following example.

```
# lvscan
  ACTIVE            '/dev/vg0/gfslv' [1.46 GB] inherit
```

CHAPTER 9. CUSTOMIZED REPORTING FOR LVM

LVM provides a wide range of configuration and command line options to produce customized reports and to filter the report's output. For a full description of LVM reporting features and capabilities, see the **lvmreport**(7) man page.

You can produce concise and customizable reports of LVM objects with the **pvs**, **lvs**, and **vgs** commands. The reports that these commands generate include one line of output for each object. Each line contains an ordered list of fields of properties related to the object. There are five ways to select the objects to be reported: by physical volume, volume group, logical volume, physical volume segment, and logical volume segment.

You can report information about physical volumes, volume groups, logical volumes, physical volume segments, and logical volume segments all at once with the **lvm fullreport** command. For information on this command and its capabilities, see the **lvm-fullreport**(8) man page.

LVM supports log reports, which contain a log of operations, messages, and per-object status with complete object identification collected during LVM command execution. For further information about the LVM log report. see the **lvmreport**(7) man page.

9.1. CONTROLLING THE FORMAT OF THE LVM DISPLAY

Whether you use the **pvs**, **lvs**, or **vgs** command determines the default set of fields displayed and the sort order. You can control the output of these commands with the following arguments:

- You can change what fields are displayed to something other than the default by using the **-o** argument. For example, the following command displays only the physical volume name and size.

```
# pvs -o pv_name,pv_size
PV PSize
/dev/sdb1 17.14G
/dev/sdc1 17.14G
/dev/sdd1 17.14G
```

- You can append a field to the output with the plus sign (+), which is used in combination with the -o argument.
  The following example displays the UUID of the physical volume in addition to the default fields.

```
# pvs -o +pv_uuid
PV VG Fmt Attr PSize PFree PV UUID
/dev/sdb1 new_vg lvm2 a- 17.14G 17.14G onFF2w-1fLC-ughJ-D9eB-M7iv-6XqA-dqGeXY
/dev/sdc1 new_vg lvm2 a- 17.14G 17.09G Joqlch-yWSj-kuEn-IdwM-01S9-X08M-mcpsVe
/dev/sdd1 new_vg lvm2 a- 17.14G 17.14G yvfvZK-Cf31-j75k-dECm-0RZ3-0dGW-UqkCS
```

- Adding the **-v** argument to a command includes some extra fields. For example, the **pvs -v** command will display the **DevSize** and **PV UUID** fields in addition to the default fields.

```
# pvs -v
Scanning for physical volume names
PV VG Fmt Attr PSize PFree DevSize PV UUID
/dev/sdb1 new_vg lvm2 a- 17.14G 17.14G 17.14G onFF2w-1fLC-ughJ-D9eB-M7iv-6XqA-
dqGeXY
/dev/sdc1 new_vg lvm2 a- 17.14G 17.09G 17.14G Joqlch-yWSj-kuEn-IdwM-01S9-XO8M-
```

```
  mcpsVe
  /dev/sdd1 new_vg lvm2 a- 17.14G 17.14G 17.14G yvfvZK-Cf31-j75k-dECm-0RZ3-0dGW-
  tUqkCS
```

- The **--noheadings** argument suppresses the headings line. This can be useful for writing scripts. The following example uses the **--noheadings** argument in combination with the **pv_name** argument, which will generate a list of all physical volumes.

```
# pvs --noheadings -o pv_name
  /dev/sdb1
  /dev/sdc1
  /dev/sdd1
```

- The **--separator *separator*** argument uses *separator* to separate each field.
  The following example separates the default output fields of the **pvs** command with an equals sign (=).

```
# pvs --separator =
  PV=VG=Fmt=Attr=PSize=PFree
  /dev/sdb1=new_vg=lvm2=a-=17.14G=17.14G
  /dev/sdc1=new_vg=lvm2=a-=17.14G=17.09G
  /dev/sdd1=new_vg=lvm2=a-=17.14G=17.14G
```

  To keep the fields aligned when using the **separator** argument, use the **separator** argument in conjunction with the **--aligned** argument.

```
# pvs --separator = --aligned
  PV =VG =Fmt =Attr=PSize =PFree
  /dev/sdb1 =new_vg=lvm2=a- =17.14G=17.14G
  /dev/sdc1 =new_vg=lvm2=a- =17.14G=17.09G
  /dev/sdd1 =new_vg=lvm2=a- =17.14G=17.14G
```

You can use the **-P** argument of the **lvs** or **vgs** command to display information about a failed volume that would otherwise not appear in the output.

For a full listing of display arguments, see the **pvs**(8), **vgs**(8) and **lvs**(8) man pages.

Volume group fields can be mixed with either physical volume (and physical volume segment) fields or with logical volume (and logical volume segment) fields, but physical volume and logical volume fields cannot be mixed. For example, the following command will display one line of output for each physical volume.

```
# vgs -o +pv_name
  VG     #PV #LV #SN Attr   VSize  VFree  PV
  new_vg   3   1   0 wz--n- 51.42G 51.37G /dev/sdc1
  new_vg   3   1   0 wz--n- 51.42G 51.37G /dev/sdd1
  new_vg   3   1   0 wz--n- 51.42G 51.37G /dev/sdb1
```

9.2. LVM OBJECT DISPLAY FIELDS

This section provides a series of tables that list the information you can display about the LVM objects with the **pvs**, **vgs**, and **lvs** commands.

For convenience, a field name prefix can be dropped if it matches the default for the command. For example, with the **pvs** command, **name** means **pv_name**, but with the **vgs** command, **name** is interpreted as **vg_name**.

Executing the following command is the equivalent of executing **pvs -o pv_free**.

```
# pvs -o free
  PFree
  17.14G
  17.09G
  17.14G
```

NOTE

The number of characters in the attribute fields in **pvs**, **vgs**, and **lvs** output may increase in later releases. The existing character fields will not change position, but new fields may be added to the end. You should take this into account when writing scripts that search for particular attribute characters, searching for the character based on its relative position to the beginning of the field, but not for its relative position to the end of the field. For example, to search for the character **p** in the ninth bit of the **lv_attr** field, you could search for the string "^/.....p/", but you should not search for the string "/*p$/".

Table 9.1, “The pvs Command Display Fields” lists the display arguments of the **pvs** command, along with the field name as it appears in the header display and a description of the field.

Table 9.1. The pvs Command Display Fields

Argument	Header	Description
dev_size	DevSize	The size of the underlying device on which the physical volume was created
pe_start	1st PE	Offset to the start of the first physical extent in the underlying device
pv_attr	Attr	Status of the physical volume: (a)llocatable or e(x)ported.
pv_fmt	Fmt	The metadata format of the physical volume (**lvm2** or **lvm1**)
pv_free	PFree	The free space remaining on the physical volume
pv_name	PV	The physical volume name
pv_pe_alloc_count	Alloc	Number of used physical extents
pv_pe_count	PE	Number of physical extents
pvseg_size	SSize	The segment size of the physical volume
pvseg_start	Start	The starting physical extent of the physical volume segment

Argument	Header	Description
pv_size	PSize	The size of the physical volume
pv_tags	PV Tags	LVM tags attached to the physical volume
pv_used	Used	The amount of space currently used on the physical volume
pv_uuid	PV UUID	The UUID of the physical volume

The **pvs** command displays the following fields by default: **pv_name**, **vg_name**, **pv_fmt**, **pv_attr**, **pv_size**, **pv_free**. The display is sorted by **pv_name**.

```
# pvs
  PV         VG     Fmt  Attr PSize  PFree
  /dev/sdb1  new_vg lvm2 a-   17.14G 17.14G
  /dev/sdc1  new_vg lvm2 a-   17.14G 17.09G
  /dev/sdd1  new_vg lvm2 a-   17.14G 17.13G
```

Using the **-v** argument with the **pvs** command adds the following fields to the default display: **dev_size**, **pv_uuid**.

```
# pvs -v
    Scanning for physical volume names
  PV         VG     Fmt  Attr PSize  PFree  DevSize PV UUID
  /dev/sdb1  new_vg lvm2 a-   17.14G 17.14G  17.14G onFF2w-1fLC-ughJ-D9eB-M7iv-6XqA-
dqGeXY
  /dev/sdc1  new_vg lvm2 a-   17.14G 17.09G  17.14G Joqlch-yWSj-kuEn-IdwM-01S9-XO8M-mcpsVe
  /dev/sdd1  new_vg lvm2 a-   17.14G 17.13G  17.14G yvfvZK-Cf31-j75k-dECm-0RZ3-0dGW-tUqkCS
```

You can use the **--segments** argument of the **pvs** command to display information about each physical volume segment. A segment is a group of extents. A segment view can be useful if you want to see whether your logical volume is fragmented.

The **pvs --segments** command displays the following fields by default: **pv_name**, **vg_name**, **pv_fmt**, **pv_attr**, **pv_size**, **pv_free**, **pvseg_start**, **pvseg_size**. The display is sorted by **pv_name** and **pvseg_size** within the physical volume.

```
# pvs --segments
  PV         VG         Fmt  Attr PSize  PFree  Start SSize
  /dev/hda2  VolGroup00 lvm2 a-   37.16G 32.00M     0  1172
  /dev/hda2  VolGroup00 lvm2 a-   37.16G 32.00M  1172    16
  /dev/hda2  VolGroup00 lvm2 a-   37.16G 32.00M  1188     1
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G     0    26
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G    26    24
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G    50    26
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G    76    24
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G   100    26
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G   126    24
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G   150    22
  /dev/sda1  vg         lvm2 a-   17.14G 16.75G   172  4217
  /dev/sdb1  vg         lvm2 a-   17.14G 17.14G     0  4389
```

```
  /dev/sdc1  vg       lvm2 a-   17.14G 17.14G     0  4389
  /dev/sdd1  vg       lvm2 a-   17.14G 17.14G     0  4389
  /dev/sde1  vg       lvm2 a-   17.14G 17.14G     0  4389
  /dev/sdf1  vg       lvm2 a-   17.14G 17.14G     0  4389
  /dev/sdg1  vg       lvm2 a-   17.14G 17.14G     0  4389
```

You can use the **pvs -a** command to see devices detected by LVM that have not been initialized as LVM physical volumes.

```
# pvs -a
  PV                         VG     Fmt  Attr PSize  PFree
  /dev/VolGroup00/LogVol01                --       0      0
  /dev/new_vg/lvol0                       --       0      0
  /dev/ram                                --       0      0
  /dev/ram0                               --       0      0
  /dev/ram2                               --       0      0
  /dev/ram3                               --       0      0
  /dev/ram4                               --       0      0
  /dev/ram5                               --       0      0
  /dev/ram6                               --       0      0
  /dev/root                               --       0      0
  /dev/sda                                --       0      0
  /dev/sdb                                --       0      0
  /dev/sdb1                  new_vg lvm2 a-   17.14G 17.14G
  /dev/sdc                                --       0      0
  /dev/sdc1                  new_vg lvm2 a-   17.14G 17.09G
  /dev/sdd                                --       0      0
  /dev/sdd1                  new_vg lvm2 a-   17.14G 17.14G
```

Table 9.2, "vgs Display Fields" lists the display arguments of the **vgs** command, along with the field name as it appears in the header display and a description of the field.

Table 9.2. vgs Display Fields

Argument	Header	Description
lv_count	#LV	The number of logical volumes the volume group contains
max_lv	MaxLV	The maximum number of logical volumes allowed in the volume group (0 if unlimited)
max_pv	MaxPV	The maximum number of physical volumes allowed in the volume group (0 if unlimited)
pv_count	#PV	The number of physical volumes that define the volume group
snap_count	#SN	The number of snapshots the volume group contains
vg_attr	Attr	Status of the volume group: (w)riteable, (r)eadonly, resi(z)eable, e(x)ported, (p)artial and (c)lustered.

Argument	Header	Description
vg_extent_count	#Ext	The number of physical extents in the volume group
vg_extent_size	Ext	The size of the physical extents in the volume group
vg_fmt	Fmt	The metadata format of the volume group (**lvm2** or **lvm1**)
vg_free	VFree	Size of the free space remaining in the volume group
vg_free_count	Free	Number of free physical extents in the volume group
vg_name	VG	The volume group name
vg_seqno	Seq	Number representing the revision of the volume group
vg_size	VSize	The size of the volume group
vg_sysid	SYS ID	LVM1 System ID
vg_tags	VG Tags	LVM tags attached to the volume group
vg_uuid	VG UUID	The UUID of the volume group

The **vgs** command displays the following fields by default: **vg_name**, **pv_count**, **lv_count**, **snap_count**, **vg_attr**, **vg_size**, **vg_free**. The display is sorted by **vg_name**.

```
# vgs
  VG     #PV #LV #SN Attr   VSize  VFree
  new_vg   3   1   1 wz--n- 51.42G 51.36G
```

Using the **-v** argument with the **vgs** command adds the following fields to the default display: **vg_extent_size**, **vg_uuid**.

```
# vgs -v
    Finding all volume groups
    Finding volume group "new_vg"
  VG     Attr   Ext   #PV #LV #SN VSize  VFree  VG UUID
  new_vg wz--n- 4.00M   3   1   1 51.42G 51.36G jxQJ0a-ZKk0-OpMO-0118-nlwO-wwqd-fD5D32
```

Table 9.3, "lvs Display Fields" lists the display arguments of the **lvs** command, along with the field name as it appears in the header display and a description of the field.

NOTE

In later releases of Red Hat Enterprise Linux, the output of the **lvs** command may differ, with additional fields in the output. The order of the fields, however, will remain the same and any additional fields will appear at the end of the display.

Table 9.3. lvs Display Fields

Argument	Header	Description
* **chunksize** * **chunk_size**	Chunk	Unit size in a snapshot volume
copy_percent	Copy%	The synchronization percentage of a mirrored logical volume; also used when physical extents are being moved with the **pv_move** command
devices	Devices	The underlying devices that make up the logical volume: the physical volumes, logical volumes, and start physical extents and logical extents
lv_ancestors	Ancestors	For thin pool snapshots, the ancestors of the logical volume
lv_descendants	Descendants	For thin pool snapshots, the descendants of the logical volume
lv_attr	Attr	The status of the logical volume. The logical volume attribute bits are as follows: * Bit 1: Volume type: (m)irrored, (M)irrored without initial sync, (o)rigin, (O)rigin with merging snapshot, (r)aid, ®aid without initial sync, (s)napshot, merging (S)napshot, (p)vmove, (v)irtual, mirror or raid (i)mage, mirror or raid (I)mage out-of-sync, mirror (l)og device, under (c)onversion, thin (V)olume, (t)hin pool, (T)hin pool data, raid or thin pool m(e)tadata or pool metadata spare, * Bit 2: Permissions: (w)riteable, (r)ead-only, ®ead-only activation of non-read-only volume * Bit 3: Allocation policy: (a)nywhere, (c)ontiguous, (i)nherited, c(l)ing, (n)ormal. This is capitalized if the volume is currently locked against allocation changes, for example while executing the **pvmove** command. * Bit 4: fixed (m)inor * Bit 5: State: (a)ctive, (s)uspended, (I)nvalid snapshot, invalid (S)uspended snapshot, snapshot (m)erge failed, suspended snapshot (M)erge failed, mapped (d)evice present without tables, mapped device present with (i)nactive table * Bit 6: device (o)pen * Bit 7: Target type: (m)irror, (r)aid, (s)napshot, (t)hin, (u)nknown, (v)irtual. This groups logical volumes related to the same kernel target together. So, for example, mirror images, mirror logs as well as mirrors themselves appear as (m) if they use the original device-mapper mirror kernel

Argument	Header	Description
		driver, whereas the raid equivalents using the md raid kernel driver all appear as (r). Snapshots using the original device-mapper driver appear as (s), whereas snapshots of thin volumes using the thin provisioning driver appear as (t). * Bit 8: Newly-allocated data blocks are overwritten with blocks of (z)eroes before use. * Bit 9: Volume Health: (p)artial, (r)efresh needed, (m)ismatches exist, (w)ritemostly. (p)artial signifies that one or more of the Physical Volumes this Logical Volume uses is missing from the system. (r)efresh signifies that one or more of the Physical Volumes this RAID Logical Volume uses had suffered a write error. The write error could be due to a temporary failure of that Physical Volume or an indication that it is failing. The device should be refreshed or replaced. (m)ismatches signifies that the RAID logical volume has portions of the array that are not coherent. Inconsistencies are discovered by initiating a **check** operation on a RAID logical volume. (The scrubbing operations, **check** and **repair**, can be performed on a RAID Logical Volume by means of the **lvchange** command.) (w)ritemostly signifies the devices in a RAID 1 logical volume that have been marked write-mostly. * Bit 10: s(k)ip activation: this volume is flagged to be skipped during activation.
lv_kernel_major	KMaj	Actual major device number of the logical volume (-1 if inactive)
lv_kernel_minor	KMIN	Actual minor device number of the logical volume (-1 if inactive)
lv_major	Maj	The persistent major device number of the logical volume (-1 if not specified)
lv_minor	Min	The persistent minor device number of the logical volume (-1 if not specified)
lv_name	LV	The name of the logical volume
lv_size	LSize	The size of the logical volume
lv_tags	LV Tags	LVM tags attached to the logical volume
lv_uuid	LV UUID	The UUID of the logical volume.
mirror_log	Log	Device on which the mirror log resides
modules	Modules	Corresponding kernel device-mapper target necessary to use this logical volume

Argument	Header	Description
move_pv	Move	Source physical volume of a temporary logical volume created with the **pvmove** command
origin	Origin	The origin device of a snapshot volume
* **regionsize** * **region_size**	Region	The unit size of a mirrored logical volume
seg_count	#Seg	The number of segments in the logical volume
seg_size	SSize	The size of the segments in the logical volume
seg_start	Start	Offset of the segment in the logical volume
seg_tags	Seg Tags	LVM tags attached to the segments of the logical volume
segtype	Type	The segment type of a logical volume (for example: mirror, striped, linear)
snap_percent	Snap%	Current percentage of a snapshot volume that is in use
stripes	#Str	Number of stripes or mirrors in a logical volume
* **stripesize** * **stripe_size**	Stripe	Unit size of the stripe in a striped logical volume

The **lvs** command provides the following display by default. The default display is sorted by **vg_name** and **lv_name** within the volume group.

```
# lvs
  LV     VG            Attr       LSize    Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  origin VG            owi-a-s---    1.00g
  snap   VG            swi-a-s--- 100.00m      origin 0.00
```

A common use of the **lvs** command is to append **devices** to the command to display the underlying devices that make up the logical volume. This example also specifies the **-a** option to display the internal volumes that are components of the logical volumes, such as RAID mirrors, enclosed in brackets. This example includes a RAID volume, a striped volume, and a thinly-pooled volume.

```
# lvs -a -o +devices
  LV              VG           Attr       LSize    Pool   Origin Data%  Meta%  Move Log Cpy%Sync Convert
Devices
  raid1           VG           rwi-a-r---   1.00g                                    100.00
raid1_rimage_0(0),raid1_rimage_1(0)
  [raid1_rimage_0] VG          iwi-aor---   1.00g                                                 /dev/sde1(7041)
```

```
  [raid1_rimage_1] VG          iwi-aor---   1.00g                                    /dev/sdf1(7041)
  [raid1_rmeta_0]  VG          ewi-aor---   4.00m                                    /dev/sde1(7040)
  [raid1_rmeta_1]  VG          ewi-aor---   4.00m                                    /dev/sdf1(7040)
  stripe1          VG          -wi-a-----  99.95g                                   /dev/sde1(0),/dev/sdf1(0)
  stripe1          VG          -wi-a-----  99.95g                                   /dev/sdd1(0)
  stripe1          VG          -wi-a-----  99.95g                                   /dev/sdc1(0)
  [lvol0_pmspare]  rhel_host-083 ewi-------   4.00m                                    /dev/vda2(0)
  pool00           rhel_host-083 twi-aotz--  <4.79g              72.90  54.69
pool00_tdata(0)
  [pool00_tdata]   rhel_host-083 Twi-ao----  <4.79g                                    /dev/vda2(1)
  [pool00_tmeta]   rhel_host-083 ewi-ao----   4.00m                                    /dev/vda2(1226)
  root             rhel_host-083 Vwi-aotz--  <4.79g pool00        72.90
  swap             rhel_host-083 -wi-ao---- 820.00m                                   /dev/vda2(1227)
```

Using the **-v** argument with the **lvs** command adds the following fields to the default display: **seg_count**, **lv_major**, **lv_minor**, **lv_kernel_major**, **lv_kernel_minor**, **lv_uuid**.

```
# lvs -v
    Finding all logical volumes
  LV        VG     #Seg Attr   LSize  Maj Min KMaj KMin Origin Snap%  Move Copy%  Log Convert LV
UUID
  lvol0     new_vg    1 owi-a- 52.00M  -1  -1 253  3                                       LBy1Tz-sr23-OjsI-LT03-
nHLC-y8XW-EhCl78
  newvgsnap1 new_vg    1 swi-a-  8.00M  -1  -1 253  5    lvol0    0.20                   1ye1OU-1clu-
o79k-20h2-ZGF0-qCJm-CfbsIx
```

You can use the **--segments** argument of the **lvs** command to display information with default columns that emphasize the segment information. When you use the **segments** argument, the **seg** prefix is optional. The **lvs --segments** command displays the following fields by default: **lv_name**, **vg_name**, **lv_attr**, **stripes**, **segtype**, **seg_size**. The default display is sorted by **vg_name**, **lv_name** within the volume group, and **seg_start** within the logical volume. If the logical volumes were fragmented, the output from this command would show that.

```
# lvs --segments
  LV      VG         Attr   #Str Type   SSize
  LogVol00 VolGroup00 -wi-ao    1 linear  36.62G
  LogVol01 VolGroup00 -wi-ao    1 linear 512.00M
  lv      vg         -wi-a-    1 linear 104.00M
  lv      vg         -wi-a-    1 linear 104.00M
  lv      vg         -wi-a-    1 linear 104.00M
  lv      vg         -wi-a-    1 linear  88.00M
```

Using the **-v** argument with the **lvs --segments** command adds the following fields to the default display: **seg_start**, **stripesize**, **chunksize**.

```
# lvs -v --segments
    Finding all logical volumes
  LV        VG     Attr   Start SSize  #Str Type   Stripe Chunk
  lvol0     new_vg owi-a-    0  52.00M    1 linear     0     0
  newvgsnap1 new_vg swi-a-    0   8.00M    1 linear     0  8.00K
```

The following example shows the default output of the **lvs** command on a system with one logical volume configured, followed by the default output of the **lvs** command with the **segments** argument specified.

```
# lvs
  LV    VG     Attr   LSize  Origin Snap%  Move Log Copy%
  lvol0 new_vg -wi-a- 52.00M
# lvs --segments
  LV    VG     Attr   #Str Type   SSize
  lvol0 new_vg -wi-a-    1 linear 52.00M
```

9.3. SORTING LVM REPORTS

Normally the entire output of the **lvs**, **vgs**, or **pvs** command has to be generated and stored internally before it can be sorted and columns aligned correctly. You can specify the **--unbuffered** argument to display unsorted output as soon as it is generated.

