VERITAS™

VERITAS Storage Foundation™ 4.1 Intelligent Storage Provisioning

Administrator's Guide

Solaris x64 Platform Edition

Maintenance Pack 1

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VERITAS Software Corporation
350 Ellis Street
Mountain View, CA 94043
USA
Phone 650–527–8000 Fax 650–527–2908
www.veritas.com

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Preface

The *VERITAS Storage Foundation Intelligent Storage Provisioning Administrator's Guide* provides information on how to use the VERITAS Intelligent Storage Provisioning (ISP) feature of the VERITAS Storage Foundation™ software.

The purpose of this guide is to introduce the concepts of ISP, and to describe how ISP enhances the usability of VERITAS Volume Manager (VxVM) by making the best use of the available storage, and by preserving the reliability and performance capabilities of application volumes throughout their lifetime. This guide also includes descriptions of the standard sets of storage pool, template and capability definitions that are provided for use with ISP.

This guide is intended for system administrators responsible for installing, configuring, and maintaining systems under the control of VxVM.

This guide assumes that you have a:

- Basic knowledge of the Solaris operating system.
- Basic understanding of Solaris system administration.
- Basic understanding of storage management using VxVM.

Note Most VERITAS Volume Manager commands require superuser or other appropriate privileges.

How This Guide Is Organized

This guide is organized as follows:

Refer to the *Release Notes* for information about the other documentation that is provided with this product.

Conventions

Convention	Usage	Example
`monospace`	Used for path names, commands, output, directory and file names, functions, and parameters.	Read tunables from the `/etc/vx/tunefstab` file. See the `ls`(1) manual page for more information.
`monospace` (**`bold`**)	Indicates user input.	# **`ls pubs`** C:\> **`dir pubs`**
italic	Identifies book titles, new terms, emphasized text, and variables replaced with a name or value.	See the *User's Guide* for details. The variable *system_name* indicates the system on which to enter the command.
bold	Depicts GUI objects, such as fields, list boxes, menu selections, etc. Also depicts GUI commands.	Enter your password in the **Password** field. Press **Return.**
blue text	Indicates hypertext links.	See "Getting Help" on page xviii.
#	Unix superuser prompt (all shells).	# **`cp /pubs/4.0/user_book /release_mgnt/4.0/archive`**

C:\>	Windows user prompt.	C:\> **`copy \pubs\4.0\user_book`**
		`c:\release_mgnt\4.0\archive`

Getting Help

For technical assistance, visit http://support.veritas.com and select phone or email support. This site also provides access to resources such as TechNotes, product alerts, software downloads, hardware compatibility lists, and the VERITAS customer email notification service. Use the Knowledge Base Search feature to access additional product information, including current and past releases of product documentation.

Diagnostic tools are also available to assist in troubleshooting problems associated with the product. These tools are available on disc or can be downloaded from the VERITAS FTP site. See the `README.VRTSspt` file in the `/support` directory for details.

For license information, software updates and sales contacts, visit https://my.veritas.com/productcenter/ContactVeritas.jsp. For information on purchasing product documentation, visit http://webstore.veritas.com.

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Understanding ISP 1

VERITAS Intelligent Storage Provisioning (ISP) allows you to organize and manage your physical storage by creating virtual storage devices, *application volumes*. You can use application volumes in the same way as traditional volumes in VERITAS Volume Manager (VxVM).

ISP creates volumes from available storage with the required capabilities that you specify. To achieve this, it selects storage by consulting the externally defined rule base for creating volumes, and compares this with the properties of the storage that is available.

ISP provides the following main functionality:

- Creation and removal of application volumes.
- Organizing storage by grouping into storage pools.
- Resizing a volume while it is online.
- Moving or evacuating subdisks of a volume.
- Adding mirrors and columns to a volume while it is online.
- Removing mirrors and columns from a volume while it is online.
- Relocating a subdisk of a volume while it is online.
- Changing the capabilities of a volume while it is online.
- Creating volume snapshots using hardware.
- Reallocation of storage to preserve the capabilities of a volume.

