Configuring and managing logical volumes

A guide to the configuration and management of LVM logical volumes
Red Hat Enterprise Linux 8 Configuring and managing logical volumes

A guide to the configuration and management of LVM logical volumes
Abstract

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

PROVIDING FEEDBACK ON RED HAT DOCUMENTATION ........................................ 6

CHAPTER 1. LOGICAL VOLUMES ............................................................... 7
  1.1. LVM ARCHITECTURE OVERVIEW ................................................. 7
  1.2. PHYSICAL VOLUMES .................................................................. 8
    1.2.1. LVM physical volume layout ................................................ 8
    1.2.2. Multiple partitions on a disk ................................................. 9
  1.3. VOLUME GROUPS ..................................................................... 9
  1.4. LVM LOGICAL VOLUMES ............................................................... 10
    1.4.1. Linear Volumes ................................................................ 10
    1.4.2. Striped Logical Volumes ..................................................... 12
    1.4.3. RAID logical volumes .......................................................... 13
    1.4.4. Thinly-provisioned logical volumes (thin volumes) ............... 14
    1.4.5. Snapshot Volumes ............................................................... 14
    1.4.6. Thinly-provisioned snapshot volumes ................................... 15
    1.4.7. Cache Volumes .................................................................. 16

CHAPTER 2. MANAGING LOCAL STORAGE USING RHEL SYSTEM ROLES ........ 17
  2.1. INTRODUCTION TO THE STORAGE ROLE ....................................... 17
  2.2. STORAGE ROLE PARAMETERS ..................................................... 17

CHAPTER 3. DEPLOYING LVM ................................................................. 19
  3.1. CREATING LVM PHYSICAL VOLUME ........................................... 19
  3.2. CREATING LVM VOLUME GROUP ............................................... 19
  3.3. CREATING LVM LOGICAL VOLUME ........................................... 19

CHAPTER 4. CONFIGURING LVM LOGICAL VOLUMES ............................. 21
  4.1. USING CLI COMMANDS ............................................................... 21
    Specifying units in a command line argument ................................ 21
    Specifying volume groups and logical volumes ............................ 21
    Increasing output verbosity ......................................................... 21
    Displaying help for LVM CLI commands .................................... 22
  4.2. CREATING AN LVM LOGICAL VOLUME ON THREE DISKS ............ 22
  4.3. CREATING A RAID0 (STRIPED) LOGICAL VOLUME ..................... 23
  4.4. RENAMING LVM LOGICAL VOLUMES .......................................... 25
  4.5. REMOVING A DISK FROM A LOGICAL VOLUME ............................. 26
    4.5.1. Moving extents to existing physical volumes ....................... 26
    4.5.2. Moving Extents to a New Disk ............................................. 27
  4.6. CONFIGURING PERSISTENT DEVICE NUMBERS ............................. 28
  4.7. SPECIFYING LVM EXTENT SIZE ............................................... 28
  4.8. MANAGING LVM LOGICAL VOLUMES USING RHEL SYSTEM ROLES 28
    4.8.1. Example Ansible playbook to manage logical volumes .......... 28
    4.8.2. Additional resources ......................................................... 29
  4.9. REMOVING LVM LOGICAL VOLUMES .......................................... 29

CHAPTER 5. MODIFYING THE SIZE OF A LOGICAL VOLUME ................. 31
  5.1. GROWING LOGICAL VOLUMES .................................................... 31
  5.2. GROWING A FILE SYSTEM ON A LOGICAL VOLUME .................... 31
  5.3. SHRINKING LOGICAL VOLUMES ............................................... 32
  5.4. EXTENDING A STRIPED LOGICAL VOLUME .................................. 33

CHAPTER 6. MANAGING LVM VOLUME GROUPS ..................................... 35
  6.1. VOLUME GROUPS .................................................................... 35
6.2. DISPLAYING VOLUME GROUPS
6.3. COMBINING VOLUME GROUPS
6.4. SPLITTING A VOLUME GROUP
6.5. RENAMING LVM VOLUME GROUPS
6.6. MOVING A VOLUME GROUP TO ANOTHER SYSTEM
6.7. REMOVING PHYSICAL VOLUMES FROM A VOLUME GROUP
6.8. REMOVING LVM VOLUME GROUPS
6.9. ADDITIONAL RESOURCES

CHAPTER 7. MANAGING LVM PHYSICAL VOLUMES
7.1. SCANNING FOR BLOCK DEVICES TO USE AS PHYSICAL VOLUMES
7.2. SETTING THE PARTITION TYPE FOR A PHYSICAL VOLUME
7.3. RESIZING AN LVM PHYSICAL VOLUME
7.4. REMOVING PHYSICAL VOLUMES
7.5. ADDING PHYSICAL VOLUMES TO A VOLUME GROUP
7.6. REMOVING PHYSICAL VOLUMES FROM A VOLUME GROUP

CHAPTER 8. DISPLAYING LVM COMPONENTS
8.1. DISPLAYING LVM INFORMATION WITH THE LVM COMMAND
8.2. DISPLAYING PHYSICAL VOLUMES
8.3. DISPLAYING VOLUME GROUPS
8.4. DISPLAYING LOGICAL VOLUMES

CHAPTER 9. CUSTOMIZED REPORTING FOR LVM
9.1. CONTROLLING THE FORMAT OF THE LVM DISPLAY
9.2. LVM OBJECT DISPLAY FIELDS
9.3. SORTING LVM REPORTS
9.4. SPECIFYING THE UNITS FOR AN LVM REPORT DISPLAY
9.5. DISPLAYING LVM COMMAND OUTPUT IN JSON FORMAT
9.6. DISPLAYING THE LVM COMMAND LOG

CHAPTER 10. CONFIGURING RAID LOGICAL VOLUMES
10.1. CREATING RAID LOGICAL VOLUMES
10.2. CREATING A RAID0 (STRIPE) LOGICAL VOLUME
10.3. CONTROLLING THE RATE AT WHICH RAID VOLUMES ARE INITIALIZED
10.4. CONVERTING A LINEAR DEVICE TO A RAID DEVICE
10.5. CONVERTING AN LVM RAID1 LOGICAL VOLUME TO AN LVM LINEAR LOGICAL VOLUME
10.6. CONVERTING A MIRRORED LVM DEVICE TO A RAID1 DEVICE
10.7. RESIZING A RAID LOGICAL VOLUME
10.8. CHANGING THE NUMBER OF IMAGES IN AN EXISTING RAID1 DEVICE
10.9. SPLITTING OFF A RAID IMAGE AS A SEPARATE LOGICAL VOLUME
10.10. SPLITTING AND MERGING A RAID IMAGE
10.11. SETTING A RAID FAULT POLICY
  10.11.1. The allocate RAID Fault Policy
  10.11.2. The warn RAID Fault Policy
10.12. REPLACING A RAID DEVICE IN A LOGICAL VOLUME
  10.12.1. Replacing a RAID device that has not failed
  10.12.2. Replacing a failed RAID device in a logical volume
10.13. CHECKING DATA COHERENCY IN A RAID LOGICAL VOLUME (RAID SCRUBBING)
10.14. CONVERTING A RAID LEVEL (RAID TAKEOVER)
10.15. CHANGING ATTRIBUTES OF A RAID VOLUME (RAID RESHAPE)
10.16. CONTROLLING I/O OPERATIONS ON A RAID1 LOGICAL VOLUME
10.17. CHANGING THE REGION SIZE ON A RAID LOGICAL VOLUME
### CHAPTER 11. SNAPSHOT LOGICAL VOLUMES

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.1. SNAPSHOT VOLUMES</td>
<td>81</td>
</tr>
<tr>
<td>11.2. CREATING SNAPSHOT VOLUMES</td>
<td>82</td>
</tr>
<tr>
<td>11.3. MERGING SNAPSHOT VOLUMES</td>
<td>84</td>
</tr>
</tbody>
</table>

### CHAPTER 12. CREATING AND MANAGING THINLY-PROVISIONED LOGICAL VOLUMES (THIN VOLUMES)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1. THINLY-PROVISIONED LOGICAL VOLUMES (THIN VOLUMES)</td>
<td>85</td>
</tr>
<tr>
<td>12.2. CREATING THINLY-PROVISIONED LOGICAL VOLUMES</td>
<td>85</td>
</tr>
<tr>
<td>12.3. THINLY-PROVISIONED SNAPSHOT VOLUMES</td>
<td>88</td>
</tr>
<tr>
<td>12.4. CREATING THINLY-PROVISIONED SNAPSHOT VOLUMES</td>
<td>89</td>
</tr>
<tr>
<td>12.5. TRACKING AND DISPLAYING THIN SNAPSHOT VOLUMES THAT HAVE BEEN REMOVED</td>
<td>91</td>
</tr>
</tbody>
</table>