To specify an alternative ordered list of columns to sort on, use the **-O** argument of any of the reporting commands. It is not necessary to include these fields within the output itself.

The following example shows the output of the **pvs** command that displays the physical volume name, size, and free space.

```
# pvs -o pv_name,pv_size,pv_free
  PV         PSize  PFree
  /dev/sdb1  17.14G 17.14G
  /dev/sdc1  17.14G 17.09G
  /dev/sdd1  17.14G 17.14G
```

The following example shows the same output, sorted by the free space field.

```
# pvs -o pv_name,pv_size,pv_free -O pv_free
  PV         PSize  PFree
  /dev/sdc1  17.14G 17.09G
  /dev/sdd1  17.14G 17.14G
  /dev/sdb1  17.14G 17.14G
```

The following example shows that you do not need to display the field on which you are sorting.

```
# pvs -o pv_name,pv_size -O pv_free
  PV         PSize
  /dev/sdc1  17.14G
  /dev/sdd1  17.14G
  /dev/sdb1  17.14G
```

To display a reverse sort, precede a field you specify after the **-O** argument with the **-** character.

```
# pvs -o pv_name,pv_size,pv_free -O -pv_free
  PV         PSize  PFree
  /dev/sdd1  17.14G 17.14G
  /dev/sdb1  17.14G 17.14G
  /dev/sdc1  17.14G 17.09G
```

9.4. SPECIFYING THE UNITS FOR AN LVM REPORT DISPLAY

To specify the units for the LVM report display, use the **--units** argument of the report command. You can specify (b)ytes, (k)ilobytes, (m)egabytes, (g)igabytes, (t)erabytes, (e)xabytes, (p)etabytes, and

(h)uman-readable. The default display is human-readable. You can override the default by setting the **units** parameter in the **global** section of the **/etc/lvm/lvm.conf** file.

The following example specifies the output of the **pvs** command in megabytes rather than the default gigabytes.

```
# pvs --units m
  PV         VG     Fmt  Attr PSize     PFree
  /dev/sda1         lvm2 --   17555.40M 17555.40M
  /dev/sdb1  new_vg lvm2 a-   17552.00M 17552.00M
  /dev/sdc1  new_vg lvm2 a-   17552.00M 17500.00M
  /dev/sdd1  new_vg lvm2 a-   17552.00M 17552.00M
```

By default, units are displayed in powers of 2 (multiples of 1024). You can specify that units be displayed in multiples of 1000 by capitalizing the unit specification (B, K, M, G, T, H).

The following command displays the output as a multiple of 1024, the default behavior.

```
# pvs
  PV         VG     Fmt  Attr PSize  PFree
  /dev/sdb1  new_vg lvm2 a-   17.14G 17.14G
  /dev/sdc1  new_vg lvm2 a-   17.14G 17.09G
  /dev/sdd1  new_vg lvm2 a-   17.14G 17.14G
```

The following command displays the output as a multiple of 1000.

```
#  pvs --units G
  PV         VG     Fmt  Attr PSize  PFree
  /dev/sdb1  new_vg lvm2 a-   18.40G 18.40G
  /dev/sdc1  new_vg lvm2 a-   18.40G 18.35G
  /dev/sdd1  new_vg lvm2 a-   18.40G 18.40G
```

You can also specify (s)ectors (defined as 512 bytes) or custom units.

The following example displays the output of the **pvs** command as a number of sectors.

```
# pvs --units s
  PV         VG     Fmt  Attr PSize     PFree
  /dev/sdb1  new_vg lvm2 a-   35946496S 35946496S
  /dev/sdc1  new_vg lvm2 a-   35946496S 35840000S
  /dev/sdd1  new_vg lvm2 a-   35946496S 35946496S
```

The following example displays the output of the **pvs** command in units of 4 MB.

```
# pvs --units 4m
  PV         VG     Fmt  Attr PSize    PFree
  /dev/sdb1  new_vg lvm2 a-   4388.00U 4388.00U
  /dev/sdc1  new_vg lvm2 a-   4388.00U 4375.00U
  /dev/sdd1  new_vg lvm2 a-   4388.00U 4388.00U
```

9.5. DISPLAYING LVM COMMAND OUTPUT IN JSON FORMAT

You can use the **--reportformat** option of the LVM display commands to display the output in JSON format.

The following example shows the output of the **lvs** in standard default format.

```
# lvs
  LV      VG            Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  my_raid my_vg         Rwi-a-r---  12.00m                                    100.00
  root    rhel_host-075 -wi-ao----   6.67g
  swap    rhel_host-075 -wi-ao---- 820.00m
```

The following command shows the output of the same LVM configuration when you specify JSON format.

```
# lvs --reportformat json
  {
      "report": [
          {
              "lv": [
                  {"lv_name":"my_raid", "vg_name":"my_vg", "lv_attr":"Rwi-a-r---", "lv_size":"12.00m",
"pool_lv":"", "origin":"", "data_percent":"", "metadata_percent":"", "move_pv":"", "mirror_log":"",
"copy_percent":"100.00", "convert_lv":""},
                  {"lv_name":"root", "vg_name":"rhel_host-075", "lv_attr":"-wi-ao----", "lv_size":"6.67g",
"pool_lv":"", "origin":"", "data_percent":"", "metadata_percent":"", "move_pv":"", "mirror_log":"",
"copy_percent":"", "convert_lv":""},
                  {"lv_name":"swap", "vg_name":"rhel_host-075", "lv_attr":"-wi-ao----", "lv_size":"820.00m",
"pool_lv":"", "origin":"", "data_percent":"", "metadata_percent":"", "move_pv":"", "mirror_log":"",
"copy_percent":"", "convert_lv":""}
              ]
          }
      ]
  }
```

You can also set the report format as a configuration option in the **/etc/lvm/lvm.conf** file, using the **output_format** setting. The **--reportformat** setting of the command line, however, takes precedence over this setting.

9.6. DISPLAYING THE LVM COMMAND LOG

Both report-oriented and processing-oriented LVM commands can report the command log if this is enabled with the **log/report_command_log** configuration setting. You can determine the set of fields to display and to sort by for this report.

The following examples configures LVM to generate a complete log report for LVM commands. In this example, you can see that both logical volumes **lvol0** and **lvol1** were successfully processed, as was the volume group **VG** that contains the volumes.

```
# lvmconfig --type full log/command_log_selection
command_log_selection="all"

# lvs
  Logical Volume
  ==============
  LV    LSize Cpy%Sync
  lvol1 4.00m 100.00
```

```
  lvol0 4.00m

  Command Log
  ===========
  Seq LogType Context    ObjType ObjName ObjGrp  Msg     Errno RetCode
    1 status  processing lv      lvol0   vg      success     0       1
    2 status  processing lv      lvol1   vg      success     0       1
    3 status  processing vg      vg              success     0       1

# lvchange -an vg/lvol1
  Command Log
  ===========
  Seq LogType Context    ObjType ObjName ObjGrp  Msg     Errno RetCode
    1 status  processing lv      lvol1   vg      success     0       1
    2 status  processing vg      vg              success     0       1
```

For further information on configuring LVM reports and command logs, see the **lvmreport** man page.

CHAPTER 10. CONFIGURING RAID LOGICAL VOLUMES

You can create, activate, change, remove, display, and use LVM RAID volumes.

10.1. RAID LOGICAL VOLUMES

LVM supports RAID levels 0, 1, 4, 5, 6, and 10.

An LVM RAID volume has the following characteristics:

- RAID logical volumes created and managed by LVM leverage the Multiple Devices (MD) kernel drivers.
- You can temporarily split RAID1 images from the array and merge them back into the array later.
- LVM RAID volumes support snapshots.

Clusters

RAID logical volumes are not cluster-aware.

Although you can create and activate RAID logical volumes exclusively on one machine, you cannot activate them simultaneously on more than one machine.

Subvolumes

When you create a RAID logical volume, LVM creates a metadata subvolume that is one extent in size for every data or parity subvolume in the array.

For example, creating a 2-way RAID1 array results in two metadata subvolumes (**lv_rmeta_0** and **lv_rmeta_1**) and two data subvolumes (**lv_rimage_0** and **lv_rimage_1**). Similarly, creating a 3-way stripe (plus 1 implicit parity device) RAID4 results in 4 metadata subvolumes (**lv_rmeta_0**, **lv_rmeta_1**, **lv_rmeta_2**, and **lv_rmeta_3**) and 4 data subvolumes (**lv_rimage_0**, **lv_rimage_1**, **lv_rimage_2**, and **lv_rimage_3**).

Integrity

You can lose data when a RAID device fails or when soft corruption occurs. Soft corruption in data storage implies that the data retrieved from a storage device is different from the data written to that device. Adding integrity to a RAID LV helps mitigate or prevent soft corruption. To learn more about soft corruption and how to add integrity to a RAID LV, see Section 10.6, “Using DM integrity with RAID LV”.

10.2. RAID LEVELS AND LINEAR SUPPORT

RAID supports various configurations, including levels 0, 1, 4, 5, 6, 10, and linear. These RAID types are defined as follows:

Level 0

RAID level 0, often called *striping*, is a performance-oriented striped data mapping technique. This means the data being written to the array is broken down into stripes and written across the member disks of the array, allowing high I/O performance at low inherent cost but provides no redundancy. Many RAID level 0 implementations only stripe the data across the member devices up to the size of the smallest device in the array. This means that if you have multiple devices with slightly different sizes, each device gets treated as though it was the same size as the smallest drive. Therefore, the

common storage capacity of a level 0 array is equal to the capacity of the smallest member disk in a Hardware RAID or the capacity of smallest member partition in a Software RAID multiplied by the number of disks or partitions in the array.

Level 1

RAID level 1, or *mirroring*, provides redundancy by writing identical data to each member disk of the array, leaving a "mirrored" copy on each disk. Mirroring remains popular due to its simplicity and high level of data availability. Level 1 operates with two or more disks, and provides very good data reliability and improves performance for read-intensive applications but at a relatively high cost.
RAID level 1 comes at a high cost because you write the same information to all of the disks in the array, provides data reliability, but in a much less space-efficient manner than parity based RAID levels such as level 5. However, this space inefficiency comes with a performance benefit: parity-based RAID levels consume considerably more CPU power in order to generate the parity while RAID level 1 simply writes the same data more than once to the multiple RAID members with very little CPU overhead. As such, RAID level 1 can outperform the parity-based RAID levels on machines where software RAID is employed and CPU resources on the machine are consistently taxed with operations other than RAID activities.

The storage capacity of the level 1 array is equal to the capacity of the smallest mirrored hard disk in a Hardware RAID or the smallest mirrored partition in a Software RAID. Level 1 redundancy is the highest possible among all RAID types, with the array being able to operate with only a single disk present.

Level 4

Level 4 uses parity concentrated on a single disk drive to protect data. Parity information is calculated based on the content of the rest of the member disks in the array. This information can then be used to reconstruct data when one disk in the array fails. The reconstructed data can then be used to satisfy I/O requests to the failed disk before it is replaced and to repopulate the failed disk after it has been replaced.
Because the dedicated parity disk represents an inherent bottleneck on all write transactions to the RAID array, level 4 is seldom used without accompanying technologies such as write-back caching, or in specific circumstances where the system administrator is intentionally designing the software RAID device with this bottleneck in mind (such as an array that will have little to no write transactions once the array is populated with data). RAID level 4 is so rarely used that it is not available as an option in Anaconda. However, it could be created manually by the user if truly needed.

The storage capacity of Hardware RAID level 4 is equal to the capacity of the smallest member partition multiplied by the number of partitions *minus one*. Performance of a RAID level 4 array is always asymmetrical, meaning reads outperform writes. This is because writes consume extra CPU and main memory bandwidth when generating parity, and then also consume extra bus bandwidth when writing the actual data to disks because you are writing not only the data, but also the parity. Reads need only read the data and not the parity unless the array is in a degraded state. As a result, reads generate less traffic to the drives and across the buses of the computer for the same amount of data transfer under normal operating conditions.

Level 5

This is the most common type of RAID. By distributing parity across all the member disk drives of an array, RAID level 5 eliminates the write bottleneck inherent in level 4. The only performance bottleneck is the parity calculation process itself. With modern CPUs and Software RAID, that is usually not a bottleneck at all since modern CPUs can generate parity very fast. However, if you have a sufficiently large number of member devices in a software RAID5 array such that the combined aggregate data transfer speed across all devices is high enough, then this bottleneck can start to come into play.

As with level 4, level 5 has asymmetrical performance, and reads substantially outperforming writes. The storage capacity of RAID level 5 is calculated the same way as with level 4.

Level 6

This is a common level of RAID when data redundancy and preservation, and not performance, are the paramount concerns, but where the space inefficiency of level 1 is not acceptable. Level 6 uses a complex parity scheme to be able to recover from the loss of any two drives in the array. This complex parity scheme creates a significantly higher CPU burden on software RAID devices and also imposes an increased burden during write transactions. As such, level 6 is considerably more asymmetrical in performance than levels 4 and 5.
The total capacity of a RAID level 6 array is calculated similarly to RAID level 5 and 4, except that you must subtract 2 devices (instead of 1) from the device count for the extra parity storage space.

Level 10

This RAID level attempts to combine the performance advantages of level 0 with the redundancy of level 1. It also helps to alleviate some of the space wasted in level 1 arrays with more than 2 devices. With level 10, it is possible for instance to create a 3-drive array configured to store only 2 copies of each piece of data, which then allows the overall array size to be 1.5 times the size of the smallest devices instead of only equal to the smallest device (like it would be with a 3-device, level 1 array). This avoids CPU process usage to calculate parity like with RAID level 6, but it is less space efficient.
The creation of RAID level 10 is not supported during installation. It is possible to create one manually after installation.

Linear RAID

Linear RAID is a grouping of drives to create a larger virtual drive.
In linear RAID, the chunks are allocated sequentially from one member drive, going to the next drive only when the first is completely filled. This grouping provides no performance benefit, as it is unlikely that any I/O operations split between member drives. Linear RAID also offers no redundancy and decreases reliability. If any one member drive fails, the entire array cannot be used. The capacity is the total of all member disks.

10.3. LVM RAID SEGMENT TYPES

To create a RAID logical volume, you specify a raid type as the **--type** argument of the **lvcreate** command. The following table describes the possible RAID segment types.

For most users, specifying one of the five available primary types (**raid1**, **raid4**, **raid5**, **raid6**, **raid10**) should be sufficient.

Table 10.1. LVM RAID segment types

Segment type	Description
raid1	RAID1 mirroring. This is the default value for the **--type** argument of the **lvcreate** command when you specify the**-m** but you do not specify striping.
raid4	RAID4 dedicated parity disk
raid5	Same as **raid5_ls**

Segment type	Description
raid5_la	• RAID5 left asymmetric. • Rotating parity 0 with data continuation
raid5_ra	• RAID5 right asymmetric. • Rotating parity N with data continuation
raid5_ls	• RAID5 left symmetric. • Rotating parity 0 with data restart
raid5_rs	• RAID5 right symmetric. • Rotating parity N with data restart
raid6	Same as **raid6_zr**
raid6_zr	• RAID6 zero restart • Rotating parity zero (left-to-right) with data restart
raid6_nr	• RAID6 N restart • Rotating parity N (left-to-right) with data restart
raid6_nc	• RAID6 N continue • Rotating parity N (left-to-right) with data continuation
raid10	• Striped mirrors. This is the default value for the **--type** argument of the **lvcreate** command if you specify the**-m** and you specify a number of stripes that is greater than 1. • Striping of mirror sets
raid0/raid0_meta	Striping. RAID0 spreads logical volume data across multiple data subvolumes in units of stripe size. This is used to increase performance. Logical volume data will be lost if any of the data subvolumes fail.

10.4. CREATING RAID LOGICAL VOLUMES

This section provides example commands that create different types of RAID logical volume.

You can create RAID1 arrays with different numbers of copies according to the value you specify for the **-m** argument. Similarly, you specify the number of stripes for a RAID 4/5/6 logical volume with the **-i argument**. You can also specify the stripe size with the **-I** argument.

The following command creates a 2-way RAID1 array named **my_lv** in the volume group **my_vg** that is one gigabyte in size.

```
# lvcreate --type raid1 -m 1 -L 1G -n my_lv my_vg
```

The following command creates a RAID5 array (3 stripes + 1 implicit parity drive) named **my_lv** in the volume group **my_vg** that is one gigabyte in size. Note that you specify the number of stripes just as you do for an LVM striped volume; the correct number of parity drives is added automatically.

```
# lvcreate --type raid5 -i 3 -L 1G -n my_lv my_vg
```

The following command creates a RAID6 array (3 stripes + 2 implicit parity drives) named **my_lv** in the volume group **my_vg** that is one gigabyte in size.

```
# lvcreate --type raid6 -i 3 -L 1G -n my_lv my_vg
```

10.5. CREATING A RAID0 (STRIPED) LOGICAL VOLUME

A RAID0 logical volume spreads logical volume data across multiple data subvolumes in units of stripe size.

The format for the command to create a RAID0 volume is as follows.

```
lvcreate --type raid0[_meta] --stripes Stripes --stripesize StripeSize VolumeGroup
[PhysicalVolumePath ...]
```

Table 10.2. RAID0 Command Creation parameters

Parameter	Description
--type raid0[_meta]	Specifying **raid0** creates a RAID0 volume without metadata volumes. Specifying **raid0_meta** creates a RAID0 volume with metadata volumes. Because RAID0 is non-resilient, it does not have to store any mirrored data blocks as RAID1/10 or calculate and store any parity blocks as RAID4/5/6 do. Hence, it does not need metadata volumes to keep state about resynchronization progress of mirrored or parity blocks. Metadata volumes become mandatory on a conversion from RAID0 to RAID4/5/6/10, however, and specifying **raid0_meta** preallocates those metadata volumes to prevent a respective allocation failure.

Parameter	Description
--stripes *Stripes*	Specifies the number of devices to spread the logical volume across.
--stripesize *StripeSize*	Specifies the size of each stripe in kilobytes. This is the amount of data that is written to one device before moving to the next device.
VolumeGroup	Specifies the volume group to use.
PhysicalVolumePath ...	Specifies the devices to use. If this is not specified, LVM will choose the number of devices specified by the *Stripes* option, one for each stripe.

This example procedure creates an LVM RAID0 logical volume called **mylv** that stripes data across the disks at **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

1. Label the disks you will use in the volume group as LVM physical volumes with the **pvcreate** command.

WARNING

This command destroys any data on **/dev/sda1**, **/dev/sdb1**, and **/dev/sdc1**.

```
# pvcreate /dev/sda1 /dev/sdb1 /dev/sdc1
  Physical volume "/dev/sda1" successfully created
  Physical volume "/dev/sdb1" successfully created
  Physical volume "/dev/sdc1" successfully created
```

2. Create the volume group **myvg**. The following command creates the volume group **myvg**.

```
# vgcreate myvg /dev/sda1 /dev/sdb1 /dev/sdc1
  Volume group "myvg" successfully created
```

You can use the **vgs** command to display the attributes of the new volume group.

```
# vgs
  VG   #PV #LV #SN Attr   VSize  VFree
  myvg   3   0   0 wz--n- 51.45G 51.45G
```

3. Create a RAID0 logical volume from the volume group you have created. The following command creates the RAID0 volume **mylv** from the volume group **myvg**. This example creates a logical volume that is 2 gigabytes in size, with three stripes and a stripe size of 4 kilobytes.

```
# lvcreate --type raid0 -L 2G --stripes 3 --stripesize 4 -n mylv myvg
  Rounding size 2.00 GiB (512 extents) up to stripe boundary size 2.00 GiB(513 extents).
  Logical volume "mylv" created.
```

4. Create a file system on the RAID0 logical volume. The following command creates an **ext4** file system on the logical volume.

```
# mkfs.ext4 /dev/myvg/mylv
mke2fs 1.44.3 (10-July-2018)
Creating filesystem with 525312 4k blocks and 131376 inodes
Filesystem UUID: 9d4c0704-6028-450a-8b0a-8875358c0511
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912

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

The following commands mount the logical volume and report the file system disk space usage.