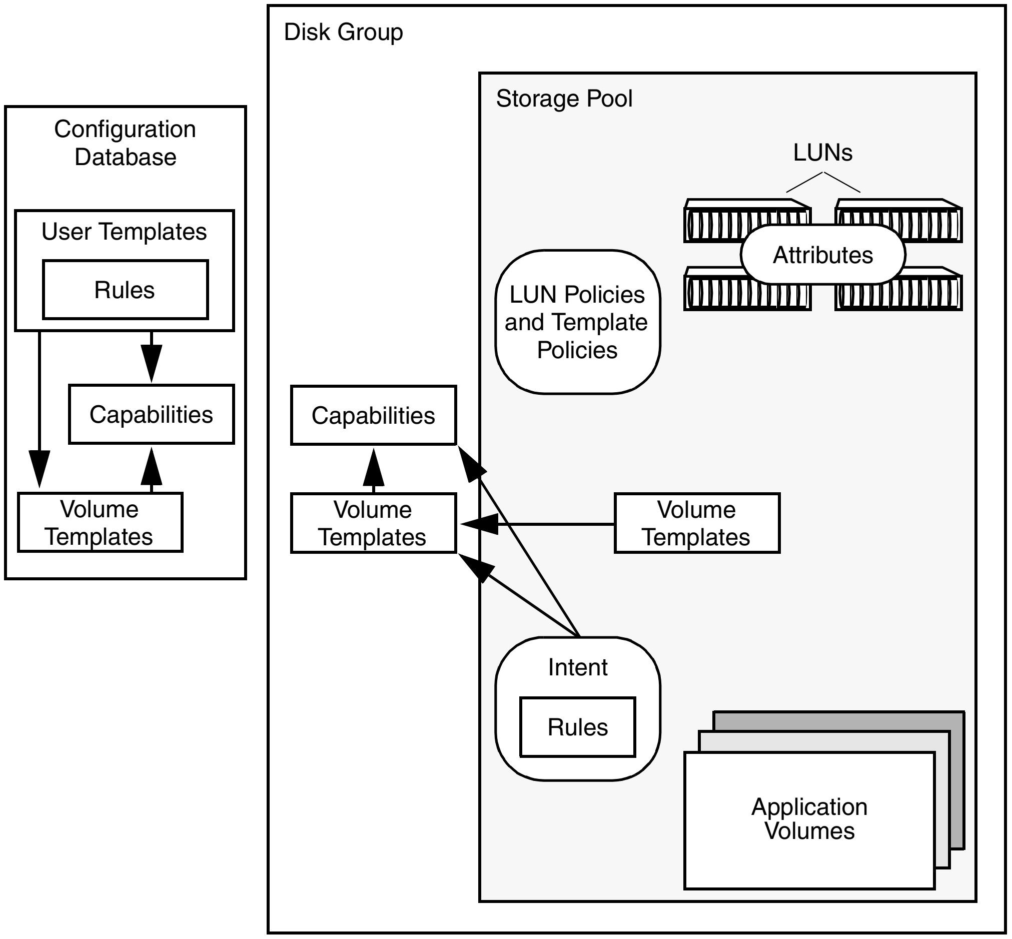
ISP is capable of understanding Storage Area Network (SAN) topology and of efficiently using the available intelligent storage. ISP interacts with other VERITAS components, where these are available, such as the VERITAS Array Integration Layer (VAIL), to take appropriate actions when configuring intelligent storage in a SAN environment.

This book describes the command-line interface to ISP, and the language that is used for writing new rules, capabilities and templates. For a description of the graphical interface to ISP that is provided by the VERITAS Enterprise Administrator (VEA), see the *VERITAS Enterprise Administrator Getting Started* guide and VEA online help.

ISP Concepts

The figure, "Relationship Between Concepts in ISP," illustrates the dependencies between the various ISP components.

Relationship Between Concepts in ISP



These concepts are defined in the following sections.

Disk Group

A disk group is a named collection of disks that share a common configuration. Volumes and other VxVM objects must be created within a disk group, and are restricted to using disks from within that disk group.

LUN

A LUN, or *logical unit*, can either correspond to a single physical disk, or to a collection of disks that are exported as a single logical entity, or virtual disk, by a device driver or by an intelligent disk array's hardware. VxVM and other VERITAS software modules may be capable of automatically discovering the special characteristics of LUNs, or you can use the Annotation Service to define new storage attributes.