### CHAPTER 13. ENABLING CACHING TO IMPROVE LOGICAL VOLUME PERFORMANCE

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1. CACHING METHODS IN LVM</td>
<td>95</td>
</tr>
<tr>
<td>13.2. LVM CACHING COMPONENTS</td>
<td>95</td>
</tr>
<tr>
<td>13.3. ENABLING DM-CACHE CACHING FOR A LOGICAL VOLUME</td>
<td>95</td>
</tr>
<tr>
<td>13.4. ENABLING DM-CACHE CACHING WITH A CACHEPOOL FOR A LOGICAL VOLUME</td>
<td>97</td>
</tr>
<tr>
<td>13.5. ENABLING DM-WRITECACHE CACHING FOR A LOGICAL VOLUME</td>
<td>98</td>
</tr>
<tr>
<td>13.6. DISABLING CACHING FOR A LOGICAL VOLUME</td>
<td>100</td>
</tr>
</tbody>
</table>

### CHAPTER 14. LOGICAL VOLUME ACTIVATION

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1. CONTROLLING AUTOACTIVATION OF LOGICAL VOLUMES</td>
<td>101</td>
</tr>
<tr>
<td>14.2. CONTROLLING LOGICAL VOLUME ACTIVATION</td>
<td>102</td>
</tr>
<tr>
<td>14.3. ACTIVATING SHARED LOGICAL VOLUMES</td>
<td>102</td>
</tr>
<tr>
<td>14.4. ACTIVATING A LOGICAL VOLUME WITH MISSING DEVICES</td>
<td>103</td>
</tr>
</tbody>
</table>

### CHAPTER 15. CONTROLLING LVM DEVICE SCANNING

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.1. THE LVM DEVICE FILTER</td>
<td>104</td>
</tr>
<tr>
<td>15.2. EXAMPLES OF LVM DEVICE FILTER CONFIGURATIONS</td>
<td>104</td>
</tr>
<tr>
<td>15.3. APPLYING AN LVM DEVICE FILTER CONFIGURATION</td>
<td>105</td>
</tr>
</tbody>
</table>

### CHAPTER 16. LAYERING LVM PHYSICAL VOLUMES ON TOP OF LOGICAL VOLUMES

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.1. LVM ALLOCATION POLICIES</td>
<td>107</td>
</tr>
<tr>
<td>16.2. PREVENTING ALLOCATION ON A PHYSICAL VOLUME</td>
<td>108</td>
</tr>
<tr>
<td>16.3. EXTENDING A LOGICAL VOLUME WITH THE CLING ALLOCATION POLICY</td>
<td>108</td>
</tr>
</tbody>
</table>

### CHAPTER 17. CONTROLLING LVM ALLOCATION

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.1. GATHERING DIAGNOSTIC DATA ON LVM</td>
<td>110</td>
</tr>
<tr>
<td>17.2. DISPLAYING INFORMATION ON FAILED LVM DEVICES</td>
<td>111</td>
</tr>
<tr>
<td>17.3. REMOVING LVM PHYSICAL VOLUMES FROM A VOLUME GROUP</td>
<td>112</td>
</tr>
<tr>
<td>17.4. RECOVERING AN LVM PHYSICAL VOLUME WITH DAMAGED METADATA</td>
<td>113</td>
</tr>
<tr>
<td>17.4.1. Discovering that an LVM volume has missing or corrupted metadata</td>
<td>113</td>
</tr>
<tr>
<td>17.4.2. Finding the metadata of a missing LVM physical volume</td>
<td>113</td>
</tr>
<tr>
<td>17.4.3. Restoring metadata on an LVM physical volume</td>
<td>114</td>
</tr>
<tr>
<td>17.5. REPLACING A MISSING LVM PHYSICAL VOLUME</td>
<td>116</td>
</tr>
<tr>
<td>17.5.1. Finding the metadata of a missing LVM physical volume</td>
<td>116</td>
</tr>
<tr>
<td>17.5.2. Restoring metadata on an LVM physical volume</td>
<td>116</td>
</tr>
<tr>
<td>18.6. TROUBLESHOOTING DUPLICATE PHYSICAL VOLUME WARNINGS FOR MULTIPATHED LVM DEVICES</td>
<td>118</td>
</tr>
</tbody>
</table>

### CHAPTER 18. TROUBLESHOOTING LVM

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.1. GATHERING DIAGNOSTIC DATA ON LVM</td>
<td>110</td>
</tr>
<tr>
<td>18.2. DISPLAYING INFORMATION ON FAILED LVM DEVICES</td>
<td>111</td>
</tr>
<tr>
<td>18.3. REMOVING LVM PHYSICAL VOLUMES FROM A VOLUME GROUP</td>
<td>112</td>
</tr>
<tr>
<td>18.4. RECOVERING AN LVM PHYSICAL VOLUME WITH DAMAGED METADATA</td>
<td>113</td>
</tr>
<tr>
<td>18.4.1. Discovering that an LVM volume has missing or corrupted metadata</td>
<td>113</td>
</tr>
<tr>
<td>18.4.2. Finding the metadata of a missing LVM physical volume</td>
<td>113</td>
</tr>
<tr>
<td>18.4.3. Restoring metadata on an LVM physical volume</td>
<td>114</td>
</tr>
<tr>
<td>18.5. REPLACING A MISSING LVM PHYSICAL VOLUME</td>
<td>116</td>
</tr>
<tr>
<td>18.5.1. Finding the metadata of a missing LVM physical volume</td>
<td>116</td>
</tr>
<tr>
<td>18.5.2. Restoring metadata on an LVM physical volume</td>
<td>116</td>
</tr>
<tr>
<td>18.6. TROUBLESHOOTING DUPLICATE PHYSICAL VOLUME WARNINGS FOR MULTIPATHED LVM DEVICES</td>
<td>118</td>
</tr>
<tr>
<td>18.6.1. Volume groups</td>
<td>118</td>
</tr>
<tr>
<td>18.6.2. Rounding errors in LVM output</td>
<td>118</td>
</tr>
<tr>
<td>18.6.3. Preventing the rounding error when creating an LVM volume</td>
<td>119</td>
</tr>
<tr>
<td>18.7. TROUBLESHOOTING DUPLICATE PHYSICAL VOLUME WARNINGS FOR MULTIPATHED LVM DEVICES</td>
<td>118</td>
</tr>
</tbody>
</table>
18.7.1. Root cause of duplicate PV warnings
18.7.2. Cases of duplicate PV warnings
18.7.3. The LVM device filter
18.7.4. Example LVM device filters that prevent duplicate PV warnings
18.7.5. Applying an LVM device filter configuration
18.7.6. Additional resources
PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

We appreciate your input on our documentation. Please let us know how we could make it better. To do so:

• For simple comments on specific passages:
  1. Make sure you are viewing the documentation in the Multi-page HTML format. In addition, ensure you see the Feedback button in the upper right corner of the document.
  2. Use your mouse cursor to highlight the part of text that you want to comment on.
  3. Click the Add Feedback pop-up that appears below the highlighted text.
  4. Follow the displayed instructions.

• For submitting more complex feedback, create a Bugzilla ticket:
  1. Go to the Bugzilla website.
  2. As the Component, use Documentation.
  3. Fill in the Description field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
  4. Click Submit Bug.
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 reformating 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 OVERVIEW

The underlying physical storage unit of an LVM logical volume is a block device such as a partition or whole disk. This device is initialized as an LVM physical volume (PV).

To create an LVM logical volume, the physical volumes are combined into a volume group (VG). This creates a pool of disk space out of which LVM logical volumes (LVs) can be allocated. This process is analogous to the way in which disks are divided into partitions. A logical volume is used by file systems and applications (such as databases).
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 overwrite 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
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.

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.
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.
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).

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 RAID0/1/4/5/6/10. An LVM RAID volume has the following characteristics:
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. 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.

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.

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.

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 on 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

2.2. STORAGE ROLE PARAMETERS

The section provides a table with input variables that the storage role accepts.

Table 2.1. Storage role parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>storage_volumes</td>
<td>List of file systems on all unpartitioned disks to be managed.</td>
<td>Partitions are currently unsupported.</td>
</tr>
</tbody>
</table>

### Parameter Description Additional information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>storage_pools</td>
<td>List of pools to be managed.</td>
<td>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.</td>
</tr>
<tr>
<td>storage_safe_mode</td>
<td>Boolean option to enable and disable safe mode.</td>
<td>In safe mode, the storage role does not reformat disks containing data such as file systems or LVM physical volumes, but instead the role aborts with an error message. By default, safe mode is on to prevent accidentally overwriting existing data. Red Hat recommends to keep safe mode enabled, and disable it only for specific cases and after thorough testing.</td>
</tr>
</tbody>
</table>

The **storage** role only changes file systems, volumes, and pools that are listed in the following variables:

- **storage_pools**
- **storage_volumes**

**Additional resources**

For more information, install the `rhel-system-roles` package, and see the `/usr/share/doc/rhel-system-roles/storage/` and `/usr/share/ansible/roles/rhel-system-roles.storage/` directories.
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).

Prerequisites

- The lvm2 package is installed.