```
# mount /dev/myvg/mylv /mnt
# df
Filesystem            1K-blocks     Used  Available Use% Mounted on
/dev/mapper/myvg-mylv    2002684     6168    1875072   1% /mnt
```

10.6. USING DM INTEGRITY WITH RAID LV

As a system administrator, you can use device mapper (DM) integrity with a RAID LV to minimize the risk of data loss due to soft corruption or bit rot.

10.6.1. Soft data corruption

Soft corruption in data storage implies that the data retrieved from a storage device is different from the data written to that device. The corrupted data can exist indefinitely on storage devices. You might not discover this corrupted data until you retrieve and attempt to use this data.

Depending on the type of configuration, a Redundant Array of Independent Disks (RAID) LV prevents data loss when a device fails. If a device comprising a RAID array fails, the data can be recovered from other devices that are part of that RAID LV. However, a RAID configuration does not ensure the integrity of the data itself. Soft corruption, silent corruption, soft errors, and silent errors are terms that describe data that has become corrupted, even if the system design and software continues to function as expected.

DM integrity is used with RAID levels 1, 4, 5, 6, and 10 to help mitigate or prevent data loss due to soft corruption. The RAID layer ensures that a non-corrupted copy of the data can fix the soft corruption errors. The integrity layer sits above each RAID image while an extra sub LV stores the integrity metadata (data checksums) for each RAID image. When you retrieve data from an RAID LV with integrity, the integrity data checksums analyze the data for corruption. If corruption is detected, the integrity layer returns an error message, and the RAID layer retrieves a non-corrupted copy of the data from another RAID image. The RAID layer automatically rewrites non-corrupted data over the corrupted data to repair the soft corruption.

When creating a new RAID LV with DM integrity or adding integrity to an existing RAID LV, consider the following:

- The integrity metadata requires additional storage space. For each RAID image, every 500MB data requires 4MB of additional storage space because of the checksums that get added to the data.
- While some RAID configurations are impacted more than others, adding DM integrity impacts performance due to latency when accessing the data. A RAID1 configuration typically offers better performance than RAID5 or its variants.
- The RAID integrity block size also impacts performance. Configuring a larger RAID integrity block size offers better performance. However, a smaller RAID integrity block size offers greater backward compatibility.
- There are two integrity modes available: bitmap or journal. The bitmap integrity mode typically offers better performance than journal mode.

TIP

If you experience performance issues, Red Hat recommends that you either use RAID1 with integrity or that you test the performance of a particular RAID configuration to ensure that it meets your requirements.

10.6.2. Creating a RAID LV with DM integrity

When you create an RAID LV, adding DM integrity helps mitigate the risk of losing data due to soft corruption.

Prerequisites

- You must have root access.

Procedure

- To create a RAID LV with DM integrity:

```
# lvcreate --type <raid-level> --raidintegrity y -L <usable-size> -n <logical-volume> <volume-group>
```

where

<raid-level>
Specifies the RAID level of the RAID LV that you want to create.

<usable-size>
Specifies the usable size in MB.

<logical-volume>
Specifies the name of the LV that you want to create.

<volume-group>
Specifies the name of the volume group that you want to create the RAID LV under.

In the following example, we create an RAID LV with integrity named **test-lv** in the **test-vg** volume group, with a usable size of 256M and RAID level 1.

Example RAID LV with integrity

```
# lvcreate --type raid1 --raidintegrity y -L256M -n test-lv test-vg
Creating integrity metadata LV test-lv_rimage_0_imeta with size 8.00 MiB.
  Logical volume "test-lv_rimage_0_imeta" created.
  Creating integrity metadata LV test-lv_rimage_1_imeta with size 8.00 MiB.
  Logical volume "test-lv_rimage_1_imeta" created.
  Logical volume "test-lv" created.
```

10.6.3. Adding DM integrity to an existing RAID LV

You can add DM integrity to an existing RAID LV to help mitigate the risk of losing data due to soft corruption.

Prerequisites

- You must have root access.

Procedure

- To add DM integrity to an existing RAID LV:

  ```
  # lvconvert --raidintegrity y <volume-group>/<logical-volume>
  ```

  where

  <volume-group>

  Specifies the name of the volume group that you want to create the RAID LV under.

  <logical-volume>

  Specifies the name of the LV that you want to create.

10.6.4. Removing integrity from a RAID LV

Adding integrity to a RAID LV limits the number of operations that you can perform on that RAID LV. Therefore, you must remove the integrity before performing certain operations.

Prerequisites

- You must have root access.

Procedure

- To remove integrity from a RAID LV:

  ```
  # lvconvert --raidintegrity n <volume-group>/<logical-volume>
  ```

  where

  <volume-group>

  Specifies the name of the volume group that you want to create the RAID LV under.

  <logical-volume>

Specifies the name of the LV that you want to create.

10.6.5. Viewing DM integrity information

When you create a RAID LV with integrity or when you add integrity to an existing RAID LV, use the following command to view information about the integrity:

```
# lvs -a <volume-group>
```

where *<volume-group>* is the name of the volume group that contains the RAID LV with integrity.

The following example shows information about the **test-lv** RAID LV that was created in the **test-vg** volume group.

```
# lvs -a test-vg
  LV                  VG      Attr       LSize   Origin                  Cpy%Sync
  test-lv             test-vg rwi-a-r--- 256.00m                          2.10
  [test-lv_rimage_0]      test-vg gwi-aor--- 256.00m [test-lv_rimage_0_iorig] 93.75
  [test-lv_rimage_0_imeta]  test-vg ewi-ao----   8.00m
  [test-lv_rimage_0_iorig]  test-vg -wi-ao---- 256.00m
  [test-lv_rimage_1]      test-vg gwi-aor--- 256.00m [test-lv_rimage_1_iorig] 85.94
  [test-lv_rimage_1_imeta]  test-vg ewi-ao----   8.00m
  [test-lv_rimage_1_iorig]  test-vg -wi-ao---- 256.00m
  [test-lv_rmeta_0]       test-vg ewi-aor---   4.00m
  [test-lv_rmeta_1]       test-vg ewi-aor---   4.00m
```

Synchronization

When you create a RAID LV with integrity or add integrity to an existing RAID LV, we recommend that you wait for the integrity synchronization and the RAID metadata to complete before using the LV. Otherwise, the background initialization might impact the LV's performance. The **Cpy%Sync** column indicates the synchronization progress for both the top level RAID LV and for each RAID image. The RAID image is indicated in the LV column by **raid_image_N**. Refer to the LV column to ensure that the synchronization progress displays **100%** for the top level RAID LV and for each RAID image.

RAID images using integrity

The **g** attribute in the attributes listed under the **Attr** column indicates that the RAID image is using integrity. The integrity checksums are stored in the **_imeta** RAID LV.

To display the type for each RAID LV, add the **-o+segtype** option to the **lvs** command:

```
# lvs -a my-vg -o+segtype
  LV                  VG      Attr       LSize   Origin                  Cpy%Sync Type
  test-lv             test-vg rwi-a-r--- 256.00m                           87.96   raid1
  [test-lv_rimage_0]      test-vg gwi-aor--- 256.00m [test-lv_rimage_0_iorig] 100.00   integrity
  [test-lv_rimage_0_imeta] test-vg ewi-ao----   8.00m                                  linear
  [test-lv_rimage_0_iorig] test-vg -wi-ao---- 256.00m                                  linear
  [test-lv_rimage_1]      test-vg gwi-aor--- 256.00m [test-lv_rimage_1_iorig] 100.00   integrity
  [test-lv_rimage_1_imeta] test-vg ewi-ao----   8.00m                                  linear
  [test-lv_rimage_1_iorig] test-vg -wi-ao---- 256.00m                                  linear
  [test-lv_rmeta_0]       test-vg ewi-aor---   4.00m                                linear
  [test-lv_rmeta_1]       test-vg ewi-aor---   4.00m                                linear
```

Integrity mismatches

There is an incremental counter that counts the number of mismatches detected on each RAID image. To view the data mismatches detected by integrity on a particular RAID image, run the following command:

 # lvs -o+integritymismatches *<volume-group>*/*<logical-volume>*_raid-image_*<n>*

where

<volume-group>

Specifies the name of the volume group that you want to create the RAID LV under.

<logical-volume>

Specifies the name of the LV that you want to create.

<n>

Specifies the RAID image that you want to view the integrity mismatch information for.

You must run the command for each RAID image that you want to view. In the following example, we will view the data mismatches from **rimage_0** under **test-vg/test-lv**.

```
# lvs -o+integritymismatches test-vg/test-lv_rimage_0
  LV                VG      Attr       LSize   Origin                    Cpy%Sync IntegMismatches
  [test-lv_rimage_0] test-vg gwi-aor--- 256.00m [test-lv_rimage_0_iorig]    100.00                0
```

We can see that integrity has not detected any data mismatches and thus the **IntegMismatches** counter shows zero (0).

Integrity mismatches in kernel message logs

You can also find data integrity information in the kernel message logs, as shown in the following examples.

Example of dm-integrity mismatches from the kernel message logs

```
device-mapper: integrity: dm-12: Checksum failed at sector 0x24e7
```

Example of dm-integrity data corrections from the kernel message logs

```
md/raid1:mdX: read error corrected (8 sectors at 9448 on dm-16)
```

10.6.6. Additional resources

- For more information on all the available options, see the **lvmraid** command man page(s).

10.7. CONTROLLING THE RATE AT WHICH RAID VOLUMES ARE INITIALIZED

When you create RAID10 logical volumes, the background I/O required to initialize the logical volumes with a **sync** operation can crowd out other I/O operations to LVM devices, such as updates to volume group metadata, particularly when you are creating many RAID logical volumes. This can cause the other LVM operations to slow down.

You can control the rate at which a RAID logical volume is initialized by implementing recovery throttling. You control the rate at which **sync** operations are performed by setting the minimum and maximum I/O

rate for those operations with the **--minrecoveryrate** and **--maxrecoveryrate** options of the **lvcreate** command. You specify these options as follows.

- **--maxrecoveryrate *Rate*[bBsSkKmMgG]**
  Sets the maximum recovery rate for a RAID logical volume so that it will not crowd out nominal I/O operations. The *Rate* is specified as an amount per second for each device in the array. If no suffix is given, then kiB/sec/device is assumed. Setting the recovery rate to 0 means it will be unbounded.

- **--minrecoveryrate *Rate*[bBsSkKmMgG]**
  Sets the minimum recovery rate for a RAID logical volume to ensure that I/O for **sync** operations achieves a minimum throughput, even when heavy nominal I/O is present. The *Rate* is specified as an amount per second for each device in the array. If no suffix is given, then kiB/sec/device is assumed.

The following command creates a 2-way RAID10 array with 3 stripes that is 10 gigabytes in size with a maximum recovery rate of 128 kiB/sec/device. The array is named **my_lv** and is in the volume group **my_vg**.

```
# lvcreate --type raid10 -i 2 -m 1 -L 10G --maxrecoveryrate 128 -n my_lv my_vg
```

You can also specify minimum and maximum recovery rates for a RAID scrubbing operation.

10.8. CONVERTING A LINEAR DEVICE TO A RAID DEVICE

You can convert an existing linear logical volume to a RAID device by using the **--type** argument of the **lvconvert** command.

The following command converts the linear logical volume **my_lv** in volume group **my_vg** to a 2-way RAID1 array.

```
# lvconvert --type raid1 -m 1 my_vg/my_lv
```

Since RAID logical volumes are composed of metadata and data subvolume pairs, when you convert a linear device to a RAID1 array, a new metadata subvolume is created and associated with the original logical volume on (one of) the same physical volumes that the linear volume is on. The additional images are added in metadata/data subvolume pairs. For example, if the original device is as follows:

```
# lvs -a -o name,copy_percent,devices my_vg
  LV     Copy%  Devices
  my_lv         /dev/sde1(0)
```

After conversion to a 2-way RAID1 array the device contains the following data and metadata subvolume pairs:

```
# lvconvert --type raid1 -m 1 my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           6.25   my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sde1(0)
  [my_lv_rimage_1]       /dev/sdf1(1)
  [my_lv_rmeta_0]        /dev/sde1(256)
  [my_lv_rmeta_1]        /dev/sdf1(0)
```

If the metadata image that pairs with the original logical volume cannot be placed on the same physical volume, the **lvconvert** will fail.

10.9. CONVERTING AN LVM RAID1 LOGICAL VOLUME TO AN LVM LINEAR LOGICAL VOLUME

You can convert an existing RAID1 LVM logical volume to an LVM linear logical volume with the **lvconvert** command by specifying the **-m0** argument. This removes all the RAID data subvolumes and all the RAID metadata subvolumes that make up the RAID array, leaving the top-level RAID1 image as the linear logical volume.

The following example displays an existing LVM RAID1 logical volume.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sde1(1)
  [my_lv_rimage_1]       /dev/sdf1(1)
  [my_lv_rmeta_0]        /dev/sde1(0)
  [my_lv_rmeta_1]        /dev/sdf1(0)
```

The following command converts the LVM RAID1 logical volume **my_vg/my_lv** to an LVM linear device.

```
# lvconvert -m0 my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV      Copy%  Devices
  my_lv          /dev/sde1(1)
```

When you convert an LVM RAID1 logical volume to an LVM linear volume, you can specify which physical volumes to remove. The following example shows the layout of an LVM RAID1 logical volume made up of two images: **/dev/sda1** and **/dev/sdb1**. In this example, the **lvconvert** command specifies that you want to remove **/dev/sda1**, leaving **/dev/sdb1** as the physical volume that makes up the linear device.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sda1(1)
  [my_lv_rimage_1]       /dev/sdb1(1)
  [my_lv_rmeta_0]        /dev/sda1(0)
  [my_lv_rmeta_1]        /dev/sdb1(0)
# lvconvert -m0 my_vg/my_lv /dev/sda1
# lvs -a -o name,copy_percent,devices my_vg
  LV    Copy%  Devices
  my_lv        /dev/sdb1(1)
```

10.10. CONVERTING A MIRRORED LVM DEVICE TO A RAID1 DEVICE

You can convert an existing mirrored LVM device with a segment type of **mirror** to a RAID1 LVM device with the **lvconvert** command by specifying the **--type raid1** argument. This renames the mirror subvolumes (***mimage***) to RAID subvolumes (***rimage***). In addition, the mirror log is removed and metadata subvolumes (***rmeta***) are created for the data subvolumes on the same physical volumes as the corresponding data subvolumes.

The following example shows the layout of a mirrored logical volume **my_vg/my_lv**.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           15.20 my_lv_mimage_0(0),my_lv_mimage_1(0)
  [my_lv_mimage_0]       /dev/sde1(0)
  [my_lv_mimage_1]       /dev/sdf1(0)
  [my_lv_mlog]           /dev/sdd1(0)
```

The following command converts the mirrored logical volume **my_vg/my_lv** to a RAID1 logical volume.

```
# lvconvert --type raid1 my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sde1(0)
  [my_lv_rimage_1]       /dev/sdf1(0)
  [my_lv_rmeta_0]        /dev/sde1(125)
  [my_lv_rmeta_1]        /dev/sdf1(125)
```

10.11. RESIZING A RAID LOGICAL VOLUME

You can resize a RAID logical volume in the following ways;

- You can increase the size of a RAID logical volume of any type with the **lvresize** or **lvextend** command. This does not change the number of RAID images. For striped RAID logical volumes the same stripe rounding constraints apply as when you create a striped RAID logical volume.
- You can reduce the size of a RAID logical volume of any type with the **lvresize** or **lvreduce** command. This does not change the number of RAID images. As with the **lvextend** command, the same stripe rounding constraints apply as when you create a striped RAID logical volume.
- You can change the number of stripes on a striped RAID logical volume (**raid4/5/6/10**) with the **--stripes N** parameter of the **lvconvert** command. This increases or reduces the size of the RAID logical volume by the capacity of the stripes added or removed. Note that **raid10** volumes are capable only of adding stripes. This capability is part of the RAID *reshaping* feature that allows you to change attributes of a RAID logical volume while keeping the same RAID level. For information on RAID reshaping and examples of using the **lvconvert** command to reshape a RAID logical volume, see the **lvmraid**(7) man page.

10.12. CHANGING THE NUMBER OF IMAGES IN AN EXISTING RAID1 DEVICE

You can change the number of images in an existing RAID1 array just as you can change the number of images in the earlier implementation of LVM mirroring. Use the **lvconvert** command to specify the number of additional metadata/data subvolume pairs to add or remove.

When you add images to a RAID1 device with the **lvconvert** command, you can specify the total number of images for the resulting device, or you can specify how many images to add to the device. You can also optionally specify on which physical volumes the new metadata/data image pairs will reside.

Metadata subvolumes (named ***rmeta***) always exist on the same physical devices as their data subvolume counterparts ***rimage***). The metadata/data subvolume pairs will not be created on the same physical volumes as those from another metadata/data subvolume pair in the RAID array (unless you

specify **--alloc anywhere**).

The format for the command to add images to a RAID1 volume is as follows:

```
lvconvert -m new_absolute_count vg/lv [removable_PVs]
lvconvert -m +num_additional_images vg/lv [removable_PVs]
```

For example, the following command displays the LVM device **my_vg/my_lv**, which is a 2-way RAID1 array:

```
# lvs -a -o name,copy_percent,devices my_vg
  LV               Copy%  Devices
  my_lv             6.25  my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]        /dev/sde1(0)
  [my_lv_rimage_1]        /dev/sdf1(1)
  [my_lv_rmeta_0]         /dev/sde1(256)
  [my_lv_rmeta_1]         /dev/sdf1(0)
```

The following command converts the 2-way RAID1 device **my_vg/my_lv** to a 3-way RAID1 device:

```
# lvconvert -m 2 my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV               Copy%  Devices
  my_lv             6.25 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]        /dev/sde1(0)
  [my_lv_rimage_1]        /dev/sdf1(1)
  [my_lv_rimage_2]        /dev/sdg1(1)
  [my_lv_rmeta_0]         /dev/sde1(256)
  [my_lv_rmeta_1]         /dev/sdf1(0)
  [my_lv_rmeta_2]         /dev/sdg1(0)
```

When you add an image to a RAID1 array, you can specify which physical volumes to use for the image. The following command converts the 2-way RAID1 device **my_vg/my_lv** to a 3-way RAID1 device, specifying that the physical volume **/dev/sdd1** be used for the array:

```
# lvs -a -o name,copy_percent,devices my_vg
  LV               Copy%  Devices
  my_lv            56.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]        /dev/sda1(1)
  [my_lv_rimage_1]        /dev/sdb1(1)
  [my_lv_rmeta_0]         /dev/sda1(0)
  [my_lv_rmeta_1]         /dev/sdb1(0)
# lvconvert -m 2 my_vg/my_lv /dev/sdd1
# lvs -a -o name,copy_percent,devices my_vg
  LV               Copy%  Devices
  my_lv            28.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]        /dev/sda1(1)
  [my_lv_rimage_1]        /dev/sdb1(1)
  [my_lv_rimage_2]        /dev/sdd1(1)
  [my_lv_rmeta_0]         /dev/sda1(0)
  [my_lv_rmeta_1]         /dev/sdb1(0)
  [my_lv_rmeta_2]         /dev/sdd1(0)
```

To remove images from a RAID1 array, use the following command. When you remove images from a

RAID1 device with the **lvconvert** command, you can specify the total number of images for the resulting device, or you can specify how many images to remove from the device. You can also optionally specify the physical volumes from which to remove the device.

```
lvconvert -m new_absolute_count vg/lv [removable_PVs]
lvconvert -m -num_fewer_images vg/lv [removable_PVs]
```

Additionally, when an image and its associated metadata subvolume volume are removed, any higher-numbered images will be shifted down to fill the slot. If you remove **lv_rimage_1** from a 3-way RAID1 array that consists of **lv_rimage_0**, **lv_rimage_1**, and **lv_rimage_2**, this results in a RAID1 array that consists of **lv_rimage_0** and **lv_rimage_1**. The subvolume **lv_rimage_2** will be renamed and take over the empty slot, becoming **lv_rimage_1**.

The following example shows the layout of a 3-way RAID1 logical volume **my_vg/my_lv**.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sde1(1)
  [my_lv_rimage_1]       /dev/sdf1(1)
  [my_lv_rimage_2]       /dev/sdg1(1)
  [my_lv_rmeta_0]        /dev/sde1(0)
  [my_lv_rmeta_1]        /dev/sdf1(0)
  [my_lv_rmeta_2]        /dev/sdg1(0)
```

The following command converts the 3-way RAID1 logical volume into a 2-way RAID1 logical volume.

```
# lvconvert -m1 my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sde1(1)
  [my_lv_rimage_1]       /dev/sdf1(1)
  [my_lv_rmeta_0]        /dev/sde1(0)
  [my_lv_rmeta_1]        /dev/sdf1(0)
```

The following command converts the 3-way RAID1 logical volume into a 2-way RAID1 logical volume, specifying the physical volume that contains the image to remove as **/dev/sde1**.

```
# lvconvert -m1 my_vg/my_lv /dev/sde1
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sdf1(1)
  [my_lv_rimage_1]       /dev/sdg1(1)
  [my_lv_rmeta_0]        /dev/sdf1(0)
  [my_lv_rmeta_1]        /dev/sdg1(0)
```

10.13. SPLITTING OFF A RAID IMAGE AS A SEPARATE LOGICAL VOLUME

You can split off an image of a RAID logical volume to form a new logical volume.

The format of the command to split off a RAID image is as follows:

```
lvconvert --splitmirrors count -n splitname vg/lv [removable_PVs]
```

Just as when you are removing a RAID image from an existing RAID1 logical volume, when you remove a RAID data subvolume (and its associated metadata subvolume) from the middle of the device any higher numbered images will be shifted down to fill the slot. The index numbers on the logical volumes that make up a RAID array will thus be an unbroken sequence of integers.

NOTE

You cannot split off a RAID image if the RAID1 array is not yet in sync.

The following example splits a 2-way RAID1 logical volume, **my_lv**, into two linear logical volumes, **my_lv** and **new**.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv             12.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]        /dev/sde1(1)
  [my_lv_rimage_1]        /dev/sdf1(1)
  [my_lv_rmeta_0]         /dev/sde1(0)
  [my_lv_rmeta_1]         /dev/sdf1(0)
# lvconvert --splitmirror 1 -n new my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV      Copy%  Devices
  my_lv          /dev/sde1(1)
  new            /dev/sdf1(1)
```

The following example splits a 3-way RAID1 logical volume, **my_lv**, into a 2-way RAID1 logical volume, **my_lv**, and a linear logical volume, **new**

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv             100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]        /dev/sde1(1)
  [my_lv_rimage_1]        /dev/sdf1(1)
  [my_lv_rimage_2]        /dev/sdg1(1)
  [my_lv_rmeta_0]         /dev/sde1(0)
  [my_lv_rmeta_1]         /dev/sdf1(0)
  [my_lv_rmeta_2]         /dev/sdg1(0)
# lvconvert --splitmirror 1 -n new my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV            Copy%  Devices
  my_lv             100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]        /dev/sde1(1)
  [my_lv_rimage_1]        /dev/sdf1(1)
  [my_lv_rmeta_0]         /dev/sde1(0)
  [my_lv_rmeta_1]         /dev/sdf1(0)
  new                     /dev/sdg1(1)
```

10.14. SPLITTING AND MERGING A RAID IMAGE

You can temporarily split off an image of a RAID1 array for read-only use while keeping track of any changes by using the **--trackchanges** argument in conjunction with the **--splitmirrors** argument of the **lvconvert** command. This allows you to merge the image back into the array at a later time while resyncing only those portions of the array that have changed since the image was split.

The format for the **lvconvert** command to split off a RAID image is as follows.