Attribute

A storage attribute allows the properties of a LUN to be defined in an arbitrary conceptual space. For example, attributes can describe properties such as:

- Disk access name
- Disk media name
- Manufacturer
- Model type
- Physical location, such as rack number, frame number, floor, building, or site
- Hardware RAID configuration
- Failover properties
- Performance properties

Note You can use the *annotation service*, provided in the VEA graphical user interface, to create and delete storage attributes.

Attributes may be used to capture information about special features that storage possesses, such as:

- Hardware-supported cloning, such as EMC Business Continuity Volumes (BCV)
- Hardware-supported replication, such as the EMC Symmetrix Remote Data Facility (SRDF)
- Hardware redundancy, such as mirrored parity, and caching

It should only be necessary to enter such information manually if VxVM cannot discover it automatically. An example of a user-defined attribute is physical location.

Note Attribute names and their string values are case sensitive. You can use the `vxvoladm listattrs` command to discover the correct spelling of LUN attribute names.

Storage Pool

A data storage pool is defined within a disk group in VxVM for use by ISP. A storage pool is a policy-based container for LUNs and volumes. This means that the templates, capabilities and policies that are associated with a storage pool define how storage is organized within the pool.

For convenience, storage pool definitions are provided that include a number of associated templates that can be used for different purposes. See "Storage Pools" on page 163 for details of the storage pool definitions that are provided.

Two types of storage pool are defined: *data pools* and *clone pools*. These are described in the following sections.

Data Pool

The first storage pool that is created within a disk group. All other storage pools that are subsequently created within a disk group are clone pools.

Note Only one data pool can be created within a disk group.

It should not usually be necessary to move a data pool to another disk group. However, if this is required, only an entire data pool can be moved. An individual application volume within a data pool cannot be moved. If you want to move a data pool into a different disk group, you must ensure that the data pool contains only those objects that you require.

Clone Pool

A storage pool that contains one or more full-sized instant volume snapshot replicas of volumes within a data pool. (A volume snapshot is an image of a volume's contents at the moment in time that the snapshot was taken. See the *VERITAS Volume Manager Administrator's Guide* for more information about volume snapshots.)

Note Only full-sized and space-optimized instant snapshots are supported for use with ISP. Third-mirror break-off volume snapshots are not supported.

A clone pool can be moved into another disk group, but an individual snapshot within it cannot. If you want to move a clone pool into a different disk group, you must ensure that the clone pool contains only those snapshots that you require.

Storage Pool Set

A storage pool set is a bundled definition of the capabilities of a data pool and its clone pools. For convenience, you can use a storage pool set definition to define both pools in a single operation. See "Storage Pool Sets" on page 167 for details of the storage pool sets that are provided.

Policy

A storage pool's policies define how it behaves when more storage is required, and when you try to create volumes whose capabilities are not permitted by the current templates. The two policies that are associated with a storage pool are:

`AutoGrow`	Defines how a storage pool uses LUNs. This policy can take the following *level* values:	
	`pool`	Use storage that has been manually assigned to the storage pool.
	`diskgroup`	Use storage that has been assigned to the disk group.
`SelfSufficient`	Defines how a storage pool uses templates. This policy can take the following *level* values:	
	`pool`	Use templates that have been manually assigned to the storage pool.
	`diskgroup`	Use templates that have been manually assigned to the disk group.
	`host`	Use templates that have been installed in the ISP repository on this host.