Procedure

1. To create multiple physical volumes, use the space-delimited device names as arguments to `pvcreate` command:

   ```
   # pvcreate /dev/vdb1 /dev/vdb2
   ```

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

   For more information, see `pvcreate` man page.

3.2. CREATING LVM VOLUME GROUP

This procedure describes how to create an LVM volume group (VG).

Prerequisites

- The lvm2 package is installed.
- One or more physical volumes are created. See the instruction how to do so in Section 3.1, “Creating LVM physical volume”.

Procedure

1. To create a volume group, use the following command:

   ```
   # vgcreate myvg /dev/vdb1 /dev/vdb2
   ```

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

   For more information, see `vgcreate` man page.

   It is possible to extend the above VG with the PVs later. To extend a VG, use the following command:

   ```
   # vgextend myvg /dev/vdb3
   ```

3.3. CREATING LVM LOGICAL VOLUME
This procedure describes how to create LVM logical volume (LV).

Prerequisites

- The **lvm2** package is installed.
- The volume group is created. See the instruction how to do so in Section 3.2, “Creating LVM volume group”.

Procedure

1. To create a logical volume, use the following command:

   ```sh
   # lvcreate -n lv01 -L 500M myvg
   ```

   The `-n` option allows the user to set the LV name to `lv01`. The `-L` option allows the user to set the size of LV in units of Mb in this example, 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 will fail if the VG does not have a sufficient number of free physical extents for the requested size and type.

   For more information, see the **lvcreate** man page.
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 lv0
Creating volume group backup "/etc/lvm/backup/new_vg" (seqno 2).
Activating logical volume new_vg/lv0.
activation/volume_list configuration setting not defined: Checking only host tags for new_vg/lv0.
Creating new_vg-lv0
Loading table for new_vg-lv0 (253:0).
Resuming new_vg-lv0 (253:0).
Wiping known signatures on logical volume "new_vg/lv0"
Initializing 4.00 KiB of logical volume "new_vg/lv0" with value 0.
Logical volume "lv0" 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.

```bash
# 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.

```
# 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
```

**WARNING**
This command destroys any data on `/dev/sda1`, `/dev/sdb1`, and `/dev/sdc1`. 
# 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 myvg mylv
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
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>--type raid0[meta]</strong></td>
<td>Specifying <code>raid0</code> creates a RAID0 volume without metadata volumes. Specifying <code>raid0_meta</code> 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 <code>raid0_meta</code> preallocates those metadata volumes to prevent a respective allocation failure.</td>
</tr>
<tr>
<td><strong>--stripes Stripes</strong></td>
<td>Specifies the number of devices to spread the logical volume across.</td>
</tr>
<tr>
<td><strong>--stripesize StripeSize</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>VolumeGroup</strong></td>
<td>Specifies the volume group to use.</td>
</tr>
<tr>
<td><strong>PhysicalVolumePath ...</strong></td>
<td>Specifies the devices to use. If this is not specified, LVM will choose the number of devices specified by the <code>Stripes</code> option, one for each stripe.</td>
</tr>
</tbody>
</table>

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.

   ```bash
   # 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`.

   ```bash
   ```
# 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

<table>
<thead>
<tr>
<th>VG</th>
<th>PV</th>
<th>LV</th>
<th>SN</th>
<th>Attr</th>
<th>VSize</th>
<th>VFree</th>
</tr>
</thead>
<tbody>
<tr>
<td>myvg</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>wz--n-</td>
<td>51.45G</td>
<td>51.45G</td>
</tr>
</tbody>
</table>

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 renames an existing logical volume using the command-line LVM interface.

Procedure

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

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:

   [root@node-n]# lvchange --activate n vg-name/lv-name

3. Use the `lvrename` utility to rename an existing logical volume:
# lvrename vg-name original-lv-name new-lv-name

Optionally, you can specify the full paths to the devices:

# lvrename /dev/vg-name/original-lv-name /dev/vg-name/new-lv-name

Additional resources

- The lvrename(8) man page

4.5. REMOVING A DISK FROM A LOGICAL VOLUME

These example procedures show how you can 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.

4.5.1. Moving extents to existing physical volumes

In this example, the logical volume is distributed across four physical volumes in the volume group myvg.

```
# pvs -o+pv_used
PV   VG  Fmt  Attr PSize  PFree  Used
/dev/sda1 myvg lvm2 a- 17.15G  7.15G 10.00G
/dev/sdb1 myvg lvm2 a- 17.15G 17.15G     0
/dev/sdc1 myvg lvm2 a- 17.15G 12.15G  5.00G
/dev/sdd1 myvg lvm2 a- 17.15G  2.15G 15.00G
```

This example moves the extents off of /dev/sdb1 so that it can be removed from the volume group.

1. If there are enough free extents on the other physical volumes in the volume group, you can execute the pvmove command on the device you want to remove with no other options and the extents will be distributed to the other devices.

In a cluster, the pvmove command can move only logical volume that are active exclusively on a single node.

```
# pvmove /dev/sdb1
/dev/sdb1: Moved: 2.0%
... 
/dev/sdb1: Moved: 79.2%
... 
/dev/sdb1: Moved: 100.0%
```

After the pvmove command has finished executing, the distribution of extents is as follows:

```
# pvs -o+pv_used
PV   VG  Fmt  Attr PSize  PFree  Used
/dev/sda1 myvg lvm2 a- 17.15G  7.15G 10.00G
/dev/sdb1 myvg lvm2 a- 17.15G 17.15G  0
/dev/sdc1 myvg lvm2 a- 17.15G 12.15G  5.00G
/dev/sdd1 myvg lvm2 a- 17.15G  2.15G 15.00G
```

2. Use the vgreduce command to remove the physical volume /dev/sdb1 from the volume group.

# vgreduce myvg /dev/sdb1
Removed "/dev/sdb1" from volume group "myvg"

# pvs
PV  VG  Fmt  Attr  PSize  PFree
/dev/sda1  myvg  lvm2  a-   17.15G  7.15G
/dev/sdb1  lvm2  --   17.15G 17.15G
/dev/sdc1  myvg  lvm2  a-   17.15G 12.15G
/dev/sdd1  myvg  lvm2  a-   17.15G  2.15G

The disk can now be physically removed or allocated to other users.

### 4.5.2. Moving Extents to a New Disk

In this example, the logical volume is distributed across three physical volumes in the volume group `myvg` as follows:

```
# pvs -o+pv_used
PV  VG  Fmt  Attr  PSize  PFree  Used
/dev/sda1  myvg  lvm2  a-   17.15G  7.15G 10.00G
/dev/sdb1  myvg  lvm2  a-   17.15G 15.15G  2.00G
/dev/sdc1  myvg  lvm2  a-   17.15G 15.15G  2.00G
```

This example procedure moves the extents of `/dev/sdb1` to a new device, `/dev/sdd1`.

1. Create a new physical volume from `/dev/sdd1`.

```sh
# pvcreate /dev/sdd1
Physical volume "/dev/sdd1" successfully created
```

2. Add the new physical volume `/dev/sdd1` to the existing volume group `myvg`.

```sh
# vgextend myvg /dev/sdd1
Volume group "myvg" successfully extended
```

```
# pvs -o+pv_used
PV  VG  Fmt  Attr  PSize  PFree  Used
/dev/sda1  myvg  lvm2  a-   17.15G  7.15G 10.00G
/dev/sdb1  myvg  lvm2  a-   17.15G 15.15G  2.00G
/dev/sdc1  myvg  lvm2  a-   17.15G 15.15G  2.00G
/dev/sdd1  myvg  lvm2  a-   17.15G 17.15G  0
```

3. Use the `pvmove` command to move the data from `/dev/sdb1` to `/dev/sdd1`.

```sh
# pvmove /dev/sdb1 /dev/sdd1
/dev/sdb1: Moved: 10.0%
... 
/dev/sdb1: Moved: 79.7%
... 
/dev/sdb1: Moved: 100.0%
```

```
# pvs -o+pv_used
PV  VG  Fmt  Attr  PSize  PFree  Used
/dev/sda1  myvg  lvm2  a-   17.15G  7.15G 10.00G
```
4. After you have moved the data off /dev/sdb1, you can remove it from the volume group.

```
# vgreduce myvg /dev/sdb1
Removed "/dev/sdb1" from volume group "myvg"
```

You can now reallocate the disk to another volume group or remove the disk from the system.

### 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 a LVM logical volume called `mylv` in a volume group called `myvg`. The volume group consists of the following disks:

- /dev/sda
- /dev/sdb
- /dev/sdc

The playbook creates an ext4 file system on the logical volume, and persistently mounts the file system.

```yaml
- 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
```

**NOTE**

If a volume group called `myvg` already exists, the logical volume is added to it.

If a volume group called `myvg` does not exist, it is created.

### 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 removes an existing logical volume using the command-line LVM interface.

The following commands remove the logical volume `/dev/vg-name/lv-name` from the volume group `vg-name`.