```
lvconvert --splitmirrors count --trackchanges vg/lv [removable_PVs]
```

When you split off a RAID image with the **--trackchanges** argument, you can specify which image to split but you cannot change the name of the volume being split. In addition, the resulting volumes have the following constraints.

- The new volume you create is read-only.
- You cannot resize the new volume.
- You cannot rename the remaining array.
- You cannot resize the remaining array.
- You can activate the new volume and the remaining array independently.

You can merge an image that was split off with the **--trackchanges** argument specified by executing a subsequent **lvconvert** command with the **--merge** argument. When you merge the image, only the portions of the array that have changed since the image was split are resynced.

The format for the **lvconvert** command to merge a RAID image is as follows.

```
lvconvert --merge raid_image
```

The following example creates a RAID1 logical volume and then splits off an image from that volume while tracking changes to the remaining array.

```
# lvcreate --type raid1 -m 2 -L 1G -n my_lv my_vg
  Logical volume "my_lv" created
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sdb1(1)
  [my_lv_rimage_1]       /dev/sdc1(1)
  [my_lv_rimage_2]       /dev/sdd1(1)
  [my_lv_rmeta_0]        /dev/sdb1(0)
  [my_lv_rmeta_1]        /dev/sdc1(0)
  [my_lv_rmeta_2]        /dev/sdd1(0)
# lvconvert --splitmirrors 1 --trackchanges my_vg/my_lv
  my_lv_rimage_2 split from my_lv for read-only purposes.
  Use 'lvconvert --merge my_vg/my_lv_rimage_2' to merge back into my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sdb1(1)
  [my_lv_rimage_1]       /dev/sdc1(1)
  my_lv_rimage_2         /dev/sdd1(1)
```

```
  [my_lv_rmeta_0]       /dev/sdb1(0)
  [my_lv_rmeta_1]       /dev/sdc1(0)
  [my_lv_rmeta_2]       /dev/sdd1(0)
```

The following example splits off an image from a RAID1 volume while tracking changes to the remaining array, then merges the volume back into the array.

```
# lvconvert --splitmirrors 1 --trackchanges my_vg/my_lv
  lv_rimage_1 split from my_lv for read-only purposes.
  Use 'lvconvert --merge my_vg/my_lv_rimage_1' to merge back into my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sdc1(1)
  my_lv_rimage_1         /dev/sdd1(1)
  [my_lv_rmeta_0]        /dev/sdc1(0)
  [my_lv_rmeta_1]        /dev/sdd1(0)
# lvconvert --merge my_vg/my_lv_rimage_1
  my_vg/my_lv_rimage_1 successfully merged back into my_vg/my_lv
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sdc1(1)
  [my_lv_rimage_1]       /dev/sdd1(1)
  [my_lv_rmeta_0]        /dev/sdc1(0)
  [my_lv_rmeta_1]        /dev/sdd1(0)
```

10.15. SETTING A RAID FAULT POLICY

LVM RAID handles device failures in an automatic fashion based on the preferences defined by the **raid_fault_policy** field in the **lvm.conf** file.

- If the **raid_fault_policy** field is set to **allocate**, the system will attempt to replace the failed device with a spare device from the volume group. If there is no available spare device, this will be reported to the system log.
- If the **raid_fault_policy** field is set to **warn**, the system will produce a warning and the log will indicate that a device has failed. This allows the user to determine the course of action to take.

As long as there are enough devices remaining to support usability, the RAID logical volume will continue to operate.

10.15.1. The allocate RAID Fault Policy

In the following example, the **raid_fault_policy** field has been set to **allocate** in the **lvm.conf** file. The RAID logical volume is laid out as follows.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sde1(1)
  [my_lv_rimage_1]       /dev/sdf1(1)
  [my_lv_rimage_2]       /dev/sdg1(1)
```

```
  [my_lv_rmeta_0]       /dev/sde1(0)
  [my_lv_rmeta_1]       /dev/sdf1(0)
  [my_lv_rmeta_2]       /dev/sdg1(0)
```

If the **/dev/sde** device fails, the system log will display error messages.

```
# grep lvm /var/log/messages
Jan 17 15:57:18 bp-01 lvm[8599]: Device #0 of raid1 array, my_vg-my_lv, has failed.
Jan 17 15:57:18 bp-01 lvm[8599]: /dev/sde1: read failed after 0 of 2048 at
250994294784: Input/output error
Jan 17 15:57:18 bp-01 lvm[8599]: /dev/sde1: read failed after 0 of 2048 at
250994376704: Input/output error
Jan 17 15:57:18 bp-01 lvm[8599]: /dev/sde1: read failed after 0 of 2048 at 0:
Input/output error
Jan 17 15:57:18 bp-01 lvm[8599]: /dev/sde1: read failed after 0 of 2048 at
4096: Input/output error
Jan 17 15:57:19 bp-01 lvm[8599]: Couldn't find device with uuid
3lugiV-3eSP-AFAR-sdrP-H20O-wM2M-qdMANy.
Jan 17 15:57:27 bp-01 lvm[8599]: raid1 array, my_vg-my_lv, is not in-sync.
Jan 17 15:57:36 bp-01 lvm[8599]: raid1 array, my_vg-my_lv, is now in-sync.
```

Since the **raid_fault_policy** field has been set to **allocate**, the failed device is replaced with a new device from the volume group.

```
# lvs -a -o name,copy_percent,devices vg
  Couldn't find device with uuid 3lugiV-3eSP-AFAR-sdrP-H20O-wM2M-qdMANy.
  LV            Copy%  Devices
  lv            100.00 lv_rimage_0(0),lv_rimage_1(0),lv_rimage_2(0)
  [lv_rimage_0]        /dev/sdh1(1)
  [lv_rimage_1]        /dev/sdf1(1)
  [lv_rimage_2]        /dev/sdg1(1)
  [lv_rmeta_0]         /dev/sdh1(0)
  [lv_rmeta_1]         /dev/sdf1(0)
  [lv_rmeta_2]         /dev/sdg1(0)
```

Note that even though the failed device has been replaced, the display still indicates that LVM could not find the failed device. This is because, although the failed device has been removed from the RAID logical volume, the failed device has not yet been removed from the volume group. To remove the failed device from the volume group, you can execute **vgreduce --removemissing *VG***.

If the **raid_fault_policy** has been set to **allocate** but there are no spare devices, the allocation will fail, leaving the logical volume as it is. If the allocation fails, you have the option of fixing the drive, then initiating recovery of the failed device with the **--refresh** option of the **lvchange** command. Alternately, you can replace the failed device.

10.15.2. The warn RAID Fault Policy

In the following example, the **raid_fault_policy** field has been set to **warn** in the **lvm.conf** file. The RAID logical volume is laid out as follows.

```
# lvs -a -o name,copy_percent,devices my_vg
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sdh1(1)
  [my_lv_rimage_1]       /dev/sdf1(1)
```

```
[my_lv_rimage_2]      /dev/sdg1(1)
[my_lv_rmeta_0]       /dev/sdh1(0)
[my_lv_rmeta_1]       /dev/sdf1(0)
[my_lv_rmeta_2]       /dev/sdg1(0)
```

If the /**dev**/**sdh** device fails, the system log will display error messages. In this case, however, LVM will not automatically attempt to repair the RAID device by replacing one of the images. Instead, if the device has failed you can replace the device with the **--repair** argument of the **lvconvert** command.

10.16. REPLACING A RAID DEVICE IN A LOGICAL VOLUME

You can replace a RAID device in a logical volume.

- If there has been no failure on the RAID device, follow Section 10.16.1, "Replacing a RAID device that has not failed".
- If the RAID device has failed, follow Section 10.16.4, "Replacing a failed RAID device in a logical volume".

10.16.1. Replacing a RAID device that has not failed

To replace a RAID device in a logical volume, use the **--replace** argument of the **lvconvert** command.

Prerequisites

- The RAID device has not failed. The following commands will not work if the RAID device has failed.

Procedure

- Replace the RAID device:

```
# lvconvert --replace dev_to_remove vg/lv possible_replacements
```

  - Replace *dev_to_remove* with the path to the physical volume that you want to replace.
  - Replace *vg/lv* with the volume group and logical volume name of the RAID array.
  - Replace *possible_replacements* with the path to the physical volume that you want to use as a replacement.

Example 10.1. Replacing a RAID1 device

The following example creates a RAID1 logical volume and then replaces a device in that volume.

1. Create the RAID1 array:

```
# lvcreate --type raid1 -m 2 -L 1G -n my_lv my_vg

  Logical volume "my_lv" created
```

2. Examine the RAID1 array:

```
# lvs -a -o name,copy_percent,devices my_vg
```

```
  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sdb1(1)
  [my_lv_rimage_1]       /dev/sdb2(1)
  [my_lv_rimage_2]       /dev/sdc1(1)
  [my_lv_rmeta_0]        /dev/sdb1(0)
  [my_lv_rmeta_1]        /dev/sdb2(0)
  [my_lv_rmeta_2]        /dev/sdc1(0)
```

3. Replace the /**dev**/**sdb2** physical volume:

```
# lvconvert --replace /dev/sdb2 my_vg/my_lv
```

4. Examine the RAID1 array with the replacement:

```
# lvs -a -o name,copy_percent,devices my_vg

  LV              Copy%  Devices
  my_lv           37.50 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sdb1(1)
  [my_lv_rimage_1]       /dev/sdc2(1)
  [my_lv_rimage_2]       /dev/sdc1(1)
  [my_lv_rmeta_0]        /dev/sdb1(0)
  [my_lv_rmeta_1]        /dev/sdc2(0)
  [my_lv_rmeta_2]        /dev/sdc1(0)
```

Example 10.2. Specifying the replacement physical volume

The following example creates a RAID1 logical volume and then replaces a device in that volume, specifying which physical volume to use for the replacement.

1. Create the RAID1 array:

```
# lvcreate --type raid1 -m 1 -L 100 -n my_lv my_vg

  Logical volume "my_lv" created
```

2. Examine the RAID1 array:

```
# lvs -a -o name,copy_percent,devices my_vg

  LV              Copy%  Devices
  my_lv           100.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sda1(1)
  [my_lv_rimage_1]       /dev/sdb1(1)
  [my_lv_rmeta_0]        /dev/sda1(0)
  [my_lv_rmeta_1]        /dev/sdb1(0)
```

3. Examine the physical volumes:

```
# pvs
```

```
  PV         VG       Fmt  Attr PSize    PFree
  /dev/sda1  my_vg    lvm2 a--  1020.00m  916.00m
  /dev/sdb1  my_vg    lvm2 a--  1020.00m  916.00m
  /dev/sdc1  my_vg    lvm2 a--  1020.00m 1020.00m
  /dev/sdd1  my_vg    lvm2 a--  1020.00m 1020.00m
```

4. Replace the **/dev/sdb1** physical volume with **/dev/sdd1**:

```
# lvconvert --replace /dev/sdb1 my_vg/my_lv /dev/sdd1
```

5. Examine the RAID1 array with the replacement:

```
# lvs -a -o name,copy_percent,devices my_vg

  LV              Copy%  Devices
  my_lv             28.00 my_lv_rimage_0(0),my_lv_rimage_1(0)
  [my_lv_rimage_0]       /dev/sda1(1)
  [my_lv_rimage_1]       /dev/sdd1(1)
  [my_lv_rmeta_0]        /dev/sda1(0)
  [my_lv_rmeta_1]        /dev/sdd1(0)
```

Example 10.3. Replacing multiple RAID devices

You can replace more than one RAID device at a time by specifying multiple **replace** arguments, as in the following example.

1. Create a RAID1 array:

```
# lvcreate --type raid1 -m 2 -L 100 -n my_lv my_vg

  Logical volume "my_lv" created
```

2. Examine the RAID1 array:

```
# lvs -a -o name,copy_percent,devices my_vg

  LV              Copy%  Devices
  my_lv            100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]       /dev/sda1(1)
  [my_lv_rimage_1]       /dev/sdb1(1)
  [my_lv_rimage_2]       /dev/sdc1(1)
  [my_lv_rmeta_0]        /dev/sda1(0)
  [my_lv_rmeta_1]        /dev/sdb1(0)
  [my_lv_rmeta_2]        /dev/sdc1(0)
```

3. Replace the **/dev/sdb1** and **/dev/sdc1** physical volumes:

```
# lvconvert --replace /dev/sdb1 --replace /dev/sdc1 my_vg/my_lv
```

4. Examine the RAID1 array with the replacements:

```
# lvs -a -o name,copy_percent,devices my_vg
```

```
LV              Copy%  Devices
my_lv             60.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
[my_lv_rimage_0]       /dev/sda1(1)
[my_lv_rimage_1]       /dev/sdd1(1)
[my_lv_rimage_2]       /dev/sde1(1)
[my_lv_rmeta_0]        /dev/sda1(0)
[my_lv_rmeta_1]        /dev/sdd1(0)
[my_lv_rmeta_2]        /dev/sde1(0)
```

10.16.2. Failed devices in LVM RAID

RAID is not like traditional LVM mirroring. LVM mirroring required failed devices to be removed or the mirrored logical volume would hang. RAID arrays can keep on running with failed devices. In fact, for RAID types other than RAID1, removing a device would mean converting to a lower level RAID (for example, from RAID6 to RAID5, or from RAID4 or RAID5 to RAID0).

Therefore, rather than removing a failed device unconditionally and potentially allocating a replacement, LVM allows you to replace a failed device in a RAID volume in a one-step solution by using the **--repair** argument of the **lvconvert** command.

10.16.3. Recovering a failed RAID device in a logical volume

If the LVM RAID device failure is a transient failure or you are able to repair the device that failed, you can initiate recovery of the failed device.

Prerequisites

- The previously failed device is now working.

Procedure

- Refresh the logical volume that contains the RAID device:

```
# lvchange --refresh my_vg/my_lv
```

Verification steps

- Examine the logical volume with the recovered device:

```
# lvs --all --options name,devices,lv_attr,lv_health_status my_vg
```

10.16.4. Replacing a failed RAID device in a logical volume

This procedure replaces a failed device that serves as a physical volume in an LVM RAID logical volume.

Prerequisites

- The volume group includes a physical volume that provides enough free capacity to replace the failed device.
  If no physical volume with sufficient free extents is available on the volume group, add a new, sufficiently large physical volume using the **vgextend** utility.

Procedure

1. In the following example, a RAID logical volume is laid out as follows:

```
# lvs --all --options name,copy_percent,devices my_vg

  LV              Cpy%Sync Devices
  my_lv           100.00   my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
  [my_lv_rimage_1]         /dev/sdc1(1)
  [my_lv_rimage_2]         /dev/sdd1(1)
  [my_lv_rmeta_0]          /dev/sde1(0)
  [my_lv_rmeta_1]          /dev/sdc1(0)
  [my_lv_rmeta_2]          /dev/sdd1(0)
```

2. If the **/dev/sdc** device fails, the output of the **lvs** command is as follows:

```
# lvs --all --options name,copy_percent,devices my_vg

  /dev/sdc: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rimage_1 while checking used and
assumed devices.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rmeta_1 while checking used and
assumed devices.
  LV              Cpy%Sync Devices
  my_lv           100.00   my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
  [my_lv_rimage_1]         [unknown](1)
  [my_lv_rimage_2]         /dev/sdd1(1)
  [my_lv_rmeta_0]          /dev/sde1(0)
  [my_lv_rmeta_1]          [unknown](0)
  [my_lv_rmeta_2]          /dev/sdd1(0)
```

3. Replace the failed device and display the logical volume:

```
# lvconvert --repair my_vg/my_lv

  /dev/sdc: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rimage_1 while checking used and
assumed devices.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rmeta_1 while checking used and
assumed devices.
Attempt to replace failed RAID images (requires full device resync)? [y/n]: y
  Faulty devices in my_vg/my_lv successfully replaced.
```

Optional: To manually specify the physical volume that replaces the failed device, add the physical volume at the end of the command:

```
# lvconvert --repair my_vg/my_lv replacement_pv
```

4. Examine the logical volume with the replacement:

```
# lvs --all --options name,copy_percent,devices my_vg

  /dev/sdc: open failed: No such device or address
  /dev/sdc1: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  LV              Cpy%Sync Devices
  my_lv           43.79    my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
  [my_lv_rimage_1]         /dev/sdb1(1)
  [my_lv_rimage_2]         /dev/sdd1(1)
  [my_lv_rmeta_0]          /dev/sde1(0)
  [my_lv_rmeta_1]          /dev/sdb1(0)
  [my_lv_rmeta_2]          /dev/sdd1(0)
```

Until you remove the failed device from the volume group, LVM utilities still indicate that LVM cannot find the failed device.

5. Remove the failed device from the volume group:

```
# vgreduce --removemissing VG
```

10.17. CHECKING DATA COHERENCY IN A RAID LOGICAL VOLUME (RAID SCRUBBING)

LVM provides scrubbing support for RAID logical volumes. RAID scrubbing is the process of reading all the data and parity blocks in an array and checking to see whether they are coherent.

Procedure

1. Optional: Limit the I/O bandwidth that the scrubbing process uses.
   When you perform a RAID scrubbing operation, the background I/O required by the **sync** operations can crowd out other I/O to LVM devices, such as updates to volume group metadata. This might cause the other LVM operations to slow down. You can control the rate of the scrubbing operation by implementing recovery throttling.

   Add the following options to the **lvchange --syncaction** commands in the next steps:

   --maxrecoveryrate *Rate*[bBsSkKmMgG]

   Sets the maximum recovery rate so that the operation does crowd out nominal I/O operations. Setting the recovery rate to 0 means that the operation is unbounded.

   --minrecoveryrate *Rate*[bBsSkKmMgG]

   Sets the minimum recovery rate to ensure that I/O for **sync** operations achieves a minimum throughput, even when heavy nominal I/O is present.

   Specify the *Rate* value as an amount per second for each device in the array. If you provide no suffix, the options assume kiB per second per device.

2. Display the number of discrepancies in the array, without repairing them:

```
# lvchange --syncaction check vg/raid_lv
```

3. Correct the discrepancies in the array:

```
# lvchange --syncaction repair vg/raid_lv
```

NOTE

The **lvchange --syncaction repair** operation does not perform the same function as the **lvconvert --repair** operation:

- The **lvchange --syncaction repair** operation initiates a background synchronization operation on the array.
- The **lvconvert --repair** operation repairs or replaces failed devices in a mirror or RAID logical volume.

4. Optional: Display information about the scrubbing operation:

```
# lvs -o +raid_sync_action,raid_mismatch_count vg/lv
```

- The **raid_sync_action** field displays the current synchronization operation that the RAID volume is performing. It can be one of the following values:

  idle
  : All sync operations complete (doing nothing)

  resync
  : Initializing an array or recovering after a machine failure

  recover
  : Replacing a device in the array

  check
  : Looking for array inconsistencies

  repair
  : Looking for and repairing inconsistencies

- The **raid_mismatch_count** field displays the number of discrepancies found during a **check** operation.
- The **Cpy%Sync** field displays the progress of the **sync** operations.
- The **lv_attr** field provides additional indicators. Bit 9 of this field displays the health of the logical volume, and it supports the following indicators:
  - **m** (mismatches) indicates that there are discrepancies in a RAID logical volume. This character is shown after a scrubbing operation has detected that portions of the RAID are not coherent.
  - **r** (refresh) indicates that a device in a RAID array has suffered a failure and the kernel regards it as failed, even though LVM can read the device label and considers the device to be operational. Refresh the logical volume to notify the kernel that the device is now available, or replace the device if you suspect that it failed.

Additional resources

- For more information, see the **lvchange(8)** and **lvmraid(7)** man pages.

10.18. CONVERTING A RAID LEVEL (RAID TAKEOVER)

LVM supports Raid *takeover*, which means converting a RAID logical volume from one RAID level to another (such as from RAID 5 to RAID 6). Changing the RAID level is usually done to increase or decrease resilience to device failures or to restripe logical volumes. You use the **lvconvert** for RAID takeover. For information on RAID takeover and for examples of using the **lvconvert** to convert a RAID logical volume, see the **lvmraid**(7) man page.

10.19. CHANGING ATTRIBUTES OF A RAID VOLUME (RAID RESHAPE)

RAID *reshaping* means changing attributes of a RAID logical volume while keeping the same RAID level. Some attributes you can change include RAID layout, stripe size, and number of stripes. For information on RAID reshaping and examples of using the **lvconvert** command to reshape a RAID logical volume, see the **lvmraid**(7) man page.

10.20. CONTROLLING I/O OPERATIONS ON A RAID1 LOGICAL VOLUME

You can control the I/O operations for a device in a RAID1 logical volume by using the **--writemostly** and **--writebehind** parameters of the **lvchange** command. The format for using these parameters is as follows.

- **--[raid]writemostly *PhysicalVolume*[:{t|y|n}]**
  Marks a device in a RAID1 logical volume as **write-mostly**. All reads to these drives will be avoided unless necessary. Setting this parameter keeps the number of I/O operations to the drive to a minimum. By default, the **write-mostly** attribute is set to yes for the specified physical volume in the logical volume. It is possible to remove the **write-mostly** flag by appending **:n** to the physical volume or to toggle the value by specifying **:t**. The **--writemostly** argument can be specified more than one time in a single command, making it possible to toggle the write-mostly attributes for all the physical volumes in a logical volume at once.