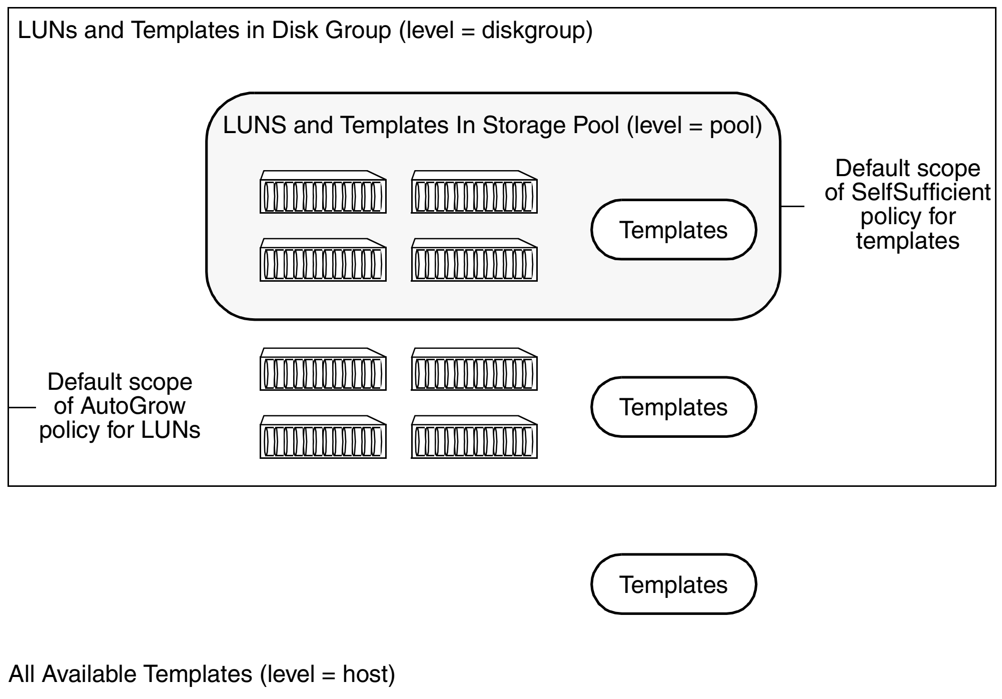
The values of these two policies can be combined to suit how the storage pool is to be used.

The policy levels that are associated with a storage pool control how it manages its templates and LUNs:

- The default level of the `AutoGrow` policy is `diskgroup`. This allows LUNs that are associated with the storage pool and its disk group to be used for allocating storage to volumes.
- The default level of the `SelfSufficient` policy is `pool`. This allows only templates that are associated with the storage pool to be used for allocating storage to volumes. The storage pool can contain only volumes with the reliability and performance capabilities that are supported by these templates.

The scope of the levels that can be configured as policy values for a storage pool is illustrated in "Scope Levels for Storage Pool Policies."

Scope Levels for Storage Pool Policies


LUNs and Templates in Disk Group (level = diskgroup)
LUNS and Templates In Storage Pool (level = pool)
Templates
Default scope of SelfSufficient policy for templates
Default scope of AutoGrow policy for LUNs
Templates
Templates
All Available Templates (level = host)

Note LUNs in other storage pools or disk groups or outside any disk group are not immediately available for aggregating into another storage pool or disk group.

Capability

A capability is a feature that is provided by a volume. For example, a volume may exhibit capabilities such as performance and reliability to various degrees. Each type of capability is defined as a set of rules.

The following table shows some simple examples of capabilities that might be supported by a storage pool:

Capability	**Adjustable Parameters**	**Description**
`DataMirroring`	`nmirs` — number of mirrors (plexes)	Provides reliability by using mirrored plexes.
`Raid5Capability`	`ncols` — minimum number of columns `nmaxcols` — maximum number of columns	Provides reliability by using RAID-5 parity.
`Raid5LogMirroring`	`nlogs` — number of log copies	Provides reliability for RAID-5 logs by mirroring.
`Striping`	`ncols` — minimum number of columns `nmaxcols` — maximum number of columns	Provides performance by striping across columns.

Capabilities have variable parameters that you can specify, such as the number of mirrors or columns. You can adjust the values of these parameters to tune the characteristics of a volume. If you do not specify parameter values, default values are used.

See "Capabilities" on page 157 for details of the capabilities that are provided.

How capabilities can provide performance and reliability is described in the following sections.

Performance

Performance specifies the capabilities of a volume based on factors such as number of columns in striped volumes, stripe unit size, preferred characteristics of storage such as using prefabricated disks that are configured in hardware.

Reliability

Reliability specifies the level of redundancy that is required from a volume as a capability. Very reliable volumes have a high degree of redundancy. For example, a very reliable volume could be configured as a software mirrored volume built upon underlying prefabricated RAID-5 capable LUNs that are configured in the enclosure hardware. A medium-level redundant volume could be a simple 2-way mirror or RAID-5 volume configured either in software or on a suitable LUN within a single enclosure.

Rule

A rule is a statement written in the VERITAS ISP language that specifies how a volume is to be created. A rule can define selection of storage or layout of storage. Rules are usually gathered together as templates for creating volumes, rather than being specified individually.