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

      ```bash
      [root@node-n]# lvchange --activate n vg-name/lv-name
      ```
3. Remove the logical volume using the `lvremove` utility:

```bash
# lvremove /dev/vg-name/lv-name
Do you really want to remove active logical volume "lv-name"? [y/n]: y
Logical volume "lv-name" 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

- The `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 LOGICAL VOLUMES

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.

The following command extends the logical volume `/dev/myvg/homevol` to 12 gigabytes.

```bash
# lvextend -L12G /dev/myvg/homevol
lvextend -- extending logical volume "/dev/myvg/homevol" to 12 GB
lvextend -- doing automatic backup of volume group "myvg"
lvextend -- logical volume "/dev/myvg/homevol" successfully extended
```

The following command adds another gigabyte to the logical volume `/dev/myvg/homevol`.

```bash
# lvextend -L+1G /dev/myvg/homevol
lvextend -- extending logical volume "/dev/myvg/homevol" to 13 GB
lvextend -- doing automatic backup of volume group "myvg"
lvextend -- logical volume "/dev/myvg/homevol" successfully extended
```

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. The following command extends the logical volume called `testlv` to fill all of the unallocated space in the volume group `myvg`.

```bash
# lvextend -l +100%FREE /dev/myvg/testlv
Extending logical volume testlv to 68.59 GB
Logical volume testlv successfully resized
```

After you have extended the logical volume it is necessary to increase the file system size to match.

By default, most file system resizing tools will increase the size of the file system to be the size of the underlying logical volume so you do not need to worry about specifying the same size for each of the two commands.

5.2. GROWING A FILE SYSTEM ON A LOGICAL VOLUME

To grow a file system on a logical volume, perform the following steps:

1. Determine whether there is sufficient unallocated space in the existing volume group to extend the logical volume. If not, perform the following procedure:
   a. Create a new physical volume with the `pvcreate` command.
   b. Use the `vgextend` command to extend the volume group that contains the logical volume with the file system you are growing to include the new physical volume.
2. Once the volume group is large enough to include the larger file system, extend the logical volume with the `lvresize` command.

3. Resize the file system on the logical volume.

Note that you can use the `-r` option of the `lvresize` command to extend the logical volume and resize the underlying file system with a single command.

### 5.3. 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.

The following command shrinks the logical volume `lvol1` in volume group `vg00` to be 64 megabytes. In this example, `lvol1` contains a file system, which this command resizes together with the logical volume. This example shows the output to the command.

```
# lvreduce --resizefs -L 64M vg00/lvol1
fsck from util-linux 2.23.2
/dev/mapper/vg00-lvol1: clean, 11/25688 files, 8896/102400 blocks
resize2fs 1.42.9 (28-Dec-2013)
Resizing the filesystem on /dev/mapper/vg00-lvol1 to 65536 (1k) blocks.
The filesystem on /dev/mapper/vg00-lvol1 is now 65536 blocks long.

Size of logical volume vg00/lvol1 changed from 100.00 MiB (25 extents) to 64.00 MiB (16 extents).
Logical volume vg00/lvol1 successfully resized.
```
Specifying the - sign before the resize value indicates that the value will be subtracted from the logical volume’s actual size. The following example shows the command you would use if, instead of shrinking a logical volume to an absolute size of 64 megabytes, you wanted to shrink the volume by a value 64 megabytes.

```bash
# lvreduce --resizefs -L -64M vg00/lvol1
```

### 5.4. 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 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.

```bash
# 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.

```bash
# 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
```

```bash
# 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.

```bash
# 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.

```bash
# vgextend vg /dev/sdc1
Volume group "vg" successfully extended
```

```bash
# 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.

```bash
# 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.

```bash
# 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.

```bash
# 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

This section describes the commands that perform the various aspects of volume group administration.

6.1. 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.

6.2. 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.

-
6.3. COMBINING 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.

The following command merges the inactive volume group `my_vg` into the active or inactive volume group `databases` giving verbose runtime information.

```
# vgmerge -v databases my_vg
```

6.4. SPLITTING A VOLUME GROUP

In this example procedure, an existing volume group consists of three physical volumes. If there is enough unused space on the physical volumes, a new volume group can be created without adding new disks.

In the initial set up, the logical volume `mylv` is carved from the volume group `myvg`, which in turn consists of the three physical volumes, `/dev/sda1`, `/dev/sdb1`, and `/dev/sdc1`.

After completing this procedure, the volume group `myvg` will consist of `/dev/sda1` and `/dev/sdb1`. A second volume group, `yourvg`, will consist of `/dev/sdc1`.

1. Use the `pvscan` command to determine how much free space is currently available in the volume group.

```
# pvscan
PV /dev/sda1  VG myvg  lvm2 [17.15 GB / 0 free]
PV /dev/sdb1  VG myvg  lvm2 [17.15 GB / 12.15 GB free]
PV /dev/sdc1  VG myvg  lvm2 [17.15 GB / 15.80 GB free]
Total: 3 [51.45 GB] / in use: 3 [51.45 GB] / in no VG: 0 [0]
```

2. Move all the used physical extents in `/dev/sdc1` to `/dev/sdb1` with the `pvmove` command. The `pvmove` command can take a long time to execute. In a cluster, the `pvmove` command can move only logical volume that are active exclusively on a single node.

```
# pvmove /dev/sdc1 /dev/sdb1
/dev/sdc1: Moved: 14.7%
/dev/sdc1: Moved: 30.3%
/dev/sdc1: Moved: 45.7%
/dev/sdc1: Moved: 61.0%
/dev/sdc1: Moved: 76.6%
/dev/sdc1: Moved: 92.2%
/dev/sdc1: Moved: 100.0%
```

After moving the data, you can see that all of the space on `/dev/sdc1` is free.
To create the new volume group `yourvg`, use the `vgsplit` command to split the volume group `myvg`.

The following command splits the volume group `yourvg` from the volume group `myvg`, moving the physical volume `/dev/sdc1` into the new volume group `yourvg`.

```bash
# lvchange -a n /dev/myvg/mylv
# vgsplit myvg yourvg /dev/sdc1
Volume group "yourvg" successfully split from "myvg"
```

You can use the `vgs` command to see the attributes of the two volume groups.

```bash
# 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
```

After creating the new volume group, create the new logical volume `yourlv`.

```bash
# lvcreate -L 5G -n yourlv yourvg
Logical volume "yourlv" created
```

Create a file system on the new logical volume and mount it.

```bash
# mkfs.ext4 /dev/yourvg/yourlv
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
# mount /dev/yourvg/yourlv /mnt
```

### 6.5. RENAMING LVM VOLUME GROUPS

This procedure renames an existing volume group using the command-line LVM interface.

**Procedure**

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

   ```bash
   [root@node-n]# vgchange --activate n vg-name
   ```
2. Use the `vgrename` utility to rename an existing volume group:

```bash
# vgrename original-vg-name new-vg-name
```

Optionally, you can specify the full paths to the devices:

```bash
# vgrename /dev/original-vg-name /dev/new-vg-name
```

### Additional resources
- The `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.

   ```bash
   # 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 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.

Before removing a physical volume from a volume group, you can make sure that the physical volume is not used by any logical volumes by using the `pvdisplay` command.

```
# pvdisplay /dev/hda1
```

<table>
<thead>
<tr>
<th>-- Physical volume ---</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV Name</td>
</tr>
<tr>
<td>VG Name</td>
</tr>
<tr>
<td>PV Size</td>
</tr>
<tr>
<td>PV#</td>
</tr>
<tr>
<td>PV Status</td>
</tr>
<tr>
<td>Allocatable</td>
</tr>
<tr>
<td>Cur LV</td>
</tr>
<tr>
<td>PE Size (KByte)</td>
</tr>
<tr>
<td>Total PE</td>
</tr>
<tr>
<td>Free PE</td>
</tr>
<tr>
<td>Allocated PE</td>
</tr>
<tr>
<td>PV UUID</td>
</tr>
</tbody>
</table>

If the physical volume is still being used you will have to migrate the data to another physical volume using the `pvmove` command. Then use the `vgreduce` command to remove the physical volume.

The following command removes the physical volume `/dev/hda1` from the volume group `my_volume_group`.

```
# vgreduce my_volume_group /dev/hda1
```

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.

If the physical volume that fails contains a mirror image of a logical volume of a mirror segment type, you can remove that image from the mirror with the `vgreduce --removemissing --mirrorsonly --force` command. This removes only the logical volumes that are mirror images from the physical volume.

### 6.8. REMOVING LVM VOLUME GROUPS

This procedure removes an existing volume group using the command-line LVM interface.

**Prerequisites**

- The volume group contains no logical volumes. To remove logical volumes from a volume group, see Section 4.9, “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:

   ```bash
   [root@node-n]# vgchange --lockstop vg-name
   ```

   Wait for the lock to stop.

2. To remove the volume group, use the `vgremove` utility:

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

Additional resources

- The `vgremove(8)` man page

6.9. ADDITIONAL RESOURCES

- The `vgchange(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 PHYSICAL VOLUMES

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

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.