- **--[raid]writebehind *IOCount***
  Specifies the maximum number of outstanding writes that are allowed to devices in a RAID1 logical volume that are marked as **write-mostly**. Once this value is exceeded, writes become synchronous, causing all writes to the constituent devices to complete before the array signals the write has completed. Setting the value to zero clears the preference and allows the system to choose the value arbitrarily.

10.21. CHANGING THE REGION SIZE ON A RAID LOGICAL VOLUME

When you create a RAID logical volume, the region size for the logical volume will be the value of the **raid_region_size** parameter in the **/etc/lvm/lvm.conf** file. You can override this default value with the **-R** option of the **lvcreate** command.

After you have created a RAID logical volume, you can change the region size of the volume with the **-R** option of the **lvconvert** command. The following example changes the region size of logical volume **vg/raidlv** to 4096K. The RAID volume must be synced in order to change the region size.

```
# lvconvert -R 4096K vg/raid1
Do you really want to change the region_size 512.00 KiB of LV vg/raid1 to 4.00 MiB? [y/n]: y
  Changed region size on RAID LV vg/raid1 to 4.00 MiB.
```

CHAPTER 11. SNAPSHOT LOGICAL VOLUMES

The LVM snapshot feature provides the ability to create virtual images of a device at a particular instant without causing a service interruption.

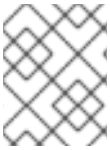
11.1. SNAPSHOT VOLUMES

The LVM snapshot feature provides the ability to create virtual images of a device at a particular instant without causing a service interruption. When a change is made to the original device (the origin) after a snapshot is taken, the snapshot feature makes a copy of the changed data area as it was prior to the change so that it can reconstruct the state of the device.

NOTE

LVM supports thinly-provisioned snapshots.

Because a snapshot copies only the data areas that change after the snapshot is created, the snapshot feature requires a minimal amount of storage. For example, with a rarely updated origin, 3-5 % of the origin's capacity is sufficient to maintain the snapshot.



NOTE

Snapshot copies of a file system are virtual copies, not an actual media backup for a file system. Snapshots do not provide a substitute for a backup procedure.

The size of the snapshot governs the amount of space set aside for storing the changes to the origin volume. For example, if you made a snapshot and then completely overwrote the origin the snapshot would have to be at least as big as the origin volume to hold the changes. You need to dimension a snapshot according to the expected level of change. So for example a short-lived snapshot of a read-mostly volume, such as /**usr**, would need less space than a long-lived snapshot of a volume that sees a greater number of writes, such as /**home**.

If a snapshot runs full, the snapshot becomes invalid, since it can no longer track changes on the origin volume. You should regularly monitor the size of the snapshot. Snapshots are fully resizable, however, so if you have the storage capacity you can increase the size of the snapshot volume to prevent it from getting dropped. Conversely, if you find that the snapshot volume is larger than you need, you can reduce the size of the volume to free up space that is needed by other logical volumes.

When you create a snapshot file system, full read and write access to the origin stays possible. If a chunk on a snapshot is changed, that chunk is marked and never gets copied from the original volume.

There are several uses for the snapshot feature:

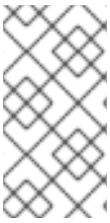
- Most typically, a snapshot is taken when you need to perform a backup on a logical volume without halting the live system that is continuously updating the data.
- You can execute the **fsck** command on a snapshot file system to check the file system integrity and determine whether the original file system requires file system repair.
- Because the snapshot is read/write, you can test applications against production data by taking a snapshot and running tests against the snapshot, leaving the real data untouched.

- You can create LVM volumes for use with Red Hat Virtualization. LVM snapshots can be used to create snapshots of virtual guest images. These snapshots can provide a convenient way to modify existing guests or create new guests with minimal additional storage.

You can use the **--merge** option of the **lvconvert** command to merge a snapshot into its origin volume. One use for this feature is to perform system rollback if you have lost data or files or otherwise need to restore your system to a previous state. After you merge the snapshot volume, the resulting logical volume will have the origin volume's name, minor number, and UUID and the merged snapshot is removed.

11.2. CREATING SNAPSHOT VOLUMES

Use the **-s** argument of the **lvcreate** command to create a snapshot volume. A snapshot volume is writable.



NOTE

LVM snapshots are not supported across the nodes in a cluster. You cannot create a snapshot volume in a shared volume group. However, if you need to create a consistent backup of data on a shared logical volume you can activate the volume exclusively and then create the snapshot.

NOTE

Snapshots are supported for RAID logical volumes.

LVM does not allow you to create a snapshot volume that is larger than the size of the origin volume plus needed metadata for the volume. If you specify a snapshot volume that is larger than this, the system will create a snapshot volume that is only as large as will be needed for the size of the origin.

By default, a snapshot volume is skipped during normal activation commands.

The following procedure creates an origin logical volume named **origin** and a snapshot volume of the original volume named **snap**.

1. Create a logical volume named **origin** from the volume group **VG**.

```
# lvcreate -L 1G -n origin VG
  Logical volume "origin" created.
```

2. Create a snapshot logical volume of **/dev/VG/origin** that is 100 MB in size named **snap**. If the original logical volume contains a file system, you can mount the snapshot logical volume on an arbitrary directory in order to access the contents of the file system to run a backup while the original file system continues to get updated.

```
# lvcreate --size 100M --snapshot --name snap /dev/VG/origin
  Logical volume "snap" created.
```

3. Display the status of logical volume **/dev/VG/origin**, showing all snapshot logical volumes and their status (active or inactive).

```
# lvdisplay /dev/VG/origin
  --- Logical volume ---
  LV Path                /dev/VG/origin
```

```
  LV Name                origin
  VG Name                VG
  LV UUID                EsFoBp-CB9H-Epl5-pUO4-Yevi-EdFS-xtFnaF
  LV Write Access        read/write
  LV Creation host, time host-083.virt.lab.msp.redhat.com, 2019-04-11 14:45:06 -0500
  LV snapshot status     source of
                         snap [active]
  LV Status              available
  # open                 0
  LV Size                1.00 GiB
  Current LE             256
  Segments               1
  Allocation             inherit
  Read ahead sectors     auto
  - currently set to     8192
  Block device           253:6
```

4. The **lvs** command, by default, displays the origin volume and the current percentage of the snapshot volume being used. The following example shows the default output for the **lvs** command after you have created the snapshot volume, with a display that includes the devices that constitute the logical volumes.

```
# lvs -a -o +devices
  LV     VG  Attr       LSize   Pool   Origin Data%  Meta%  Move Log Cpy%Sync Convert
Devices
  origin VG  owi-a-s---   1.00g                                        /dev/sde1(0)
  snap   VG  swi-a-s--- 100.00m       origin 0.00                         /dev/sde1(256)
```

WARNING

Because the snapshot increases in size as the origin volume changes, it is important to monitor the percentage of the snapshot volume regularly with the **lvs** command to be sure it does not fill. A snapshot that is 100% full is lost completely, as a write to unchanged parts of the origin would be unable to succeed without corrupting the snapshot.

In addition to the snapshot itself being invalidated when full, any mounted file systems on that snapshot device are forcibly unmounted, avoiding the inevitable file system errors upon access to the mount point. In addition, you can specify the **snapshot_autoextend_threshold** option in the **lvm.conf** file. This option allows automatic extension of a snapshot whenever the remaining snapshot space drops below the threshold you set. This feature requires that there be unallocated space in the volume group.

LVM does not allow you to create a snapshot volume that is larger than the size of the origin volume plus needed metadata for the volume. Similarly, automatic extension of a snapshot will not increase the size of a snapshot volume beyond the maximum calculated size that is necessary for the snapshot. Once a snapshot has grown large enough to cover the origin, it is no longer monitored for automatic extension.

Information on setting **snapshot_autoextend_threshold** and **snapshot_autoextend_percent** is provided in the **/etc/lvm/lvm.conf** file itself.

11.3. MERGING SNAPSHOT VOLUMES

You can use the **--merge** option of the **lvconvert** command to merge a snapshot into its origin volume. If both the origin and snapshot volume are not open, the merge will start immediately. Otherwise, the merge will start the first time either the origin or snapshot are activated and both are closed. Merging a snapshot into an origin that cannot be closed, for example a root file system, is deferred until the next time the origin volume is activated. When merging starts, the resulting logical volume will have the origin's name, minor number and UUID. While the merge is in progress, reads or writes to the origin appear as they were directed to the snapshot being merged. When the merge finishes, the merged snapshot is removed.

The following command merges snapshot volume **vg00/lvol1_snap** into its origin.

```
# lvconvert --merge vg00/lvol1_snap
```

You can specify multiple snapshots on the command line, or you can use LVM object tags to specify that multiple snapshots be merged to their respective origins. In the following example, logical volumes **vg00/lvol1**, **vg00/lvol2**, and **vg00/lvol3** are all tagged with the tag **@some_tag**. The following command merges the snapshot logical volumes for all three volumes serially: **vg00/lvol1**, then **vg00/lvol2**, then **vg00/lvol3**. If the **--background** option were used, all snapshot logical volume merges would start in parallel.

```
# lvconvert --merge @some_tag
```

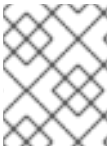
For further information on the **lvconvert --merge** command, see the **lvconvert**(8) man page.

CHAPTER 12. CREATING AND MANAGING THINLY-PROVISIONED LOGICAL VOLUMES (THIN VOLUMES)

Logical volumes can be thinly provisioned. This allows you to create logical volumes that are larger than the available extents.

12.1. THINLY-PROVISIONED LOGICAL VOLUMES (THIN VOLUMES)

Logical volumes can be thinly provisioned. This allows you to create logical volumes that are larger than the available extents. Using thin provisioning, you can manage a storage pool of free space, known as a thin pool, which can be allocated to an arbitrary number of devices when needed by applications. You can then create devices that can be bound to the thin pool for later allocation when an application actually writes to the logical volume. The thin pool can be expanded dynamically when needed for cost-effective allocation of storage space.



NOTE

Thin volumes are not supported across the nodes in a cluster. The thin pool and all its thin volumes must be exclusively activated on only one cluster node.

By using thin provisioning, a storage administrator can overcommit the physical storage, often avoiding the need to purchase additional storage. For example, if ten users each request a 100GB file system for their application, the storage administrator can create what appears to be a 100GB file system for each user but which is backed by less actual storage that is used only when needed.

NOTE

When using thin provisioning, it is important that the storage administrator monitor the storage pool and add more capacity if it starts to become full.

To make sure that all available space can be used, LVM supports data discard. This allows for re-use of the space that was formerly used by a discarded file or other block range.

For information on creating thin volumes, see Creating thinly-provisioned logical volumes .

Thin volumes provide support for a new implementation of copy-on-write (COW) snapshot logical volumes, which allow many virtual devices to share the same data in the thin pool. For information on thin snapshot volumes, see Thinly-provisioned snapshot volumes .

12.2. CREATING THINLY-PROVISIONED LOGICAL VOLUMES

This procedure provides an overview of the basic commands you use to create and grow thinly-provisioned logical volumes. For detailed information on LVM thin provisioning as well as information on using the LVM commands and utilities with thinly-provisioned logical volumes, see the **lvmthin**(7) man page.

To create a thin volume, perform the following tasks:

1. Create a volume group with the **vgcreate** command.
2. Create a thin pool with the **lvcreate** command.
3. Create a thin volume in the thin pool with the **lvcreate** command.

You can use the **-T** (or **--thin**) option of the **lvcreate** command to create either a thin pool or a thin volume. You can also use **-T** option of the **lvcreate** command to create both a thin pool and a thin volume in that pool at the same time with a single command.

The following command uses the **-T** option of the **lvcreate** command to create a thin pool named **mythinpool** in the volume group **vg001** and that is 100M in size. Note that since you are creating a pool of physical space, you must specify the size of the pool. The **-T** option of the **lvcreate** command does not take an argument; it deduces what type of device is to be created from the other options the command specifies.

```
# lvcreate -L 100M -T vg001/mythinpool
  Thin pool volume with chunk size 64.00 KiB can address at most 15.81 TiB of data.
  Logical volume "mythinpool" created.
# lvs
  LV         VG    Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  mythinpool vg001 twi-a-tz-- 100.00m             0.00   10.84
```

The following command uses the **-T** option of the **lvcreate** command to create a thin volume named **thinvolume** in the thin pool **vg001/mythinpool**. Note that in this case you are specifying virtual size, and that you are specifying a virtual size for the volume that is greater than the pool that contains it.

```
# lvcreate -V 1G -T vg001/mythinpool -n thinvolume
  WARNING: Sum of all thin volume sizes (1.00 GiB) exceeds the size of thin pool vg001/mythinpool
(100.00 MiB).
  WARNING: You have not turned on protection against thin pools running out of space.
  WARNING: Set activation/thin_pool_autoextend_threshold below 100 to trigger automatic extension
of thin pools before they get full.
  Logical volume "thinvolume" created.
# lvs
  LV         VG       Attr     LSize   Pool       Origin Data%  Move Log Copy%  Convert
  mythinpool  vg001    twi-a-tz 100.00m                    0.00
  thinvolume  vg001    Vwi-a-tz   1.00g mythinpool          0.00
```

The following command uses the **-T** option of the **lvcreate** command to create a thin pool and a thin volume in that pool by specifying both a size and a virtual size argument for the **lvcreate** command. This command creates a thin pool named **mythinpool** in the volume group **vg001** and it also creates a thin volume named **thinvolume** in that pool.

```
# lvcreate -L 100M -T vg001/mythinpool -V 1G -n thinvolume
  Thin pool volume with chunk size 64.00 KiB can address at most 15.81 TiB of data.
  WARNING: Sum of all thin volume sizes (1.00 GiB) exceeds the size of thin pool vg001/mythinpool
(100.00 MiB).
  WARNING: You have not turned on protection against thin pools running out of space.
  WARNING: Set activation/thin_pool_autoextend_threshold below 100 to trigger automatic extension
of thin pools before they get full.
  Logical volume "thinvolume" created.
# lvs
  LV         VG    Attr       LSize   Pool       Origin Data%  Meta%  Move Log Cpy%Sync Convert
  mythinpool vg001 twi-aotz-- 100.00m                    0.00   10.94
  thinvolume vg001 Vwi-a-tz--   1.00g mythinpool          0.00
```

You can also create a thin pool by specifying the **--thinpool** parameter of the **lvcreate** command. Unlike the **-T** option, the **--thinpool** parameter requires an argument, which is the name of the thin pool logical volume that you are creating. The following example specifies the **--thinpool** parameter of the **lvcreate** command to create a thin pool named **mythinpool** in the volume group **vg001** and that is 100M in size:

```
# lvcreate -L 100M --thinpool mythinpool vg001
  Thin pool volume with chunk size 64.00 KiB can address at most 15.81 TiB of data.
  Logical volume "mythinpool" created.
# lvs
  LV         VG    Attr       LSize   Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
  mythinpool vg001 twi-a-tz-- 100.00m             0.00   10.84
```

Use the following criteria for using the chunk size:

- A smaller chunk size requires more metadata and hinders performance, but provides better space utilization with snapshots.
- A bigger chunk size requires less metadata manipulation, but makes the snapshot less space efficient.

By default, **lvm2** starts with a 64KiB chunk size and increases its value when the resulting size of the thin pool metadata device grows above 128MiB, this keeps the metadata size compact. However, this may result in some big chunk size values, which are less space efficient for snapshot usage. In such cases, a smaller chunk size and a bigger metadata size is a better option.

If the volume data size is in the range of TiB, use ~15.8GiB as the metadata size, which is the maximum supported size, and set the chunk size as per your requirement. But, note that it is not possible to increase the metadata size if you need to extend the volume's data size and have a small chunk size.

WARNING

Red Hat does not recommend setting a chunk size smaller than the default value. If the chunk size is too small and your volume runs out of space for metadata, the volume is unable to create data. Monitor your logical volumes to ensure that they are expanded, or create more storage before the metadata volumes become completely full. Ensure that you set up your thin pool with a large enough chunk size so that they do not run out of room for the metadata.

Striping is supported for pool creation. The following command creates a 100M thin pool named **pool** in volume group **vg001** with two 64 kB stripes and a chunk size of 256 kB. It also creates a 1T thin volume, **vg00/thin_lv**.

```
# lvcreate -i 2 -I 64 -c 256 -L 100M -T vg00/pool -V 1T --name thin_lv
```

You can extend the size of a thin volume with the **lvextend** command. You cannot, however, reduce the size of a thin pool.

The following command resizes an existing thin pool that is 100M in size by extending it another 100M.

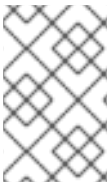
```
# lvextend -L+100M vg001/mythinpool
  Extending logical volume mythinpool to 200.00 MiB
  Logical volume mythinpool successfully resized
# lvs
```

```
  LV          VG      Attr     LSize   Pool     Origin Data%  Move Log Copy%  Convert
  mythinpool  vg001   twi-a-tz 200.00m                 0.00
  thinvolume  vg001   Vwi-a-tz   1.00g mythinpool         0.00
```

As with other types of logical volumes, you can rename the volume with the **lvrename**, you can remove the volume with the **lvremove**, and you can display information about the volume with the **lvs** and **lvdisplay** commands.

By default, the **lvcreate** command sets the size of the thin pool's metadata logical volume according to the formula (Pool_LV_size / Pool_LV_chunk_size * 64). If you will have large numbers of snapshots or if you have have small chunk sizes for your thin pool and thus expect significant growth of the size of the thin pool at a later time, you may need to increase the default value of the thin pool's metadata volume with the **--poolmetadatasize** parameter of the **lvcreate** command. The supported value for the thin pool's metadata logical volume is in the range between 2MiB and 16GiB.

You can use the **--thinpool** parameter of the **lvconvert** command to convert an existing logical volume to a thin pool volume. When you convert an existing logical volume to a thin pool volume, you must use the **--poolmetadata** parameter in conjunction with the **--thinpool** parameter of the **lvconvert** to convert an existing logical volume to the thin pool volume's metadata volume.



NOTE

Converting a logical volume to a thin pool volume or a thin pool metadata volume destroys the content of the logical volume, since in this case the **lvconvert** does not preserve the content of the devices but instead overwrites the content.

The following example converts the existing logical volume **lv1** in volume group **vg001** to a thin pool volume and converts the existing logical volume **lv2** in volume group **vg001** to the metadata volume for that thin pool volume.

```
# lvconvert --thinpool vg001/lv1 --poolmetadata vg001/lv2
  Converted vg001/lv1 to thin pool.
```

12.3. THINLY-PROVISIONED SNAPSHOT VOLUMES

Red Hat Enterprise Linux provides support for thinly-provisioned snapshot volumes. Thin snapshot volumes allow many virtual devices to be stored on the same data volume. This simplifies administration and allows for the sharing of data between snapshot volumes.

As for all LVM snapshot volumes, as well as all thin volumes, thin snapshot volumes are not supported across the nodes in a cluster. The snapshot volume must be exclusively activated on only one cluster node.

Thin snapshot volumes provide the following benefits:

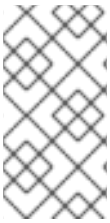
- A thin snapshot volume can reduce disk usage when there are multiple snapshots of the same origin volume.
- If there are multiple snapshots of the same origin, then a write to the origin will cause one COW operation to preserve the data. Increasing the number of snapshots of the origin should yield no major slowdown.
- Thin snapshot volumes can be used as a logical volume origin for another snapshot. This allows for an arbitrary depth of recursive snapshots (snapshots of snapshots of snapshots...).

- A snapshot of a thin logical volume also creates a thin logical volume. This consumes no data space until a COW operation is required, or until the snapshot itself is written.
- A thin snapshot volume does not need to be activated with its origin, so a user may have only the origin active while there are many inactive snapshot volumes of the origin.
- When you delete the origin of a thinly-provisioned snapshot volume, each snapshot of that origin volume becomes an independent thinly-provisioned volume. This means that instead of merging a snapshot with its origin volume, you may choose to delete the origin volume and then create a new thinly-provisioned snapshot using that independent volume as the origin volume for the new snapshot.

Although there are many advantages to using thin snapshot volumes, there are some use cases for which the older LVM snapshot volume feature may be more appropriate to your needs:

- You cannot change the chunk size of a thin pool. If the thin pool has a large chunk size (for example, 1MB) and you require a short-living snapshot for which a chunk size that large is not efficient, you may elect to use the older snapshot feature.
- You cannot limit the size of a thin snapshot volume; the snapshot will use all of the space in the thin pool, if necessary. This may not be appropriate for your needs.

In general, you should consider the specific requirements of your site when deciding which snapshot format to use.



NOTE

When using thin provisioning, it is important that the storage administrator monitor the storage pool and add more capacity if it starts to become full. For information on configuring and displaying information on thinly-provisioned snapshot volumes, see Creating thinly-provisioned snapshot volumes .

12.4. CREATING THINLY-PROVISIONED SNAPSHOT VOLUMES

Red Hat Enterprise Linux provides support for thinly-provisioned snapshot volumes.

NOTE

This section provides an overview of the basic commands you use to create and grow thinly-provisioned snapshot volumes. For detailed information on LVM thin provisioning as well as information on using the LVM commands and utilities with thinly-provisioned logical volumes, see the **lvmthin**(7) man page.

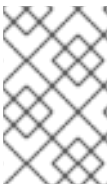
IMPORTANT

When creating a thin snapshot volume, you do not specify the size of the volume. If you specify a size parameter, the snapshot that will be created will not be a thin snapshot volume and will not use the thin pool for storing data. For example, the command **lvcreate -s vg/thinvolume -L10M** will not create a thin snapshot, even though the origin volume is a thin volume.

Thin snapshots can be created for thinly-provisioned origin volumes, or for origin volumes that are not thinly-provisioned.