```
# pvremove /dev/ram15
Labels on physical volume "/dev/ram15" successfully wiped
```

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.

Before removing a physical volume from a volume group, you can make sure that the physical volume is not used by any logical volumes by using the `pvdisplay` command.

```
# pvdisplay /dev/hda1

-- Physical volume ---
PV Name    /dev/hda1
VG Name    myvg
PV Size    1.95 GB / NOT usable 4 MB [LVM: 122 KB]
P#          1
PV Status  available
Allocatable yes (but full)
Cur LV     1
PE Size (KByte) 4096
Total PE   499
Free PE    0
Allocated PE 499
PV UUID    Sd44tK-9IRw-SrMC-MOkn-76iP-iftz-OVSen7
```

If the physical volume is still being used you will have to migrate the data to another physical volume using the `pvmove` command. Then use the `vgreduce` command to remove the physical volume.
The following command removes the physical volume `/dev/hda1` from the volume group `my_volume_group`.

```
# vgreduce my_volume_group /dev/hda1
```

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.

If the physical volume that fails contains a mirror image of a logical volume of a `mirror` segment type, you can remove that image from the mirror with the `vgreduce --removemissing --mirrorsonly --force` command. This removes only the logical volumes that are mirror images from the physical volume.
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.

```bash
# 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       Joqich-yWSj-kuEn-ldwM-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]
```

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 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 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 Attri 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 Joqlch-yWSj-kuEn-IdwM-01S9-X08M-
```
The \texttt{--noheadings} argument suppresses the headings line. This can be useful for writing scripts. The following example uses the \texttt{--noheadings} argument in combination with the \texttt{pv\_name} argument, which will generate a list of all physical volumes.

\begin{verbatim}
# pvs --noheadings -o pv\_name /dev/sdb1 /dev/sdc1 /dev/sdd1
\end{verbatim}

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

\begin{verbatim}
# 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
\end{verbatim}

To keep the fields aligned when using the \texttt{separator} argument, use the \texttt{separator} argument in conjunction with the \texttt{--aligned} argument.

\begin{verbatim}
# 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
\end{verbatim}

You can use the \texttt{-P} argument of the \texttt{lvs} or \texttt{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 \texttt{pvs(8)}, \texttt{vgs(8)} and \texttt{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.

\begin{verbatim}
# 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
\end{verbatim}

\subsection*{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 \texttt{pvs}, \texttt{vgs}, and \texttt{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`.

```bash
# 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**

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

```bash
# 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`.

```bash
# 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.

```bash
# 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
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 17.14G
/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>
<thead>
<tr>
<th>Argument</th>
<th>Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lv_count</td>
<td>#LV</td>
<td>The number of logical volumes the volume group contains</td>
</tr>
<tr>
<td>max_lv</td>
<td>MaxLV</td>
<td>The maximum number of logical volumes allowed in the volume group (0 if unlimited)</td>
</tr>
<tr>
<td>max_pv</td>
<td>MaxPV</td>
<td>The maximum number of physical volumes allowed in the volume group (0 if unlimited)</td>
</tr>
<tr>
<td>pv_count</td>
<td>#PV</td>
<td>The number of physical volumes that define the volume group</td>
</tr>
<tr>
<td>snap_count</td>
<td>#SN</td>
<td>The number of snapshots the volume group contains</td>
</tr>
<tr>
<td>vg_attr</td>
<td>Attr</td>
<td>Status of the volume group: (w)riteable, (r)eadonly, resi(z)etable, e(x)ported, (p)artial and (c)lustered.</td>
</tr>
<tr>
<td>Argument</td>
<td>Header</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>--------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>vg_extent_count</td>
<td>#Ext</td>
<td>The number of physical extents in the volume group</td>
</tr>
<tr>
<td>vg_extent_size</td>
<td>Ext</td>
<td>The size of the physical extents in the volume group</td>
</tr>
<tr>
<td>vg_fmt</td>
<td>Fmt</td>
<td>The metadata format of the volume group (lvm2 or lvm1)</td>
</tr>
<tr>
<td>vg_free</td>
<td>VFree</td>
<td>Size of the free space remaining in the volume group</td>
</tr>
<tr>
<td>vg_free_count</td>
<td>Free</td>
<td>Number of free physical extents in the volume group</td>
</tr>
<tr>
<td>vg_name</td>
<td>VG</td>
<td>The volume group name</td>
</tr>
<tr>
<td>vg_seqno</td>
<td>Seq</td>
<td>Number representing the revision of the volume group</td>
</tr>
<tr>
<td>vg_size</td>
<td>VSize</td>
<td>The size of the volume group</td>
</tr>
<tr>
<td>vg_sysid</td>
<td>SYS ID</td>
<td>LVMI System ID</td>
</tr>
<tr>
<td>vg_tags</td>
<td>VG Tags</td>
<td>LVM tags attached to the volume group</td>
</tr>
<tr>
<td>vg_uuid</td>
<td>VG UUID</td>
<td>The UUID of the volume group</td>
</tr>
</tbody>
</table>

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`.

```text
# 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`.

```text
# 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

<table>
<thead>
<tr>
<th>Argument</th>
<th>Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>* chunksize</td>
<td>Chunk</td>
<td>Unit size in a snapshot volume</td>
</tr>
<tr>
<td>* chunk_size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>copy_percent</td>
<td>Copy%</td>
<td>The synchronization percentage of a mirrored logical volume; also used when physical extents are being moved with the <code>pv_move</code> command</td>
</tr>
<tr>
<td>devices</td>
<td>Devices</td>
<td>The underlying devices that make up the logical volume: the physical volumes, logical volumes, and start physical extents and logical extents</td>
</tr>
<tr>
<td>lv_ancestors</td>
<td>Ancestors</td>
<td>For thin pool snapshots, the ancestors of the logical volume</td>
</tr>
<tr>
<td>lv_descendants</td>
<td>Descendants</td>
<td>For thin pool snapshots, the descendants of the logical volume</td>
</tr>
<tr>
<td>lv_attr</td>
<td>Attr</td>
<td>The status of the logical volume. The logical volume attribute bits are as follows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 1: Volume type: (m)irrored, (M)irrored without initial sync, (o)igin, (O)igin 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 (l)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)data or pool metadata spare,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 2: Permissions: (w)ritable, (r)ead-only, ®ead-only activation of non-read-only volume</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* 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 <code>pvmove</code> command.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 4: fixed (m)inor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 5: State: (a)ctive, (s)uspended, (l)invalid 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</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 6: device (o)pen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Bit 7: Target type: (m)irror, (r)aid, (s)napshot, (t)hin, (u)known, (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</td>
</tr>
<tr>
<td>Argument</td>
<td>Header</td>
<td>Description</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>lv_kernel_major</td>
<td>KMaj</td>
<td>Actual major device number of the logical volume (-1 if inactive)</td>
</tr>
<tr>
<td>lv_kernel_minor</td>
<td>KMIN</td>
<td>Actual minor device number of the logical volume (-1 if inactive)</td>
</tr>
<tr>
<td>lv_major</td>
<td>Maj</td>
<td>The persistent major device number of the logical volume (-1 if not specified)</td>
</tr>
<tr>
<td>lv_minor</td>
<td>Min</td>
<td>The persistent minor device number of the logical volume (-1 if not specified)</td>
</tr>
<tr>
<td>lv_name</td>
<td>LV</td>
<td>The name of the logical volume</td>
</tr>
<tr>
<td>lv_size</td>
<td>LSize</td>
<td>The size of the logical volume</td>
</tr>
<tr>
<td>lv_tags</td>
<td>LV Tags</td>
<td>LVM tags attached to the logical volume</td>
</tr>
<tr>
<td>lv_uuid</td>
<td>LV UUID</td>
<td>The UUID of the logical volume.</td>
</tr>
<tr>
<td>mirror_log</td>
<td>Log</td>
<td>Device on which the mirror log resides</td>
</tr>
<tr>
<td>modules</td>
<td>Modules</td>
<td>Corresponding kernel device-mapper target necessary to use this logical volume</td>
</tr>
</tbody>
</table>

* Bit 8: Newly-allocated data blocks are overwritten with blocks of zeroes 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.
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                                      100.00
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
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)
```
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_uid`

```
# 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-
         newvgsnap1 new_vg  1 swi-a-  8.00M  -1  -1 253  5    lvol0    0.20                         1ye1OU-1cIu-
```

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- 729.0 54.69 1 linear     0     0
newvgsnap1 new_vg swi-a-  8.00M 729.0 1 linear 820.00m 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.
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.

```bash
# 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.

```bash
# 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.

```bash
# 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.

```bash
# 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)i(lobytes, (m)ega(abytes, (g)iga(abytes, (t)era(abytes, (e)xa(abytes, (p)eta(abytes, and
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
# lvoll0 4.00m

**Command Log**

```
Seq  LogType   Context    ObjType  ObjName  ObjGrp  Msg      Errno RetCode
 1   status  processing lv      lvoll0   vg      success     0       1
 2   status  processing lv      lvoll1   vg      success     0       1
 3   status  processing vg      vg              success     0       1
```

# lvollchange -an vg/lvol1

**Command Log**

```
Seq  LogType   Context    ObjType  ObjName  ObjGrp  Msg      Errno RetCode
 1   status  processing lv      lvoll1   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

LVM supports RAID0/1/4/5/6/10.

NOTE

RAID logical volumes are not cluster-aware. While RAID logical volumes can be created and activated exclusively on one machine, they cannot be activated simultaneously on more than one machine.

To create a RAID logical volume, you specify a raid type as the `--type` argument of the `lvcreate` command. Table 10.1, “RAID Segment Types” describes the possible RAID segment types. After you have created a RAID logical volume with LVM, you can activate, change, remove, display, and use the volume just as you would any other LVM logical volume.

Table 10.1. RAID Segment Types

<table>
<thead>
<tr>
<th>Segment type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>raid1</td>
<td>RAID1 mirroring. This is the default value for the <code>--type</code> argument of the <code>lvcreate</code> command when you specify the <code>-m</code> but you do not specify striping.</td>
</tr>
<tr>
<td>raid4</td>
<td>RAID4 dedicated parity disk</td>
</tr>
<tr>
<td>raid5</td>
<td>Same as <code>raid5_ls</code></td>
</tr>
</tbody>
</table>
| 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.

---

For most users, specifying one of the five available primary types *(raid1, raid4, raid5, raid6, raid10)* should be sufficient. For more information on the different algorithms used by RAID 5/6, see chapter four of the *Common RAID Disk Data Format Specification* at [http://www.snia.org/sites/default/files/SNIA_DDF_Technical_Position_v2.0.pdf](http://www.snia.org/sites/default/files/SNIA_DDF_Technical_Position_v2.0.pdf).

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)*.

#### NOTE

You can generate commands to create logical volumes on RAID storage with the LVM RAID Calculator application. This application uses the information you input about your current or planned storage to generate these commands. The LVM RAID Calculator application can be found at [https://access.redhat.com/labs/lvmraidcalculator/](https://access.redhat.com/labs/lvmraidcalculator/).

### 10.1. 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.
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
```

## 10.2. 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--type raid0[_meta]</td>
<td>Specifying <code>raid0</code> creates a RAID0 volume without metadata volumes. Specifying <code>raid0_meta</code> 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 <code>raid0_meta</code> preallocates those metadata volumes to prevent a respective allocation failure.</td>
</tr>
<tr>
<td>--stripes Stripes</td>
<td>Specifies the number of devices to spread the logical volume across.</td>
</tr>
<tr>
<td>--stripesize StripeSize</td>
<td>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.</td>
</tr>
<tr>
<td>VolumeGroup</td>
<td>Specifies the volume group to use.</td>
</tr>
</tbody>
</table>
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.

   ```sh
   # 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`.

   ```sh
   # 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.
   ```

   ```sh
   # 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.

   ```sh
   # 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.
   
   You can use the `lvdisplay` command to display the attributes of the new logical volume.
   ```

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

   ```sh
   # mkfs.ext4 /dev/myvg/mylv
   ```

---

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhysicalVolumePath ...</td>
<td>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.</td>
</tr>
</tbody>
</table>
10.3. 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`.

```bash
# 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.

10.4. 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.

### 10.5. 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
```
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.

```bash
# 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/sdb1(0)
[my_lv_rimage_1] /dev/sdb1(0)
[my_lv_rmeta_0] /dev/sdb1(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(0)
```

### 10.6. 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`.

```bash
# 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)

# 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)
```

### 10.7. 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.

### 10.8. 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:

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

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
```
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.

```bash
# lvconvert -m1 my_vg/my_lv /dev/sde1
```

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

```bash
# 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)
```

10.9. 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:

```bash
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`.

```bash
# 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 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)
```

### 10.10. 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
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_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)
```

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 my_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
LV 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)
```
10.11. 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.

10.11.1. 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.

```bash
# 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.

```bash
# 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.

```bash
# lvs -a -o name,copy_percent,devices vg
LV          Copy%  Devices
lv          100.00 lv_rimage_0(0),lv_rimage_1(0),lv_rimage_2(0)
  [lv_rimage_0] /dev/sdh1(1)
```
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.

10.11.2. 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.

10.12. REPLACING A RAID DEVICE IN A LOGICAL VOLUME

You can replace a RAID device in a logical volume with the `lvconvert` command.

- If there has been no failure on a RAID device, use the `--replace` argument of the `lvconvert` command to replace the device.
- If the RAID device has failed, use the `--repair` argument of the `lvconvert` command to replace the failed device.

10.12.1. 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. Note that this command will not work if the RAID device has failed.

The format for the `lvconvert --replace` command is as follows.

```
lvconvert --replace dev_to_remove vg/lv [possible_replacements]
```
The following example creates a RAID1 logical volume and then replaces a device in that volume.

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

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.

```
# lvcreate --type raid1 -m 1 -L 100 -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_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)
# pvs
PV VGFmt Attr PSize PFreesda1 my_vglvm2 a-- 1020.00m 916.00m
/sdb1 my_vglvm2 a-- 1020.00m 916.00m
/sdc1 my_vglvm2 a-- 1020.00m 1020.00m
/sdd1 my_vglvm2 a-- 1020.00m 1020.00m
# lvconvert --replace /dev/sdb1 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_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)
```

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

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

---

**CHAPTER 10. CONFIGURING RAID LOGICAL VOLUMES**

75
Logical volume "my_lv" created

```bash
# 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)
    /dev/sda1(1)
    /dev/sdb1(1)
    /dev/sdc1(1)
    /dev/sdd1(1)
    /dev/sde1(1)
    /dev/sdf1(0)
    /dev/sdg1(0)
    /dev/shf1(0)
```

```
# lvconvert --replace /dev/sdb1 --replace /dev/sdc1 my_vg/my_lv
```

```bash
# 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)
    /dev/sde1(1)
    /dev/sdd1(1)
    /dev/sdc1(1)
    /dev/sda1(0)
    /dev/sdd1(0)
    /dev/sde1(0)
```

10.12.2. Replacing a failed RAID device in a logical volume

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.

In the following example, a RAID logical volume is laid out as follows.

```bash
# lvs -a -o 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)
    /dev/sde1(1)
    /dev/sdc1(1)
    /dev/sdd1(1)
    /dev/sda1(0)
    /dev/sdd1(0)
    /dev/sde1(0)
```

If the `/dev/sdc` device fails, the output of the `lvs` command is as follows.

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

```
/dev/sdc: open failed: No such device or address
```

```
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)
    /dev/sde1(1)
```

If the `/dev/sdc` device fails, the output of the `lvs` command is as follows.
Use the following commands to replace the failed device and display the logical volume.

```
# lvconvert --repair my_vg/my_lv
/dev/sdc: open failed: No such device or address
Could'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.
# lvs -a -o 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)
```

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 device failure is a transient failure or you are able to repair the device that failed, you can initiate recovery of the failed device with the `--refresh` option of the `lvchange` command.

The following command refreshes a logical volume.

```
# lvchange --refresh my_vg/my_lv
```

### 10.13. 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.

You initiate a RAID scrubbing operation with the `--syncaction` option of the `lvchange` command. You specify either a `check` or `repair` operation. A `check` operation goes over the array and records the number of discrepancies in the array but does not repair them. A `repair` operation corrects the discrepancies as it finds them.

The format of the command to scrub a RAID logical volume is as follows:
**Note**

The `lvchange --syncaction repair vg/raid_lv` operation does not perform the same function as the `lvconvert --repair vg/raid_lv` operation. The `lvchange --syncaction repair` operation initiates a background synchronization operation on the array, while the `lvconvert --repair` operation is designed to repair/replace failed devices in a mirror or RAID logical volume.

In support of the RAID scrubbing operation, the `lvs` command supports two new printable fields: `raid_sync_action` and `raid_mismatch_count`. These fields are not printed by default. To display these fields you specify them with the `-o` parameter of the `lvs`, as follows.

```bash
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 of the `lvs` command now prints the progress of any of the `raid_sync_action` operations, including `check` and `repair`.

The `lv_attr` field of the `lvs` command output now provides additional indicators in support of the RAID scrubbing operation. Bit 9 of this field displays the health of the logical volume, and it now supports the following indicators.

- `(m)`ismatches 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)`efresh 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. The logical volume should be `(r)`efreshed to notify the kernel that the device is now available, or the device should be `(r)`eplaced if it is suspected of having failed.

When you perform a RAID scrubbing operation, the background I/O required by the `sync` operations can crowd out other I/O operations to LVM devices, such as updates to volume group metadata. This can cause the other LVM operations to slow down. You can control the rate at which the RAID logical volume is scrubbed 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 `lvchange` command. You specify these options as follows.
• **--maxrecoveryrate** `Rate[bbSkKmMgG]`
  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[bbSkKmMgG]`
  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.