You can specify a name for the snapshot volume with the **--name** option of the **lvcreate** command. The following command creates a thinly-provisioned snapshot volume of the thinly-provisioned logical volume **vg001/thinvolume** that is named **mysnapshot1**.

```
# lvcreate -s --name mysnapshot1 vg001/thinvolume
  Logical volume "mysnapshot1" created
# lvs
  LV          VG      Attr     LSize   Pool       Origin     Data%  Move Log Copy%  Convert
  mysnapshot1 vg001   Vwi-a-tz   1.00g mythinpool thinvolume   0.00
  mythinpool  vg001   twi-a-tz 100.00m                        0.00
  thinvolume  vg001   Vwi-a-tz   1.00g mythinpool             0.00
```



NOTE

When using thin provisioning, it is important that the storage administrator monitor the storage pool and add more capacity if it starts to become full. For information on extending the size of a thin volume, see Creating thinly-provisioned logical volumes .

A thin snapshot volume has the same characteristics as any other thin volume. You can independently activate the volume, extend the volume, rename the volume, remove the volume, and even snapshot the volume.

By default, a snapshot volume is skipped during normal activation commands. For information on controlling the activation of a logical volume, see Logical volume activation.

You can also create a thinly-provisioned snapshot of a non-thinly-provisioned logical volume. Since the non-thinly-provisioned logical volume is not contained within a thin pool, it is referred to as an *external origin*. External origin volumes can be used and shared by many thinly-provisioned snapshot volumes, even from different thin pools. The external origin must be inactive and read-only at the time the thinly-provisioned snapshot is created.

To create a thinly-provisioned snapshot of an external origin, you must specify the **--thinpool** option. The following command creates a thin snapshot volume of the read-only inactive volume **origin_volume**. The thin snapshot volume is named **mythinsnap**. The logical volume **origin_volume** then becomes the thin external origin for the thin snapshot volume **mythinsnap** in volume group **vg001** that will use the existing thin pool **vg001/pool**. Because the origin volume must be in the same volume group as the snapshot volume, you do not need to specify the volume group when specifying the origin logical volume.

```
# lvcreate -s --thinpool vg001/pool origin_volume --name mythinsnap
```

You can create a second thinly-provisioned snapshot volume of the first snapshot volume, as in the following command.

```
# lvcreate -s vg001/mythinsnap --name my2ndthinsnap
```

You can display a list of all ancestors and descendants of a thin snapshot logical volume by specifying the **lv_ancestors** and **lv_descendants** reporting fields of the **lvs** command.

In the following example:

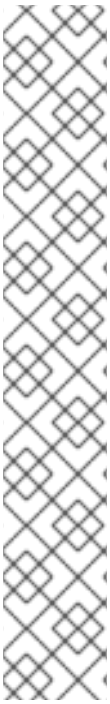
- **stack1** is an origin volume in volume group **vg001**.
- **stack2** is a snapshot of **stack1**

- **stack3** is a snapshot of **stack2**
- **stack4** is a snapshot of **stack3**

Additionally:

- **stack5** is also a snapshot of **stack2**
- **stack6** is a snapshot of **stack5**

```
$ lvs -o name,lv_ancestors,lv_descendants vg001
  LV     Ancestors           Descendants
  stack1                     stack2,stack3,stack4,stack5,stack6
  stack2 stack1              stack3,stack4,stack5,stack6
  stack3 stack2,stack1       stack4
  stack4 stack3,stack2,stack1
  stack5 stack2,stack1       stack6
  stack6 stack5,stack2,stack1
  pool
```



NOTE

The **lv_ancestors** and **lv_descendants** fields display existing dependencies but do not track removed entries which can break a dependency chain if the entry was removed from the middle of the chain. For example, if you remove the logical volume **stack3** from this sample configuration, the display is as follows.

```
$ lvs -o name,lv_ancestors,lv_descendants vg001
  LV     Ancestors           Descendants
  stack1                     stack2,stack5,stack6
  stack2 stack1              stack5,stack6
  stack4
  stack5 stack2,stack1       stack6
  stack6 stack5,stack2,stack1
  pool
```

You can configure your system to track and display logical volumes that have been removed, and you can display the full dependency chain that includes those volumes by specifying the **lv_ancestors_full** and **lv_descendants_full** fields.

12.5. TRACKING AND DISPLAYING THIN SNAPSHOT VOLUMES THAT HAVE BEEN REMOVED

You can configure your system to track thin snapshot and thin logical volumes that have been removed by enabling the **record_lvs_history** metadata option in the **lvm.conf** configuration file. This allows you to display a full thin snapshot dependency chain that includes logical volumes that have been removed from the original dependency chain and have become *historical* logical volumes.

You can configure your system to retain historical volumes for a defined period of time by specifying the retention time, in seconds, with the **lvs_history_retention_time** metadata option in the **lvm.conf** configuration file.

A historical logical volume retains a simplified representation of the logical volume that has been removed, including the following reporting fields for the volume:

- **lv_time_removed**: the removal time of the logical volume
- **lv_time**: the creation time of the logical volume
- **lv_name**: the name of the logical volume
- **lv_uuid**: the UUID of the logical volume
- **vg_name**: the volume group that contains the logical volume.

When a volume is removed, the historical logical volume name acquires a hypen as a prefix. For example, when you remove the logical volume **lvol1**, the name of the historical volume is **-lvol1**. A historical logical volume cannot be reactivated.

Even when the **record_lvs_history** metadata option enabled, you can prevent the retention of historical logical volumes on an individual basis when you remove a logical volume by specifying the **--nohistory** option of the **lvremove** command.

To include historical logical volumes in volume display, you specify the **-H|--history** option of an LVM display command. You can display a full thin snapshot dependency chain that includes historical volumes by specifying the **lv_full_ancestors** and **lv_full_descendants** reporting fields along with the **-H** option.

The following series of commands provides examples of how you can display and manage historical logical volumes.

1. Ensure that historical logical volumes are retained by setting **record_lvs_history=1** in the **lvm.conf** file. This metadata option is not enabled by default.
2. Enter the following command to display a thin provisioned snapshot chain.
   In this example:
   - **lvol1** is an origin volume, the first volume in the chain.
   - **lvol2** is a snapshot of **lvol1**.
   - **lvol3** is a snapshot of **lvol2**.
   - **lvol4** is a snapshot of **lvol3**.
   - **lvol5** is also a snapshot of **lvol3**.
     Note that even though the example **lvs** display command includes the **-H** option, no thin snapshot volume has yet been removed and there are no historical logical volumes to display.

     ```
     # lvs -H -o name,full_ancestors,full_descendants
       LV    FAncestors        FDescendants
       lvol1                   lvol2,lvol3,lvol4,lvol5
       lvol2 lvol1             lvol3,lvol4,lvol5
       lvol3 lvol2,lvol1       lvol4,lvol5
       lvol4 lvol3,lvol2,lvol1
       lvol5 lvol3,lvol2,lvol1
       pool
     ```
3. Remove logical volume **lvol3** from the snapshot chain, then run the following **lvs** command again to see how historical logical volumes are displayed, along with their ancestors and descendants.

```
# lvremove -f vg/lvol3
  Logical volume "lvol3" successfully removed
# lvs -H -o name,full_ancestors,full_descendants
  LV     FAncestors          FDescendants
  lvol1                      lvol2,-lvol3,lvol4,lvol5
  lvol2  lvol1                -lvol3,lvol4,lvol5
  -lvol3 lvol2,lvol1          lvol4,lvol5
  lvol4  -lvol3,lvol2,lvol1
  lvol5  -lvol3,lvol2,lvol1
  pool
```

4. You can use the **lv_time_removed** reporting field to display the time a historical volume was removed.

```
# lvs -H -o name,full_ancestors,full_descendants,time_removed
  LV     FAncestors          FDescendants               RTime
  lvol1                      lvol2,-lvol3,lvol4,lvol5
  lvol2  lvol1                -lvol3,lvol4,lvol5
  -lvol3 lvol2,lvol1          lvol4,lvol5                2016-03-14 14:14:32 +0100
  lvol4  -lvol3,lvol2,lvol1
  lvol5  -lvol3,lvol2,lvol1
  pool
```

5. You can reference historical logical volumes individually in a display command by specifying the *vgname/lvname* format, as in the following example. Note that the fifth bit in the **lv_attr** field is set to **h** to indicate the volume is a historical volume.

```
# lvs -H vg/-lvol3
  LV     VG   Attr       LSize
  -lvol3 vg   ----h-----    0
```

6. LVM does not keep historical logical volumes if the volume has no live descendant. This means that if you remove a logical volume at the end of a snapshot chain, the logical volume is not retained as a historical logical volume.

```
# lvremove -f vg/lvol5
  Automatically removing historical logical volume vg/-lvol5.
  Logical volume "lvol5" successfully removed
# lvs -H -o name,full_ancestors,full_descendants
  LV     FAncestors          FDescendants
  lvol1                      lvol2,-lvol3,lvol4
  lvol2  lvol1                -lvol3,lvol4
  -lvol3 lvol2,lvol1          lvol4
  lvol4  -lvol3,lvol2,lvol1
  pool
```

7. Run the following commands to remove the volume **lvol1** and **lvol2** and to see how the **lvs** command displays the volumes once they have been removed.

```
# lvremove -f vg/lvol1 vg/lvol2
  Logical volume "lvol1" successfully removed
  Logical volume "lvol2" successfully removed
# lvs -H -o name,full_ancestors,full_descendants
  LV     FAncestors          FDescendants
```

```
  -lvol1                    -lvol2,-lvol3,lvol4
  -lvol2 -lvol1               -lvol3,lvol4
  -lvol3 -lvol2,-lvol1        lvol4
  lvol4  -lvol3,-lvol2,-lvol1
  pool
```

8. To remove a historical logical volume completely, you can run the **lvremove** command again, specifying the name of the historical volume that now includes the hyphen, as in the following example.

```
# lvremove -f vg/-lvol3
Historical logical volume "lvol3" successfully removed
# lvs -H -o name,full_ancestors,full_descendants
  LV     FAncestors    FDescendants
  -lvol1               -lvol2,lvol4
  -lvol2 -lvol1        lvol4
  lvol4  -lvol2,-lvol1
  pool
```

9. A historical logical volumes is retained as long as there is a chain that includes live volumes in its descendants. This means that removing a historical logical volume also removes all of the logical volumes in the chain if no existing descendant is linked to them, as shown in the following example.

```
# lvremove -f vg/lvol4
  Automatically removing historical logical volume vg/-lvol1.
  Automatically removing historical logical volume vg/-lvol2.
  Automatically removing historical logical volume vg/-lvol4.
  Logical volume "lvol4" successfully removed
```

CHAPTER 13. ENABLING CACHING TO IMPROVE LOGICAL VOLUME PERFORMANCE

You can add caching to an LVM logical volume to improve performance. LVM then caches I/O operations to the logical volume using a fast device, such as an SSD.

The following procedures create a special LV from the fast device, and attach this special LV to the original LV to improve the performance.

13.1. CACHING METHODS IN LVM

LVM provides the following kinds of caching. Each one is suitable for different kinds of I/O patterns on the logical volume.

dm-cache

This method speeds up access to frequently used data by caching it on the faster volume. The method caches both read and write operations.
The **dm-cache** method creates logical volumes of the type **cache**.

dm-writecache

This method caches only write operations. The faster volume stores the write operations and then migrates them to the slower disk in the background. The faster volume is usually an SSD or a persistent memory (PMEM) disk.
The **dm-writecache** method creates logical volumes of the type **writecache**.

Additional resources

- For information on cache modes and other details, see the **lvmcache(7)** man page.

13.2. LVM CACHING COMPONENTS

When you enable caching for a logical volume, LVM renames and hides the original volumes, and presents a new logical volume that is composed of the original logical volumes. The composition of the new logical volume depends on the caching method and whether you are using the **cachevol** or **cachepool** option.

The **cachevol** and **cachepool** options expose different levels of control over the placement of the caching components:

- With the **cachevol** option, the faster device stores both the cached copies of data blocks and the metadata for managing the cache.
- With the **cachepool** option, separate devices can store the cached copies of data blocks and the metadata for managing the cache.
  The **dm-writecache** method is not compatible with **cachepool**.

In all configurations, LVM exposes a single resulting device, which groups together all the caching components. The resulting device has the same name as the original slow logical volume.

13.3. ENABLING DM-CACHE CACHING FOR A LOGICAL VOLUME

This procedure enables caching of commonly used data on a logical volume using the **dm-cache** method.

Prerequisites

- A slow logical volume that you want to speed up using **dm-cache** exists on your system.
- The volume group that contains the slow logical volume also contains an unused physical volume on a fast block device.

Procedure

1. Create a **cachevol** volume on the fast device:

```
# lvcreate --size cachevol-size --name fastvol vg /dev/fast-pv
```

Replace the following values:

cachevol-size

The size of the **cachevol** volume, such as **5G**

fastvol

A name for the **cachevol** volume

vg

The volume group name

/dev/fast-pv

The path to the fast block device, such as **/dev/sdf1**

2. Attach the **cachevol** volume to the main logical volume to begin caching:

```
# lvconvert --type cache --cachevol fastvol vg/main-lv
```

Replace the following values:

fastvol

The name of the **cachevol** volume

vg

The volume group name

main-lv

The name of the slow logical volume

Verification steps

- Examine the newly created devices:

```
# lvs --all --options +devices vg

LV              Pool           Type   Devices
main-lv         [fastvol_cvol] cache  main-lv_corig(0)
[fastvol_cvol]                 linear /dev/fast-pv
[main-lv_corig]                linear /dev/slow-pv
```

Additional resources

- For information on this procedure and other details, including administrative examples, see the **lvmcache(7)** man page.

13.4. ENABLING DM-CACHE CACHING WITH A CACHEPOOL FOR A LOGICAL VOLUME

This procedure enables you to create the cache data and the cache metadata logical volumes individually and then combine the volumes into a cache pool.

Prerequisites

- A slow logical volume that you want to speed up using **dm-cache** exists on your system.
- The volume group that contains the slow logical volume also contains an unused physical volume on a fast block device.

Procedure

1. Create a **cachepool** volume on the fast device:

```
# lvcreate --type cache-pool --size cachepool-size --name fastpool  vg /dev/fast
```

Replace the following values:

cachepool-size

The size of the **cachepool**, such as **5G**

fastpool

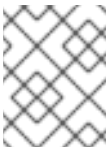
A name for the **cachepool** volume

vg

The volume group name

/dev/fast

The path to the fast block device, such as **/dev/sdf1**



NOTE

You can use **--poolmetadata** option to specify the location of the pool metadata when creating the cache-pool.

2. Attach the **cachepool** to the main logical volume to begin caching:

```
# lvconvert --type cache --cachepool fastpool vg/main
```

Replace the following values:

fastpool

The name of the **cachepool** volume

vg

The volume group name

main

The name of the slow logical volume

Verification steps

- Examine the newly created devices:

```
# lvs --all --options +devices vg

LV                  Pool              Type        Devices
[fastpool_cpool]                        cache-pool  fastpool_pool_cdata(0)
[fastpool_cpool_cdata]                      linear      /dev/sdf1(4)
[fastpool_cpool_cmeta]                      linear      /dev/sdf1(2)
[lvol0_pmspare]                         linear      /dev/sdf1(0)
main                [fastpoool_cpool]  cache       main_corig(0)
[main_corig]                            linear      /dev/sdf1(O)
```

Additional resources

- The **lvcreate(8)** man page.
- The **lvmcache(7)** man page.
- The **lvconvert(8)** man page.

13.5. ENABLING DM-WRITECACHE CACHING FOR A LOGICAL VOLUME

This procedure enables caching of write I/O operations to a logical volume using the **dm-writecache** method.

Prerequisites

- A slow logical volume that you want to speed up using **dm-writecache** exists on your system.
- The volume group that contains the slow logical volume also contains an unused physical volume on a fast block device.

Procedure

1. If the slow logical volume is active, deactivate it:

```
# lvchange --activate n vg/main-lv
```

Replace the following values:

vg

The volume group name

main-lv

The name of the slow logical volume

2. Create a deactivated **cachevol** volume on the fast device:

```
# lvcreate --activate n --size cachevol-size --name fastvol vg /dev/fast-pv
```

Replace the following values:

cachevol-size

The size of the **cachevol** volume, such as **5G**

fastvol

A name for the **cachevol** volume

vg

The volume group name

/dev/fast-pv

The path to the fast block device, such as **/dev/sdf1**

3. Attach the **cachevol** volume to the main logical volume to begin caching:

```
# lvconvert --type writecache --cachevol fastvol vg/main-lv
```

Replace the following values:

fastvol

The name of the **cachevol** volume

vg

The volume group name

main-lv

The name of the slow logical volume

4. Activate the resulting logical volume:

```
# lvchange --activate y vg/main-lv
```

Replace the following values:

vg

The volume group name

main-lv

The name of the slow logical volume

Verification steps

- Examine the newly created devices:

```
# lvs --all --options +devices vg

LV              VG Attr       LSize   Pool           Origin          Data%  Meta%  Move Log
Cpy%Sync Convert Devices
 main-lv         vg Cwi-a-C--- 500.00m [fastvol_cvol] [main-lv_worcorig] 0.00
main-lv_worcorig(0)
 [fastvol_cvol]   vg Cwi-aoC--- 252.00m
/dev/sdc1(0)
 [main-lv_worcorig] vg owi-aoC--- 500.00m
/dev/sdb1(0)
```

Additional resources

- For information, including administrative examples, see the **lvmcache(7)** man page.

13.6. DISABLING CACHING FOR A LOGICAL VOLUME

This procedure disables **dm-cache** or **dm-writecache** caching that is currently enabled on a logical volume.

Prerequisites

- Caching is enabled on a logical volume.

Procedure

1. Deactivate the logical volume:

```
# lvchange --activate n vg/main-lv
```

Replace the following values:

vg

The volume group name

main-lv

The name of the logical volume where caching is enabled

2. Detach the **cachevol** or **cachepool** volume:

```
# lvconvert --splitcache vg/main-lv
```

Replace the following values:

vg

The volume group name

main-lv

The name of the logical volume where caching is enabled

Verification steps

- Check that the logical volumes are no longer attached together:

```
# lvs --all --options +devices [replaceable]_vg_

LV      Attr       Type   Devices
fastvol -wi------- linear /dev/fast-pv
main-lv -wi------- linear /dev/slow-pv
```

Additional resources

- The **lvmcache(7)** man page

CHAPTER 14. LOGICAL VOLUME ACTIVATION

A logical volume that is an active state can be used through a block device. A logical volume that is activated is accessible and is subject to change. When you create a logical volume it is activated by default.

There are various circumstances for which you need to make an individual logical volume inactive and thus unknown to the kernel. You can activate or deactivate individual logical volume with the **-a** option of the **lvchange** command.

The format for the command to deactivate an individual logical volume is as follows.

```
lvchange -an vg/lv
```

The format for the command to activate an individual logical volume is as follows.

```
lvchange -ay vg/lv
```

You can and activate or deactivate all of the logical volumes in a volume group with the **-a** option of the **vgchange** command. This is the equivalent of running the **lvchange -a** command on each individual logical volume in the volume group.

The format for the command to deactivate all of the logical volumes in a volume group is as follows.

```
vgchange -an vg
```

The format for the command to activate all of the logical volumes in a volume group is as follows.

```
vgchange -ay vg
```

14.1. CONTROLLING AUTOACTIVATION OF LOGICAL VOLUMES

Autoactivation of a logical volume refers to the event-based automatic activation of a logical volume during system startup. As devices become available on the system (device online events), **systemd/udev** runs the **lvm2-pvscan** service for each device. This service runs the **pvscan --cache -aay *device*** command, which reads the named device. If the device belongs to a volume group, the **pvscan** command will check if all of the physical volumes for that volume group are present on the system. If so, the command will activate logical volumes in that volume group.

You can use the following configuration options in the **/etc/lvm/lvm.conf** configuration file to control autoactivation of logical volumes.

- **global/event_activation**
  When **event_activation** is disabled, **systemd/udev** will autoactivate logical volume only on whichever physical volumes are present during system startup. If all physical volumes have not appeared yet, then some logical volumes may not be autoactivated.

- **activation/auto_activation_volume_list**
  Setting **auto_activation_volume_list** to an empty list disables autoactivation entirely. Setting **auto_activation_volume_list** to specific logical volumes and volume groups limits autoactivation to those logical volumes.

For information on setting these options, see the **/etc/lvm/lvm.conf** configuration file.

14.2. CONTROLLING LOGICAL VOLUME ACTIVATION

You can control the activation of logical volume in the following ways:

- Through the **activation/volume_list** setting in the **/etc/lvm/conf** file. This allows you to specify which logical volumes are activated. For information on using this option, see the **/etc/lvm/lvm.conf** configuration file.
- By means of the activation skip flag for a logical volume. When this flag is set for a logical volume, the volume is skipped during normal activation commands.

You can set the activation skip flag on a logical volume in the following ways.

- You can turn off the activation skip flag when creating a logical volume by specifying the **-kn** or **--setactivationskip n** option of the **lvcreate** command.
- You can turn off the activation skip flag for an existing logical volume by specifying the **-kn** or **--setactivationskip n** option of the **lvchange** command.
- You can turn on the activation skip flag on again for a volume where it has been turned off with the **-ky** or **--setactivationskip y** option of the **lvchange** command.

To determine whether the activation skip flag is set for a logical volume run the **lvs** command, which displays the **k** attribute as in the following example.

```
# lvs vg/thin1s1
LV       VG  Attr       LSize Pool  Origin
thin1s1  vg  Vwi---tz-k 1.00t pool0 thin1
```

You can activate a logical volume with the **k** attribute set by using the **-K** or **--ignoreactivationskip** option in addition to the standard **-ay** or **--activate y** option.

By default, thin snapshot volumes are flagged for activation skip when they are created. You can control the default activation skip setting on new thin snapshot volumes with the **auto_set_activation_skip** setting in the **/etc/lvm/lvm.conf** file.