### 10.14. 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 `lvmdraid(7)` man page.

### 10.15. 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 `lvmdraid(7)` man page.

### 10.16. 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.

### 10.17. 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.
```
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 \texttt{--merge} option of the \texttt{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 \texttt{-s} argument of the \texttt{lvcreate} command to create a snapshot volume. A snapshot volume is writable.

\begin{itemize}
\item \textbf{NOTE}
\begin{itemize}
\item 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.
\end{itemize}
\item \textbf{NOTE}
\begin{itemize}
\item Snapshots are supported for RAID logical volumes.
\end{itemize}
\end{itemize}

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 \texttt{origin} and a snapshot volume of the original volume named \texttt{snap}.

1. Create a logical volume named \texttt{origin} from the volume group \texttt{VG}.

\begin{verbatim}
# lvcreate -L 1G -n origin VG
Logical volume "origin" created.
\end{verbatim}

2. Create a snapshot logical volume of \texttt{/dev/VG/origin} that is 100 MB in size named \texttt{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.

\begin{verbatim}
# lvcreate --size 100M --snapshot --name snap /dev/VG/origin
Logical volume "snap" created.
\end{verbatim}

3. Display the status of logical volume \texttt{/dev/VG/origin}, showing all snapshot logical volumes and their status (active or inactive).

\begin{verbatim}
# lvdisplay /dev/VG/origin
--- Logical volume ---
LV Path /dev/VG/origin
\end{verbatim}
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.
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. 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.

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.

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 `\texttt{-T}` option of the \texttt{lvcreate} command does not take an argument; it deduces what type of device is to be created from the other options the command specifies.

```shell
# 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.
```

```shell
# 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 `\texttt{-T}` option of the \texttt{lvcreate} command to create a thin volume named \texttt{thinvolume} in the thin pool \texttt{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.

```shell
# 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.
```

```shell
# 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 `\texttt{-T}` option of the \texttt{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 \texttt{lvcreate} command. This command creates a thin pool named \texttt{mythinpool} in the volume group \texttt{vg001} and it also creates a thin volume named \texttt{thinvolume} in that pool.

```shell
# 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.
```

```shell
# lvs
LV       VG       Attr     LSize   Pool       Origin Data%  Move Log Cpy%Sync Convert
mythinpool vg001 twi-a-tz-- 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 `\texttt{--thinpool}` parameter of the \texttt{lvcreate} command. Unlike the `\texttt{-T}` option, the `\texttt{--thinpool}` parameter requires an argument, which is the name of the thin pool logical volume that you are creating. The following example specifies the `\texttt{--thinpool}` parameter of the \texttt{lvcreate} command to create a thin pool named \texttt{mythinpool} in the volume group \texttt{vg001} and that is 100M in size:

```shell
# 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.
```
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
```

```
# lvs
LV VG  Attr  LSize  Pool Origin Data%  Move Log Cpy% Sync Convert
mythinpool  vg001  twi-a-tz--  100.00m  0.00  10.84
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 \((\text{Pool LV size} / \text{Pool LV chunk size} * 64)\). 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.

### 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
```

```bash
# lsvs
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
```
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 stack2,stack1
 stack4 stack3,stack2,stack1
```

Red Hat Enterprise Linux 8 Configuring and managing logical volumes

90
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 hyphen 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                     -lvol3,lvol2,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.
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
```

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
```

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,-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
```

```
LV     FAncestors           FDescendants
-lvol1                      -lvol2,-lvol3,lvol4
-lvol2 -lvol1               -lvol3,lvol4
-lvol3 -lvol2,-lvol1        lvol4
lvol4  -lvol3,-lvol2,-lvol1
pool
```

```
LV     FAncestors    FDescendants
-lvol1                      -lvol2,-lvol3,lvol4
-lvol2 -lvol1               -lvol3,lvol4
-lvol3 -lvol2,-lvol1        lvol4
lvol4  -lvol3,-lvol2,-lvol1
pool
```

```
LV     FAncestors    FDescendants
-lvol1                      -lvol2,-lvol3,lvol4
-lvol2 -lvol1               -lvol3,lvol4
-lvol3 -lvol2,-lvol1        lvol4
lvol4  -lvol3,-lvol2,-lvol1
pool
```

CHAPTER 12. CREATING AND MANAGING THINLY-PROVISIONED LOGICAL VOLUMES (THIN VOLUMES)
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`.

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 cache pool 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 cache pool, such as 5G
   - `fastpool`: A name for the cache pool 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 cache pool to the main logical volume to begin caching:

   ```
   # lvconvert --type cache --cachepool fastpool vg /dev/main
   ```

   Replace the following values:

   - `fastpool`: The name of the cache pool volume
   - `vg`: The volume group name
   - `/dev/main`: The name of the slow logical volume

Verification steps
Examine the newly created devices:

```
# lvs --all --options +devices vg
```

<table>
<thead>
<tr>
<th>LV</th>
<th>Pool</th>
<th>Type</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>[fastpool_cpool]</td>
<td>cache-pool</td>
<td>fastpool_pool_cdata(0)</td>
<td></td>
</tr>
<tr>
<td>[fastpool_cpool_cdata]</td>
<td>linear</td>
<td>/dev/sdf1(4)</td>
<td></td>
</tr>
<tr>
<td>[fastpool_cpool_cmdata]</td>
<td>linear</td>
<td>/dev/sdf1(2)</td>
<td></td>
</tr>
<tr>
<td>[lvol0_pmspare]</td>
<td>linear</td>
<td>/dev/sdf1(0)</td>
<td></td>
</tr>
<tr>
<td>main</td>
<td>[fastpool_cpool]</td>
<td>cache</td>
<td>main_corig(0)</td>
</tr>
<tr>
<td>[main_corig]</td>
<td>linear</td>
<td>/dev/sdf1(0)</td>
<td></td>
</tr>
</tbody>
</table>

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:

   ```bash
   # 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:

   ```bash
   # 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:

  ```bash
  # 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_wcorig] 0.00
  main-lv_wcorig(0)
  [fastvol_cvol] vg Cwi-aoC--- 252.00m
  /dev/sdc1(0)
  [main-lv_wcorig] 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:

   ```shell
   # 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:

   ```shell
   # 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:

  ```shell
  # lvs --all --options +devices [replaceable]_vg_
  ```

<table>
<thead>
<tr>
<th>LV</th>
<th>Attr</th>
<th>Type</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>fastvol</td>
<td>-wi-</td>
<td>linear</td>
<td>/dev/fast-pv</td>
</tr>
<tr>
<td>main-lv</td>
<td>-wi-</td>
<td>linear</td>
<td>/dev/slow-pv</td>
</tr>
</tbody>
</table>

**Additional resources**

- The `lvcache(7)` man page
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.

<table>
<thead>
<tr>
<th>Activation Mode</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>complete</td>
<td>Allows only logical volumes with no missing physical volumes to be activated. This is the most restrictive mode.</td>
</tr>
<tr>
<td>degraded</td>
<td>Allows RAID logical volumes with missing physical volumes to be activated.</td>
</tr>
<tr>
<td>partial</td>
<td>Allows any logical volume with missing physical volumes to be activated. This option should be used for recovery or repair only.</td>
</tr>
</tbody>
</table>

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.

```bash
# pvs -a -o +pv_tags /dev/sd[bcddefgh]
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**.

```bash
# 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.

```bash
# 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.

```bash
# 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.

```bash
# 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_1] taft iwi-aor--- 20.00g /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)
```
CHAPTER 18. TROUBLESHOOTING LVM

You can use LVM tools to troubleshoot a variety of issues in LVM volumes and groups.