The following command activates a thin snapshot logical volume that has the activation skip flag set.

```
# lvchange -ay -K VG/SnapLV
```

The following command creates a thin snapshot without the activation skip flag

```
# lvcreate --type thin -n SnapLV -kn -s ThinLV --thinpool VG/ThinPoolLV
```

The following command removes the activation skip flag from a snapshot logical volume.

```
# lvchange -kn VG/SnapLV
```

14.3. ACTIVATING SHARED LOGICAL VOLUMES

You can control logical volume activation of a shared logical volume with the **-a** option of the **lvchange** and **vgchange** commands, as follows.

Command	Activation
lvchange -ay|e	Activate the shared logical volume in exclusive mode, allowing only a single host to activate the logical volume. If the activation fails, as would happen if the logical volume is active on another host, an error is reported.
lvchange -asy	Activate the shared logical volume in shared mode, allowing multiple hosts to activate the logical volume concurrently. If the activation fails, as would happen if the logical volume is active exclusively on another host, an error is reported. If the logical type prohibits shared access, such as a snapshot, the command will report an error and fail. Logical volume types that cannot be used concurrently from multiple hosts include thin, cache, raid, and snapshot.
lvchange -an	Deactivate the logical volume.

14.4. ACTIVATING A LOGICAL VOLUME WITH MISSING DEVICES

You can configure which logical volumes with missing devices are activated by setting the **activation_mode** parameter with the **lvchange** command to one of the following values.

Activation Mode	Meaning
complete	Allows only logical volumes with no missing physical volumes to be activated. This is the most restrictive mode.
degraded	Allows RAID logical volumes with missing physical volumes to be activated.
partial	Allows any logical volume with missing physical volumes to be activated. This option should be used for recovery or repair only.

The default value of **activation_mode** is determined by the **activation_mode** setting in the **/etc/lvm/lvm.conf** file. For further information, see the **lvmraid**(7) man page.

CHAPTER 15. CONTROLLING LVM DEVICE SCANNING

You can control LVM device scanning by configuring filters in the **/etc/lvm/lvm.conf** file. The filters in the **lvm.conf** file consist of a series of simple regular expressions that get applied to the device names in the **/dev** directory to decide whether to accept or reject each block device found.

15.1. THE LVM DEVICE FILTER

LVM tools scan for devices in the **/dev** directory and check every device there for LVM metadata. A filter in the **/etc/lvm/lvm.conf** file controls which devices LVM scans.

The filter is a list of patterns that LVM applies to each device found by a scan of the **/dev** directory, or the directory specified by the **dir** keyword in the **/etc/lvm/lvm.conf** file. Patterns are regular expressions delimited by any character and preceded by **a** for *accept* or **r** for *reject*. The first regular expression in the list that matches a device determines if LVM accepts or rejects (ignores) the device. LVM accepts devices that do not match any patterns.

The following is the default configuration of the filter, which scans all devices:

```
filter = [ "a/.*/" ]
```

15.2. EXAMPLES OF LVM DEVICE FILTER CONFIGURATIONS

The following examples show the use of filters to control which devices LVM scans.

WARNING

Some of the examples presented here might unintentionally match extra devices on the system and might not represent recommended practice for your system. For example, **a/loop/** is equivalent to **a/.*loop.*/** and would match **/dev/solooperation/lvol1**.

- The following filter adds all discovered devices, which is the default behavior because no filter is configured in the configuration file:

  ```
  filter = [ "a/.*/" ]
  ```

- The following filter removes the **cdrom** device in order to avoid delays if the drive contains no media:

  ```
  filter = [ "r|^/dev/cdrom$|" ]
  ```

- The following filter adds all loop devices and removes all other block devices:

  ```
  filter = [ "a/loop/", "r/.*/" ]
  ```

- The following filter adds all loop and IDE devices and removes all other block devices:

```
filter = [ "a|loop|", "a|/dev/hd.*|", "r|.*|" ]
```

- The following filter adds just partition 8 on the first IDE drive and removes all other block devices:

```
filter = [ "a|^/dev/hda8$|", "r/.*/" ]
```

15.3. APPLYING AN LVM DEVICE FILTER CONFIGURATION

This procedure changes the configuration of the LVM device filter, which controls the devices that LVM scans.

Prerequisites

- Prepare the device filter pattern that you want to use.

Procedure

1. Test your device filter pattern without modifying the **/etc/lvm/lvm.conf** file.
   Use an LVM command with the **--config 'devices{ filter = [*your device filter pattern*] }'** option. For example:

```
# lvs --config 'devices{ filter = [ "a|/dev/emcpower.*|", "r|.*|" ] }'
```

2. Edit the **filter** option in the **/etc/lvm/lvm.conf** configuration file to use your new device filter pattern.

3. Check that no physical volumes or volume groups that you want to use are missing with the new configuration:

```
# pvscan
```

```
# vgscan
```

4. Rebuild the **initramfs** file system so that LVM scans only the necessary devices upon reboot:

```
# dracut --force --verbose
```

CHAPTER 16. LAYERING LVM PHYSICAL VOLUMES ON TOP OF LOGICAL VOLUMES

You can configure LVM so that it is possible to create physical volumes on top of logical volumes.

By default, LVM commands do not scan the logical volumes on your system. This default behavior provides the following advantages:

- If there are many active logical volumes on the system, every LVM command would require additional time, negatively impacting performance and causing unwanted delays or timeouts.
- If logical volumes contain physical volumes from a guest VM image, the host usually does not want to scan or use those layered physical volumes which belong to the guest. Note, however, that in the cases where a guest VM's physical volume exists directly on an SCSI device visible to the host, in order to prevent LVM on the host from accessing those physical volumes you will need to configure a filter, as described in Chapter 15, *Controlling LVM device scanning*.

Scanning logical volumes may be necessary when layering physical volumes on top of logical volumes is intentional. This will allow the **pvcreate** command to be run on a logical volume. To configure LVM to scan all logical volumes, set the **scan_lvs** configuration option in the **/etc/lvm/lvm.conf** file to **scan_lvs=1**. To restrict which logical volumes LVM commands scan, you can then set up device filters in the **/etc/lvm/lvm.conf** configuration file, as described in Chapter 15, *Controlling LVM device scanning*.

CHAPTER 17. CONTROLLING LVM ALLOCATION

By default, a volume group allocates physical extents according to common-sense rules such as not placing parallel stripes on the same physical volume. This is the **normal** allocation policy. You can use the **--alloc** argument of the **vgcreate** command to specify an allocation policy of **contiguous**, **anywhere**, or **cling**. In general, allocation policies other than **normal** are required only in special cases where you need to specify unusual or nonstandard extent allocation.

17.1. LVM ALLOCATION POLICIES

When an LVM operation needs to allocate physical extents for one or more logical volumes, the allocation proceeds as follows:

- The complete set of unallocated physical extents in the volume group is generated for consideration. If you supply any ranges of physical extents at the end of the command line, only unallocated physical extents within those ranges on the specified physical volumes are considered.

- Each allocation policy is tried in turn, starting with the strictest policy (**contiguous**) and ending with the allocation policy specified using the **--alloc** option or set as the default for the particular logical volume or volume group. For each policy, working from the lowest-numbered logical extent of the empty logical volume space that needs to be filled, as much space as possible is allocated, according to the restrictions imposed by the allocation policy. If more space is needed, LVM moves on to the next policy.

The allocation policy restrictions are as follows:

- An allocation policy of **contiguous** requires that the physical location of any logical extent that is not the first logical extent of a logical volume is adjacent to the physical location of the logical extent immediately preceding it.
  When a logical volume is striped or mirrored, the **contiguous** allocation restriction is applied independently to each stripe or mirror image (leg) that needs space.

- An allocation policy of **cling** requires that the physical volume used for any logical extent be added to an existing logical volume that is already in use by at least one logical extent earlier in that logical volume. If the configuration parameter **allocation/cling_tag_list** is defined, then two physical volumes are considered to match if any of the listed tags is present on both physical volumes. This allows groups of physical volumes with similar properties (such as their physical location) to be tagged and treated as equivalent for allocation purposes.
  When a Logical Volume is striped or mirrored, the **cling** allocation restriction is applied independently to each stripe or mirror image (leg) that needs space.

- An allocation policy of **normal** will not choose a physical extent that shares the same physical volume as a logical extent already allocated to a parallel logical volume (that is, a different stripe or mirror image/leg) at the same offset within that parallel logical volume.
  When allocating a mirror log at the same time as logical volumes to hold the mirror data, an allocation policy of **normal** will first try to select different physical volumes for the log and the data. If that is not possible and the **allocation/mirror_logs_require_separate_pvs** configuration parameter is set to 0, it will then allow the log to share physical volume(s) with part of the data.

  Similarly, when allocating thin pool metadata, an allocation policy of **normal** will follow the same considerations as for allocation of a mirror log, based on the value of the **allocation/thin_pool_metadata_require_separate_pvs** configuration parameter.

- If there are sufficient free extents to satisfy an allocation request but a **normal** allocation policy would not use them, the **anywhere** allocation policy will, even if that reduces performance by placing two stripes on the same physical volume.

The allocation policies can be changed using the **vgchange** command.

NOTE

If you rely upon any layout behavior beyond that documented in this section according to the defined allocation policies, you should note that this might change in future versions of the code. For example, if you supply on the command line two empty physical volumes that have an identical number of free physical extents available for allocation, LVM currently considers using each of them in the order they are listed; there is no guarantee that future releases will maintain that property. If it is important to obtain a specific layout for a particular Logical Volume, then you should build it up through a sequence of **lvcreate** and **lvconvert** steps such that the allocation policies applied to each step leave LVM no discretion over the layout.

To view the way the allocation process currently works in any specific case, you can read the debug logging output, for example by adding the **-vvvv** option to a command.

17.2. PREVENTING ALLOCATION ON A PHYSICAL VOLUME

You can prevent allocation of physical extents on the free space of one or more physical volumes with the **pvchange** command. This may be necessary if there are disk errors, or if you will be removing the physical volume.

The following command disallows the allocation of physical extents on **/dev/sdk1**.

```
# pvchange -x n /dev/sdk1
```

You can also use the **-xy** arguments of the **pvchange** command to allow allocation where it had previously been disallowed.

17.3. EXTENDING A LOGICAL VOLUME WITH THE CLING ALLOCATION POLICY

When extending an LVM volume, you can use the **--alloc cling** option of the **lvextend** command to specify the **cling** allocation policy. This policy will choose space on the same physical volumes as the last segment of the existing logical volume. If there is insufficient space on the physical volumes and a list of tags is defined in the **/etc/lvm/lvm.conf** file, LVM will check whether any of the tags are attached to the physical volumes and seek to match those physical volume tags between existing extents and new extents.

For example, if you have logical volumes that are mirrored between two sites within a single volume group, you can tag the physical volumes according to where they are situated by tagging the physical volumes with **@site1** and **@site2** tags. You can then specify the following line in the **lvm.conf** file:

```
cling_tag_list = [ "@site1", "@site2" ]
```

In the following example, the **lvm.conf** file has been modified to contain the following line:

```
cling_tag_list = [ "@A", "@B" ]
```

Also in this example, a volume group **taft** has been created that consists of the physical volumes **/dev/sdb1**, **/dev/sdc1**, **/dev/sdd1**, **/dev/sde1**, **/dev/sdf1**, **/dev/sdg1**, and **/dev/sdh1**. These physical volumes have been tagged with tags **A**, **B**, and **C**. The example does not use the **C** tag, but this will show that LVM uses the tags to select which physical volumes to use for the mirror legs.

```
# pvs -a -o +pv_tags /dev/sd[bcdefgh]
  PV         VG   Fmt  Attr PSize  PFree  PV Tags
  /dev/sdb1  taft lvm2 a--  15.00g 15.00g A
  /dev/sdc1  taft lvm2 a--  15.00g 15.00g B
  /dev/sdd1  taft lvm2 a--  15.00g 15.00g B
  /dev/sde1  taft lvm2 a--  15.00g 15.00g C
  /dev/sdf1  taft lvm2 a--  15.00g 15.00g C
  /dev/sdg1  taft lvm2 a--  15.00g 15.00g A
  /dev/sdh1  taft lvm2 a--  15.00g 15.00g A
```

The following command creates a 10 gigabyte mirrored volume from the volume group **taft**.

```
# lvcreate --type raid1 -m 1 -n mirror --nosync -L 10G taft
  WARNING: New raid1 won't be synchronised. Don't read what you didn't write!
  Logical volume "mirror" created
```

The following command shows which devices are used for the mirror legs and RAID metadata subvolumes.

```
# lvs -a -o +devices
  LV              VG   Attr       LSize  Log Cpy%Sync Devices
  mirror          taft Rwi-a-r--- 10.00g       100.00 mirror_rimage_0(0),mirror_rimage_1(0)
  [mirror_rimage_0] taft iwi-aor--- 10.00g             /dev/sdb1(1)
  [mirror_rimage_1] taft iwi-aor--- 10.00g             /dev/sdc1(1)
  [mirror_rmeta_0]  taft ewi-aor---  4.00m             /dev/sdb1(0)
  [mirror_rmeta_1]  taft ewi-aor---  4.00m             /dev/sdc1(0)
```

The following command extends the size of the mirrored volume, using the **cling** allocation policy to indicate that the mirror legs should be extended using physical volumes with the same tag.

```
# lvextend --alloc cling -L +10G taft/mirror
  Extending 2 mirror images.
  Extending logical volume mirror to 20.00 GiB
  Logical volume mirror successfully resized
```

The following display command shows that the mirror legs have been extended using physical volumes with the same tag as the leg. Note that the physical volumes with a tag of **C** were ignored.

```
# lvs -a -o +devices
  LV              VG   Attr       LSize  Log Cpy%Sync Devices
  mirror          taft Rwi-a-r--- 20.00g       100.00 mirror_rimage_0(0),mirror_rimage_1(0)
  [mirror_rimage_0] taft iwi-aor--- 20.00g             /dev/sdb1(1)
  [mirror_rimage_0] taft iwi-aor--- 20.00g             /dev/sdg1(0)
  [mirror_rimage_1] taft iwi-aor--- 20.00g             /dev/sdc1(1)
  [mirror_rimage_1] taft iwi-aor--- 20.00g             /dev/sdd1(0)
  [mirror_rmeta_0]  taft ewi-aor---  4.00m             /dev/sdb1(0)
  [mirror_rmeta_1]  taft ewi-aor---  4.00m             /dev/sdc1(0)
```

17.4. DIFFERENTIATING BETWEEN LVM RAID OBJECTS USING TAGS

You can assign tags to LVM RAID objects to group them, so that you can automate the control of LVM RAID behavior, such as activation, by group.

The physical volume (PV) tags are responsible for the allocation control in the LVM raid, as opposed to logical volume (LV) or volume group (VG) tags, because allocation in lvm occurs at the PV level based on allocation policies. To distinguish storage types by their different properties, tag them appropriately (e.g. NVMe, SSD, HDD). Red Hat recommends that you tag each new PV appropriately after you add it to a VG.

This procedure adds object tags to your logical volumes, assuming **/dev/sda** is an SSD, and **/dev/sd[b-f]** are HDDs with one partition.

Prerequisites

- The **lvm2** package is installed.
- Storage devices to use as PVs are available.

Procedure

1. Create a volume group.

```
# vgcreate MyVG /dev/sd[a-f]1
```

2. Add tags to your physical volumes.

```
# pvchange --addtag ssds /dev/sda1

# pvchange --addtag hdds /dev/sd[b-f]1
```

3. Create a RAID6 logical volume.

```
# lvcreate --type raid6 --stripes 3 -L1G -nr6 MyVG @hdds
```

4. Create a linear cache pool volume.

```
# lvcreate -nr6pool -L512m MyVG @ssds
```

5. Convert the RAID6 volume to be cached.

```
# lvconvert --type cache --cachevol MyVG/r6pool MyVG/r6
```

Additional resources

- The **lvcreate(8)**, **lvconvert(8)**, **lvmraid(7)** and **lvmcache(7)** man pages.

CHAPTER 18. GROUPING LVM OBJECTS WITH TAGS

As a system administrator, you can assign tags to LVM objects to group them, so that you can automate the control of LVM behavior, such as activation, by group.

18.1. LVM OBJECT TAGS

An LVM tag is a word that is used to group LVM2 objects of the same type together. Tags are attached to objects such as physical volumes, volume groups, and logical volumes, as well as to hosts in a cluster configuration.

Tags are given on the command line in place of PV, VG or LV arguments. Tags should be prefixed with @ to avoid ambiguity. Each tag is expanded by replacing it with all objects possessing that tag which are of the type expected by its position on the command line.

LVM tags are strings of up to 1024 characters. LVM tags cannot start with a hyphen.

A valid tag consists of a limited range of characters only. The allowed characters are **A-Z a-z 0-9 _ + . -** / **= ! : # &**.

Only objects in a volume group can be tagged. Physical volumes lose their tags if they are removed from a volume group; this is because tags are stored as part of the volume group metadata and that is deleted when a physical volume is removed.

18.2. LISTING LVM TAGS

The following example shows how to list LVM tags.

Procedure

- Use the following command to list all the logical volumes with the **database** tag:

```
# lvs @database
```

- Use the following command to list the currently active host tags:

```
# lvm tags
```

18.3. ADDING LVM OBJECT TAGS

This procedure describes how to add LVM object tags.

Prerequisites

- The **lvm2** package is installed.
- One or more physical volumes, volume groups, or logical volumes are created.

Procedure

- To create an object tag, add the **--addtag** option to an LVM command:
  - To create tags from physical volumes, add the option to the **pvchange** command.

- To create tags from volume groups, add the option to the **vgchange** or **vgcreate** commands.
- To create tags from logical volumes, add the option to the **lvchange** or **lvcreate** commands.

18.4. REMOVING LVM OBJECT TAGS

This procedure describes how to remove LVM object tags.

Prerequisites

- The **lvm2** package is installed.
- Object tags on physical volumes, volume groups, or logical volumes are created.

Procedure

- To delete an object tag, add the **--deltag** option to an LVM command:
  - To delete tags from physical volumes, add the option to the **pvchange** command.
  - To delete tags from volume groups, add the option to the **vgchange** or **vgcreate** commands.
  - To delete tags from logical volumes, add the option to the **lvchange** or **lvcreate** commands.

18.5. DEFINING LVM HOST TAGS

This procedure describes how to define LVM host tags in a cluster configuration. You can define host tags in the configuration files.

Procedure

- Set **hosttags = 1** in the **tags** section to automatically define host tag using the machine's host name.
  This allows you to use a common configuration file which can be replicated on all your machines so they hold identical copies of the file, but the behavior can differ between machines according to the host name.

For each host tag, an extra configuration file is read if it exists: **lvm_hosttag.conf**. If that file defines new tags, then further configuration files will be appended to the list of files to read in.

For example, the following entry in the configuration file always defines **tag1**, and defines **tag2** if the host name is **host1**:

```
tags { tag1 { }  tag2 { host_list = ["host1"] } }
```

18.6. CONTROLLING LOGICAL VOLUME ACTIVATION WITH TAGS

This procedure describes how to specify in the configuration file that only certain logical volumes should be activated on that host.

Prerequisites

- A bulleted list of conditions that must be satisfied before the user starts following this assembly.
- You can also link to other modules or assemblies the user must follow before starting this assembly.
- Delete the section title and bullets if the assembly has no prerequisites.

Procedure

For example, the following entry acts as a filter for activation requests (such as **vgchange -ay**) and only activates **vg1/lvol0** and any logical volumes or volume groups with the **database** tag in the metadata on that host:

```
activation { volume_list = ["vg1/lvol0", "@database" ] }
```

The special match **@*** that causes a match only if any metadata tag matches any host tag on that machine.

As another example, consider a situation where every machine in the cluster has the following entry in the configuration file:

```
tags { hosttags = 1 }
```

If you want to activate **vg1/lvol2** only on host **db2**, do the following:

1. Run **lvchange --addtag @db2 vg1/lvol2** from any host in the cluster.
2. Run **lvchange -ay vg1/lvol2**.

This solution involves storing host names inside the volume group metadata.

CHAPTER 19. TROUBLESHOOTING LVM

You can use LVM tools to troubleshoot a variety of issues in LVM volumes and groups.

19.1. GATHERING DIAGNOSTIC DATA ON LVM

If an LVM command is not working as expected, you can gather diagnostics in the following ways.

Procedure

- Use the following methods to gather different kinds of diagnostic data:
  - Add the **-v** argument to any LVM command to increase the verbosity level of the command output. Verbosity can be further increased by adding additional **v's**. A maximum of four such **v's** is allowed, for example, **-vvvv**.
  - In the **log** section of the **/etc/lvm/lvm.conf** configuration file, increase the value of the **level** option. This causes LVM to provide more details in the system log.
  - If the problem is related to the logical volume activation, enable LVM to log messages during the activation:
    i. Set the **activation = 1** option in the **log** section of the **/etc/lvm/lvm.conf** configuration file.
    ii. Execute the LVM command with the **-vvvv** option.
    iii. Examine the command output.
    iv. Reset the **activation** option to **0**.
    If you do not reset the option to **0**, the system might become unresponsive during low memory situations.
  - Display an information dump for diagnostic purposes:

```
# lvmdump
```

  - Display additional system information:

```
# lvs -v
```

```
# pvs --all
```

```
# dmsetup info --columns
```

  - Examine the last backup of the LVM metadata in the **/etc/lvm/backup/** directory and archived versions in the **/etc/lvm/archive/** directory.
  - Check the current configuration information:

```
# lvmconfig
```

  - Check the **/run/lvm/hints** cache file for a record of which devices have physical volumes on them.

Additional resources

- **lvmdump(8)** man page

19.2. DISPLAYING INFORMATION ON FAILED LVM DEVICES

You can display information about a failed LVM volume that can help you determine why the volume failed.

Procedure

- Display the failed volumes using the **vgs** or **lvs** utility.

Example 19.1. Failed volume groups

In this example, one of the devices that made up the volume group *myvg* failed. The volume group is unusable but you can see information about the failed device.

```
# vgs --options +devices
 /dev/vdb1: open failed: No such device or address
 /dev/vdb1: open failed: No such device or address
  WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-
z1lf4s.
  WARNING: VG myvg is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s (last
written to /dev/sdb1).
  WARNING: Couldn't find all devices for LV myvg/mylv while checking used and assumed
devices.

VG    #PV #LV #SN Attr   VSize  VFree  Devices
myvg   2   2   0 wz-pn- <3.64t <3.60t [unknown](0)
myvg   2   2   0 wz-pn- <3.64t <3.60t [unknown](5120),/dev/vdb1(0)
```

Example 19.2. Failed logical volume

In this example, one of the devices failed due to which the logical volume in the volume group failed. The command output shows the failed logical volumes.

```
# lvs --all --options +devices

  /dev/vdb1: open failed: No such device or address
  /dev/vdb1: open failed: No such device or address
  WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-
z1lf4s.
  WARNING: VG myvg is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s (last
written to /dev/sdb1).
  WARNING: Couldn't find all devices for LV myvg/mylv while checking used and assumed
devices.

  LV    VG  Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert
Devices
  mylv myvg -wi-a---p- 20.00g                                                    [unknown](0)
[unknown](5120),/dev/sdc1(0)
```

Example 19.3. Failed leg of a mirrored logical volume

The following examples show the command output from the **vgs** and **lvs** utilities when a leg of a mirrored logical volume has failed.

```
# vgs --all --options +devices

  VG    #PV #LV #SN Attr   VSize VFree Devices
  corey 4 4 0 rz-pnc 1.58T 1.34T my_mirror_mimage_0(0),my_mirror_mimage_1(0)
  corey 4 4 0 rz-pnc 1.58T 1.34T /dev/sdd1(0)
  corey 4 4 0 rz-pnc 1.58T 1.34T unknown device(0)
  corey 4 4 0 rz-pnc 1.58T 1.34T /dev/sdb1(0)
```

```
# lvs --all --options +devices

  LV                VG    Attr   LSize   Origin Snap%  Move Log          Copy%  Devices
  my_mirror corey mwi-a- 120.00G my_mirror_mlog 1.95
my_mirror_mimage_0(0),my_mirror_mimage_1(0)
  [my_mirror_mimage_0] corey iwi-ao 120.00G unknown device(0)
  [my_mirror_mimage_1] corey iwi-ao 120.00G /dev/sdb1(0)
  [my_mirror_mlog] corey lwi-ao 4.00M /dev/sdd1(0)
```

19.3. REMOVING LOST LVM PHYSICAL VOLUMES FROM A VOLUME GROUP

If a physical volume fails, you can activate the remaining physical volumes in the volume group and remove all the logical volumes that used that physical volume from the volume group.

Procedure

1. Activate the remaining physical volumes in the volume group:

```
# vgchange --activate y --partial myvg
```

2. Check which logical volumes will be removed:

```
# vgreduce --removemissing --test myvg
```

3. Remove all the logical volumes that used the lost physical volume from the volume group:

```
# vgreduce --removemissing --force myvg
```

4. Optional: If you accidentally removed logical volumes that you wanted to keep, you can reverse the **vgreduce** operation:

```
# vgcfgrestore myvg
```

WARNING

If you remove a thin pool, LVM cannot reverse the operation.

19.4. FINDING THE METADATA OF A MISSING LVM PHYSICAL VOLUME

If the volume group's metadata area of a physical volume is accidentally overwritten or otherwise destroyed, you get an error message indicating that the metadata area is incorrect, or that the system was unable to find a physical volume with a particular UUID.

This procedure finds the latest archived metadata of a physical volume that is missing or corrupted.

Procedure

1. Find the archived metadata file of the volume group that contains the physical volume. The archived metadata files are located at the **/etc/lvm/archive/*volume-group-name_backup-number*.vg** path:

   ```
   # cat /etc/lvm/archive/myvg_00000-1248998876.vg
   ```

   Replace *00000-1248998876* with the backup-number. Select the last known valid metadata file, which has the highest number for the volume group.

2. Find the UUID of the physical volume. Use one of the following methods.

   - List the logical volumes:

     ```
     # lvs --all --options +devices

       Couldn't find device with uuid 'FmGRh3-zhok-iVI8-7qTD-S5BI-MAEN-NYM5Sk'.
     ```

   - Examine the archived metadata file. Find the UUID as the value labeled **id =** in the **physical_volumes** section of the volume group configuration.

   - Deactivate the volume group using the **--partial** option:

     ```
     # vgchange --activate n --partial myvg

       PARTIAL MODE. Incomplete logical volumes will be processed.
       WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s.
       WARNING: VG myvg is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s (last written to /dev/vdb1).
       0 logical volume(s) in volume group "myvg" now active
     ```

19.5. RESTORING METADATA ON AN LVM PHYSICAL VOLUME

This procedure restores metadata on a physical volume that is either corrupted or replaced with a new device. You might be able to recover the data from the physical volume by rewriting the metadata area on the physical volume.

WARNING

Do not attempt this procedure on a working LVM logical volume. You will lose your data if you specify the incorrect UUID.

Prerequisites

- You have identified the metadata of the missing physical volume. For details, see Finding the metadata of a missing LVM physical volume.

Procedure

1. Restore the metadata on the physical volume:

```
# pvcreate --uuid physical-volume-uuid \
        --restorefile /etc/lvm/archive/volume-group-name_backup-number.vg \
        block-device
```

NOTE

The command overwrites only the LVM metadata areas and does not affect the existing data areas.

Example 19.4. Restoring a physical volume on */dev/vdb1*

The following example labels the ***/dev/vdb1*** device as a physical volume with the following properties:

- The UUID of **FmGRh3-zhok-iVI8-7qTD-S5BI-MAEN-NYM5Sk**
- The metadata information contained in **VG_00050.vg**, which is the most recent good archived metadata for the volume group

```
# pvcreate --uuid "FmGRh3-zhok-iVI8-7qTD-S5BI-MAEN-NYM5Sk" \
        --restorefile /etc/lvm/archive/VG_00050.vg \
        /dev/vdb1

  ...
  Physical volume "/dev/vdb1" successfully created
```

2. Restore the metadata of the volume group:

```
# vgcfgrestore myvg

 Restored volume group myvg
```

3. Display the logical volumes on the volume group:

```
# lvs --all --options +devices myvg
```

The logical volumes are currently inactive. For example:

```
  LV     VG   Attr   LSize   Origin Snap%  Move Log Copy%  Devices
  mylv myvg   -wi--- 300.00G                             /dev/vdb1 (0),/dev/vdb1(0)
  mylv myvg   -wi--- 300.00G                             /dev/vdb1 (34728),/dev/vdb1(0)
```

4. If the segment type of the logical volumes is RAID, resynchronize the logical volumes:

```
# lvchange --resync myvg/mylv
```

5. Activate the logical volumes:

```
# lvchange --activate y myvg/mylv
```

6. If the on-disk LVM metadata takes at least as much space as what overrode it, this procedure can recover the physical volume. If what overrode the metadata went past the metadata area, the data on the volume may have been affected. You might be able to use the **fsck** command to recover that data.

Verification steps

- Display the active logical volumes:

```
# lvs --all --options +devices

  LV     VG   Attr   LSize   Origin Snap%  Move Log Copy%  Devices
  mylv myvg   -wi--- 300.00G                             /dev/vdb1 (0),/dev/vdb1(0)
  mylv myvg   -wi--- 300.00G                             /dev/vdb1 (34728),/dev/vdb1(0)
```

19.6. ROUNDING ERRORS IN LVM OUTPUT

LVM commands that report the space usage in volume groups round the reported number to **2** decimal places to provide human-readable output. This includes the **vgdisplay** and **vgs** utilities.

As a result of the rounding, the reported value of free space might be larger than what the physical extents on the volume group provide. If you attempt to create a logical volume the size of the reported free space, you might get the following error:

```
Insufficient free extents
```

To work around the error, you must examine the number of free physical extents on the volume group, which is the accurate value of free space. You can then use the number of extents to create the logical volume successfully.

19.7. PREVENTING THE ROUNDING ERROR WHEN CREATING AN LVM VOLUME

When creating an LVM logical volume, you can specify the size of the logical volume to avoid rounding error.

Procedure

1. Find the number of free physical extents in the volume group:

```
# vgdisplay myvg
```

Example 19.5. Free extents in a volume group

For example, the following volume group has 8780 free physical extents:

```
--- Volume group ---
 VG Name               myvg
 System ID
 Format                lvm2
 Metadata Areas        4
 Metadata Sequence No  6
 VG Access             read/write
[...]
Free  PE / Size       8780 / 34.30 GB
```

2. Create the logical volume. Enter the volume size in extents rather than bytes.

Example 19.6. Creating a logical volume by specifying the number of extents

```
# lvcreate --extents 8780 --name mylv myvg
```

Example 19.7. Creating a logical volume to occupy all the remaining space

Alternatively, you can extend the logical volume to use a percentage of the remaining free space in the volume group. For example:

```
# lvcreate --extents 100%FREE --name mylv myvg
```

Verification steps

- Check the number of extents that the volume group now uses:

```
# vgs --options +vg_free_count,vg_extent_count

  VG     #PV #LV #SN  Attr   VSize   VFree  Free  #Ext
  myvg   2   1   0   wz--n- 34.30G    0    0     8780
```

19.8. TROUBLESHOOTING LVM RAID

You can troubleshoot various issues in LVM RAID devices to correct data errors, recover devices, or replace failed devices.

19.8.1. Checking data coherency in a RAID logical volume (RAID scrubbing)

LVM provides scrubbing support for RAID logical volumes. RAID scrubbing is the process of reading all the data and parity blocks in an array and checking to see whether they are coherent.

Procedure

1. Optional: Limit the I/O bandwidth that the scrubbing process uses.
   When you perform a RAID scrubbing operation, the background I/O required by the **sync** operations can crowd out other I/O to LVM devices, such as updates to volume group metadata. This might cause the other LVM operations to slow down. You can control the rate of the scrubbing operation by implementing recovery throttling.

   Add the following options to the **lvchange --syncaction** commands in the next steps:

   --maxrecoveryrate *Rate*[bBsSkKmMgG]

   Sets the maximum recovery rate so that the operation does crowd out nominal I/O operations. Setting the recovery rate to 0 means that the operation is unbounded.

   --minrecoveryrate *Rate*[bBsSkKmMgG]

   Sets the minimum recovery rate to ensure that I/O for **sync** operations achieves a minimum throughput, even when heavy nominal I/O is present.

   Specify the *Rate* value as an amount per second for each device in the array. If you provide no suffix, the options assume kiB per second per device.

2. Display the number of discrepancies in the array, without repairing them:

```
# lvchange --syncaction check vg/raid_lv
```

3. Correct the discrepancies in the array:

```
# lvchange --syncaction repair vg/raid_lv
```

NOTE

The **lvchange --syncaction repair** operation does not perform the same function as the **lvconvert --repair** operation:

- The **lvchange --syncaction repair** operation initiates a background synchronization operation on the array.
- The **lvconvert --repair** operation repairs or replaces failed devices in a mirror or RAID logical volume.

4. Optional: Display information about the scrubbing operation:

```
# lvs -o +raid_sync_action,raid_mismatch_count vg/lv
```

- The **raid_sync_action** field displays the current synchronization operation that the RAID volume is performing. It can be one of the following values:

  idle

  All sync operations complete (doing nothing)

  resync

  Initializing an array or recovering after a machine failure

  recover

  Replacing a device in the array

  check

  Looking for array inconsistencies

  repair

  Looking for and repairing inconsistencies

- The **raid_mismatch_count** field displays the number of discrepancies found during a **check** operation.

- The **Cpy%Sync** field displays the progress of the **sync** operations.

- The **lv_attr** field provides additional indicators. Bit 9 of this field displays the health of the logical volume, and it supports the following indicators:

  - **m** (mismatches) indicates that there are discrepancies in a RAID logical volume. This character is shown after a scrubbing operation has detected that portions of the RAID are not coherent.

  - **r** (refresh) indicates that a device in a RAID array has suffered a failure and the kernel regards it as failed, even though LVM can read the device label and considers the device to be operational. Refresh the logical volume to notify the kernel that the device is now available, or replace the device if you suspect that it failed.

Additional resources

- For more information, see the **lvchange(8)** and **lvmraid(7)** man pages.

19.8.2. Failed devices in LVM RAID

RAID is not like traditional LVM mirroring. LVM mirroring required failed devices to be removed or the mirrored logical volume would hang. RAID arrays can keep on running with failed devices. In fact, for RAID types other than RAID1, removing a device would mean converting to a lower level RAID (for example, from RAID6 to RAID5, or from RAID4 or RAID5 to RAID0).

Therefore, rather than removing a failed device unconditionally and potentially allocating a replacement, LVM allows you to replace a failed device in a RAID volume in a one-step solution by using the **--repair** argument of the **lvconvert** command.

19.8.3. Recovering a failed RAID device in a logical volume

If the LVM RAID device failure is a transient failure or you are able to repair the device that failed, you can initiate recovery of the failed device.

Prerequisites

- The previously failed device is now working.

Procedure

- Refresh the logical volume that contains the RAID device:

```
# lvchange --refresh my_vg/my_lv
```

Verification steps

- Examine the logical volume with the recovered device:

```
# lvs --all --options name,devices,lv_attr,lv_health_status my_vg
```

19.8.4. Replacing a failed RAID device in a logical volume

This procedure replaces a failed device that serves as a physical volume in an LVM RAID logical volume.

Prerequisites

- The volume group includes a physical volume that provides enough free capacity to replace the failed device.
  If no physical volume with sufficient free extents is available on the volume group, add a new, sufficiently large physical volume using the **vgextend** utility.

Procedure

1. In the following example, a RAID logical volume is laid out as follows:

```
# lvs --all --options name,copy_percent,devices my_vg

  LV              Cpy%Sync Devices
  my_lv             100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
  [my_lv_rimage_1]         /dev/sdc1(1)
  [my_lv_rimage_2]         /dev/sdd1(1)
  [my_lv_rmeta_0]          /dev/sde1(0)
  [my_lv_rmeta_1]          /dev/sdc1(0)
  [my_lv_rmeta_2]          /dev/sdd1(0)
```

2. If the **/dev/sdc** device fails, the output of the **lvs** command is as follows:

```
# lvs --all --options name,copy_percent,devices my_vg

  /dev/sdc: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rimage_1 while checking used and assumed devices.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rmeta_1 while checking used and assumed devices.
  LV              Cpy%Sync Devices
  my_lv             100.00 my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
```

```
[my_lv_rimage_1]        [unknown](1)
[my_lv_rimage_2]        /dev/sdd1(1)
[my_lv_rmeta_0]         /dev/sde1(0)
[my_lv_rmeta_1]         [unknown](0)
[my_lv_rmeta_2]         /dev/sdd1(0)
```

3. Replace the failed device and display the logical volume:

```
# lvconvert --repair my_vg/my_lv

  /dev/sdc: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rimage_1 while checking used and
assumed devices.
  WARNING: Couldn't find all devices for LV my_vg/my_lv_rmeta_1 while checking used and
assumed devices.
Attempt to replace failed RAID images (requires full device resync)? [y/n]: y
  Faulty devices in my_vg/my_lv successfully replaced.
```

Optional: To manually specify the physical volume that replaces the failed device, add the physical volume at the end of the command:

```
# lvconvert --repair my_vg/my_lv replacement_pv
```

4. Examine the logical volume with the replacement:

```
# lvs --all --options name,copy_percent,devices my_vg

  /dev/sdc: open failed: No such device or address
  /dev/sdc1: open failed: No such device or address
  Couldn't find device with uuid A4kRl2-vIzA-uyCb-cci7-bOod-H5tX-IzH4Ee.
  LV              Cpy%Sync Devices
  my_lv             43.79  my_lv_rimage_0(0),my_lv_rimage_1(0),my_lv_rimage_2(0)
  [my_lv_rimage_0]         /dev/sde1(1)
  [my_lv_rimage_1]         /dev/sdb1(1)
  [my_lv_rimage_2]         /dev/sdd1(1)
  [my_lv_rmeta_0]          /dev/sde1(0)
  [my_lv_rmeta_1]          /dev/sdb1(0)
  [my_lv_rmeta_2]          /dev/sdd1(0)
```

Until you remove the failed device from the volume group, LVM utilities still indicate that LVM cannot find the failed device.

5. Remove the failed device from the volume group:

```
# vgreduce --removemissing VG
```

19.9. TROUBLESHOOTING DUPLICATE PHYSICAL VOLUME WARNINGS FOR MULTIPATHED LVM DEVICES

When using LVM with multipathed storage, LVM commands that list a volume group or logical volume might display messages such as the following:

```
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/dm-5 not /dev/sdd
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/emcpowerb not /dev/sde
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/sddlmab not /dev/sdf
```

You can troubleshoot these warnings to understand why LVM displays them, or to hide the warnings.

19.9.1. Root cause of duplicate PV warnings

When a multipath software such as Device Mapper Multipath (DM Multipath), EMC PowerPath, or Hitachi Dynamic Link Manager (HDLM) manages storage devices on the system, each path to a particular logical unit (LUN) is registered as a different SCSI device.

The multipath software then creates a new device that maps to those individual paths. Because each LUN has multiple device nodes in the **/dev** directory that point to the same underlying data, all the device nodes contain the same LVM metadata.

Table 19.1. Example device mappings in different multipath software

Multipath software	SCSI paths to a LUN	Multipath device mapping to paths
DM Multipath	**/dev/sdb** and **/dev/sdc**	**/dev/mapper/mpath1** or **/dev/mapper/mpatha**
EMC PowerPath		**/dev/emcpowera**
HDLM		**/dev/sddlmab**

As a result of the multiple device nodes, LVM tools find the same metadata multiple times and report them as duplicates.

19.9.2. Cases of duplicate PV warnings

LVM displays the duplicate PV warnings in either of the following cases:

Single paths to the same device

The two devices displayed in the output are both single paths to the same device.
The following example shows a duplicate PV warning in which the duplicate devices are both single paths to the same device.

```
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/sdd not /dev/sdf
```

If you list the current DM Multipath topology using the **multipath -ll** command, you can find both **/dev/sdd** and **/dev/sdf** under the same multipath map.

These duplicate messages are only warnings and do not mean that the LVM operation has failed. Rather, they are alerting you that LVM uses only one of the devices as a physical volume and ignores the others.

If the messages indicate that LVM chooses the incorrect device or if the warnings are disruptive to users, you can apply a filter. The filter configures LVM to search only the necessary devices for physical volumes, and to leave out any underlying paths to multipath devices. As a result, the

warnings no longer appear.

Multipath maps

The two devices displayed in the output are both multipath maps.
The following examples show a duplicate PV warning for two devices that are both multipath maps. The duplicate physical volumes are located on two different devices rather than on two different paths to the same device.

```
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/mapper/mpatha not /dev/mapper/mpathc

Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUi: using /dev/emcpowera not /dev/emcpowerh
```

This situation is more serious than duplicate warnings for devices that are both single paths to the same device. These warnings often mean that the machine is accessing devices that it should not access: for example, LUN clones or mirrors.

Unless you clearly know which devices you should remove from the machine, this situation might be unrecoverable. Red Hat recommends that you contact Red Hat Technical Support to address this issue.

19.9.3. The LVM device filter

LVM tools scan for devices in the **/dev** directory and check every device there for LVM metadata. A filter in the **/etc/lvm/lvm.conf** file controls which devices LVM scans.

The filter is a list of patterns that LVM applies to each device found by a scan of the **/dev** directory, or the directory specified by the **dir** keyword in the **/etc/lvm/lvm.conf** file. Patterns are regular expressions delimited by any character and preceded by **a** for *accept* or **r** for *reject*. The first regular expression in the list that matches a device determines if LVM accepts or rejects (ignores) the device. LVM accepts devices that do not match any patterns.

The following is the default configuration of the filter, which scans all devices:

```
filter = [ "a/.*/" ]
```

19.9.4. Example LVM device filters that prevent duplicate PV warnings

The following examples show LVM device filters that avoid the duplicate physical volume warnings that are caused by multiple storage paths to a single logical unit (LUN).

The filter that you configure must include all devices that LVM needs to be check for metadata, such as the local hard drive with the root volume group on it and any multipathed devices. By rejecting the underlying paths to a multipath device (such as **/dev/sdb**, **/dev/sdd**, and so on), you can avoid these duplicate PV warnings, because LVM finds each unique metadata area once on the multipath device itself.

- This filter accepts the second partition on the first hard drive and any DM Multipath devices, but rejects everything else:

  ```
  filter = [ "a|/dev/sda2$|", "a|/dev/mapper/mpath.*|", "r|.*|" ]
  ```

- This filter accepts all HP SmartArray controllers and any EMC PowerPath devices:

```
filter = [ "a|/dev/cciss/.*|", "a|/dev/emcpower.*|", "r|.*|" ]
```

- This filter accepts any partitions on the first IDE drive and any multipath devices:

```
filter = [ "a|/dev/hda.*|", "a|/dev/mapper/mpath.*|", "r|.*|" ]
```

19.9.5. Applying an LVM device filter configuration

This procedure changes the configuration of the LVM device filter, which controls the devices that LVM scans.

Prerequisites

- Prepare the device filter pattern that you want to use.

Procedure

1. Test your device filter pattern without modifying the **/etc/lvm/lvm.conf** file.
   Use an LVM command with the **--config 'devices{ filter = [*your device filter pattern*] }'** option. For example:

```
# lvs --config 'devices{ filter = [ "a|/dev/emcpower.*|", "r|.*|" ] }'
```

2. Edit the **filter** option in the **/etc/lvm/lvm.conf** configuration file to use your new device filter pattern.

3. Check that no physical volumes or volume groups that you want to use are missing with the new configuration:

```
# pvscan
```

```
# vgscan
```

4. Rebuild the **initramfs** file system so that LVM scans only the necessary devices upon reboot:

```
# dracut --force --verbose
```

19.9.6. Additional resources

- Chapter 15, *Controlling LVM device scanning*