18.1. 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 -vvvv argument to any LVM command to increase the verbosity level of the command output.
  - 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:
    - Set the activation = 1 option in the log section of the /etc/lvm/lvm.conf configuration file.
    - Run the LVM command with the -vvvv option.
    - Examine the command output.
    - 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/archive/ directory and archived versions in the /etc/lvm/backup/ 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.
18.2. 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 18.1. Failed volume groups**

In this example, one of the devices that made up the volume group `vg` failed. The volume group is unusable but you can see information about the failed device.

```
# vgs --options +devices
/dev/sdb: open failed: No such device or address
/dev/sdb: open failed: No such device or address
WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s.
WARNING: VG vg is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s (last written to /dev/sdb1).
WARNING: Couldn't find all devices for LV vg/linear while checking used and assumed devices.
WARNING: Couldn't find all devices for LV vg/stripe while checking used and assumed devices.
VG #PV #LV #SN Attr   VSize  VFree  Devices
vg   2   2   0 wz-pn- <3.64t <3.60t [unknown](0)  
vg   2   2   0 wz-pn- <3.64t <3.60t [unknown](5120),/dev/sdc1(0)
```

**Example 18.2. Failed linear and striped LV**

In this example, the failed device caused both a linear and a striped logical volume in the volume group to fail. The command output shows the failed logical volumes.

```
# lvs --all --options +devices
/dev/sdb: open failed: No such device or address
/dev/sdb: open failed: No such device or address
WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s.
WARNING: VG vg is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s (last written to /dev/sdb1).
WARNING: Couldn't find all devices for LV vg/linear while checking used and assumed devices.
WARNING: Couldn't find all devices for LV vg/stripe while checking used and assumed devices.
LV     VG Attr       LSize  Pool Origin Data%  Meta%  Move Log Cpy%Sync Convert Devices
```
Example 18.3. 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)
```

18.3. 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 volume-group
   ```

2. Check which logical volumes will be removed:
   ```
   # vgreduce --removemissing --test volume-group
   ```

3. Remove all the logical volumes that used the lost physical volume from the volume group:
   ```
   # vgreduce --removemissing --force volume-group
   ```

4. Optional: If you accidentally removed logical volumes that you wanted to keep, you can reverse the `vgreduce` operation:
18.4. RECOVERING AN LVM PHYSICAL VOLUME WITH DAMAGED METADATA

If the volume group 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. You might be able to recover the data from the physical volume by rewriting the metadata area on the physical volume.

18.4.1. Discovering that an LVM volume has missing or corrupted metadata

The following example shows the command output you might see if the metadata area on a physical volume is missing or corrupted.

Procedure

- Try to list the logical volumes:

  # lvs --all --options +devices

Example 18.4. Output with missing or corrupted metadata

In this example, certain logical volumes are located on a physical volume that has missing or corrupted metadata.

    Couldn't find device with uuid 'FmGRh3-zhok-iVI8-7qTD-S5BI-MAEN-NYM5Sk'.
    Couldn't find all physical volumes for volume group VG.
    Couldn't find device with uuid 'FmGRh3-zhok-iVI8-7qTD-S5BI-MAEN-NYM5Sk'.
    Couldn't find all physical volumes for volume group VG.
    ...

18.4.2. Finding the metadata of a missing LVM physical volume

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. 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-S5Bl-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 volume-group-name
  PARTIAL MODE. Incomplete logical volumes will be processed.
  WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s.
  WARNING: VG raid_sanity is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s
  (last written to /dev/sdb1).
  0 logical volume(s) in volume group "raid_sanity" now active
  ```

### 18.4.3. 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.

**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 Section 18.4.2, “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 18.5. Restoring a physical volume on /dev/sdh1

The following example labels the /dev/sdh1 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/sdh1
... 
Physical volume "/dev/sdh1" successfully created
```

2. Restore the metadata of the volume group:

```
# vgcfgrestore volume-group-name
```

```
Restored volume group volume-group-name
```

3. Display the logical volumes on the volume group:

```
# lvs --all --options +devices volume-group-name
```

```
The logical volumes are currently inactive. For example:

<table>
<thead>
<tr>
<th>LV</th>
<th>VG</th>
<th>Attr</th>
<th>LSize</th>
<th>Origin Snap%</th>
<th>Move Log Copy%</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>stripe</td>
<td>VG</td>
<td>-wi-</td>
<td>300.00G</td>
<td></td>
<td></td>
<td>/dev/sdh1 (0),/dev/sda1(0)</td>
</tr>
<tr>
<td>stripe</td>
<td>VG</td>
<td>-wi-</td>
<td>300.00G</td>
<td></td>
<td></td>
<td>/dev/sdh1 (34728),/dev/sdb1(0)</td>
</tr>
</tbody>
</table>
```

4. If the segment type of the logical volumes is RAID or mirror, resynchronize the logical volumes:

```
# lvchange --resync volume-group-name/logical-volume-name
```

5. Activate the logical volumes:

```
# lvchange --activate y /dev/volume-group-name/logical-volume-name
```

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
```
18.5. REPLACING A MISSING LVM PHYSICAL VOLUME

If a physical volume fails or otherwise needs to be replaced, you can label a new physical volume to replace the one that has been lost in the existing volume group.

Prerequisites

- You have replaced the physical volume with a new storage device.
  TODO: Reevaluate the placement of this step.

18.5.1. Finding the metadata of a missing LVM physical volume

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. 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:
     ```bash
     # 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:
     ```bash
     # vgchange --activate n --partial volume-group-name
     
     PARTIAL MODE. Incomplete logical volumes will be processed.
     WARNING: Couldn't find device with uuid 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s.
     WARNING: VG raid_sanity is missing PV 42B7bu-YCMp-CEVD-CmKH-2rk6-fiO9-z1lf4s
     (last written to /dev/sdb1).
     0 logical volume(s) in volume group "raid_sanity" now active
     ```

18.5.2. 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.
**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 Section 18.5.1, “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 18.6. Restoring a physical volume on /dev/sdh1**

   The following example labels the `/dev/sdh1` 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/sdh1
   ...
   Physical volume "/dev/sdh1" successfully created
   ```

2. Restore the metadata of the volume group:

   ```
   # vgcfgrestore volume-group-name
   ```

   Restored volume group `volume-group-name`

3. Display the logical volumes on the volume group:
# lvs --all --options +devices volume-group-name

The logical volumes are currently inactive. For example:

```
LV    VG   Attr  LSize  Origin Snap%  Move Log Copy%  Devices
stripe VG  -wi---  300.00G                               /dev/sdh1 (0),/dev/sda1(0)
stripe VG  -wi---  300.00G                               /dev/sdh1 (34728),/dev/sdb1(0)
```

4. If the segment type of the logical volumes is RAID or mirror, resynchronize the logical volumes:

```
# lvchange --resync volume-group-name/logical-volume-name
```

5. Activate the logical volumes:

```
# lvchange --activate y /dev/volume-group-name/logical-volume-name
```

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:

```
LV    VG   Attr  LSize  Origin Snap%  Move Log Copy%  Devices
stripe VG  -wi-a-  300.00G                               /dev/sdh1 (0),/dev/sda1(0)
stripe VG  -wi-a-  300.00G                               /dev/sdh1 (34728),/dev/sdb1(0)
```

### 18.6. TROUBLESHOOTING INSUFFICIENT FREE EXTENTS FOR A LOGICAL VOLUME

You might get the **Insufficient free extents** error message when attempting to create a logical volume, even when you think that the volume group has enough free space. You can troubleshoot this error to be able to create a logical volume on the volume group.

#### 18.6.1. 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.

#### 18.6.2. 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.

### 18.6.3. Preventing the rounding error when creating an LVM volume

When creating an LVM logical volume, you can specify the size of the logical volume so that no rounding error occurs.

**Procedure**

1. Find the number of free physical extents in the volume group:

   ```
   # vgdisplay volume-group-name
   ``

   **Example 18.7. Free extents in a volume group**

   For example, the following volume group has 8780 free physical extents:
   
   ```
   --- Volume group ---
   ...
   Free  PE / Size       8780 / 34.30 GB
   ```

2. Create the logical volume. Enter the volume size in extents rather than bytes.

   **Example 18.8. Creating a logical volume by specifying the number of extents**

   ```
   # lvcreate --extents 8780 --name testlv testvg
   ```

   **Example 18.9. Creating a logical volume to occupy all the remaining space**

   Alternately, 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 testlv2 testvg
   ```

**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
testvg 2   1   0 wz--n- 34.30G    0     0  8780
```

## 18.7. 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 GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: using /dev/dm-5 not /dev/sdd
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: using /dev/emcpowerb not /dev/sde
Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: using /dev/sddlmab not /dev/sdf

You can troubleshoot these warnings to understand why LVM displays them, or to hide the warnings.

### 18.7.1. 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>
<thead>
<tr>
<th>Multipath software</th>
<th>SCSI paths to a LUN</th>
<th>Multipath device mapping to paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM Multipath</td>
<td>/dev/sdb and /dev/sdc</td>
<td>/dev/mapper/mpath1 or /dev/mapper/mpatha</td>
</tr>
<tr>
<td>EMC PowerPath</td>
<td></td>
<td>/dev/emcpowera</td>
</tr>
<tr>
<td>HDLM</td>
<td></td>
<td>/dev/sddlmab</td>
</tr>
</tbody>
</table>

As a result of the multiple device nodes, LVM tools find the same metadata multiple times and report them as duplicates.

### 18.7.2. Cases of duplicate PV warnings

LVM displays the duplicate PV warnings in either of the following cases:

- The two devices displayed in the output are both single paths to the same device.
- The two devices displayed in the output are both multipath maps.

**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 GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: 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 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 GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: using /dev/mapper/mpatha not /dev/mapper/mpathc

Found duplicate PV GDjTZf7Y03GJHjteqOwrye2dcSCjdaUj: 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.

**18.7.3. 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/.*" ]
```

**18.7.4. 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|.*" ]
  ```

### 18.7.5. 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
   ```

### 18.7.6. Additional resources
- Chapter 15, Controlling LVM device scanning