Examples of storage selection and storage layout rules are described in the following sections.

Storage Selection Rules

Storage selection rules specify what storage can be used to create volumes. The following are examples of storage selection rules:

Rule	Description
`affinity`	Attempts to select storage with shared attributes.
`confineto`	Restricts selection of storage by specifying attributes.
`exclude`	Prevents storage with certain attributes from being selected.
`select`	Specifies the storage to be used.
`separateby`	Defines fault domains for objects such as plexes.
`strong separateby`	Does not allow objects in different fault domains to share attributes.

For example, the following rule specifies that any LUNs may be selected from the named enclosures:

```
select "Enclosure"="ENC01", "Enclosure"="ENC02"
```

The next rule specifies that LUNs may be selected from the set of Hitachi disks that are located in `Room1`:

```
confineto "VendorName"="HITACHI", "Room"="Room1"
```

This example of a separation rule specifies that enclosures are to be treated as individual fault domains:

```
separateby "Enclosure"
```

Storage Layout Rules

Storage layout rules specify how storage is used to create volumes. The following are examples of storage layout rules:

Rule	Description
`log`	Specifies the type of log and its degree of redundancy.
`mirror`	Specifies how many mirrors a volume should have.
`parity`	Specifies whether redundancy is provided by using parity.
`stripe`	Specifies how many columns a volume should have.
`striped`	Specifies whether a volume is striped.

For example, the following rule specifies that a volume can be created using parity to provide data redundancy:

```
parity true
```

Volume Template

A volume template (or template for short) is a meaningful collection of rules that provide a capability. A template can specify one or more capabilities that a volume created using the template may have, and consists of a collection of storage selection and layout rules. For example, a template may allow you to create a volume that is able to tolerate the failure of a certain number of controllers, or that has a certain number of copies of the volume data.

When creating a volume, it is easier to specify its desired capabilities than to specify the precise layout of the volume on the available storage. ISP selects the appropriate templates and uses them to create a volume with the desired capabilities.

If you specify parameter values for a volume's capabilities, the rules that are defined within the chosen template use these values when selecting and laying out storage. If not specified, the default parameter values for a volume's capabilities are assumed by the template.

The following table shows some simple examples of templates and the capabilities that they might provide:

Template	Provides Capabilities	Adjustable Parameters for the Capability
`DataMirroring`	`DataMirroring`	`nmirs` — number of mirrors (plexes)
`Raid5Volume`	`Raid5Capability`, `Raid5LogMirroring`	`ncols` — minimum number of columns `nlogs` — number of log copies `nmaxcols` — maximum number of columns
`Striping`	`Striping`	`ncols` — minimum number of columns `nmaxcols` — maximum number of columns

See "Volume Templates" on page 153 for details of the templates that are provided.

Template Sets

A template set consists of related capabilities and templates that have been collected together for convenience. Associating a template set with a storage pool is equivalent to associating each of its member templates separately with the storage pool. See "Template Sets" on page 148 for details of the template sets that are provided.

User Template

A user template (or user-defined template) defines an arbitrary collection of capabilities, templates and rules to which you want volumes of a certain type to conform. For example, you might want all volumes that you create to store database tables to share the same reliability and performance capabilities, and also that they only be allocated from a restricted set of storage.

It is useful to create user templates if you regularly create volumes with similar capabilities.

The following table shows some examples of user templates that might be created:

User Template	Description
`OracleTable`	Provides a reliable high-performance volume that is suitable for use by a database table.
`OracleIndex`	Provides an extremely high-performance volume that is suitable for a database index.

As for templates, each user template can have a number of adjustable parameters that you can use for tuning the characteristics of the created volumes.

Note A user template is not directly associated with a storage pool. Its association is implied by its reference to capabilities and templates.

Application Volume

An application volume is created by ISP, and then exported for use by an application such as a database or file system. It is identical to a traditional volume that you would create using `vxassist` and other VxVM commands, except that you can only administer it by using the `vxvoladm` command, or via the interface to ISP that is provided by the VEA. Similarly, traditional volumes cannot be administered by using the `vxvoladm` command, or via the VEA interface to ISP.

Note In this book, the term *volume* always means *application volume* unless it is specified that a traditional VxVM volume is meant.

Intent

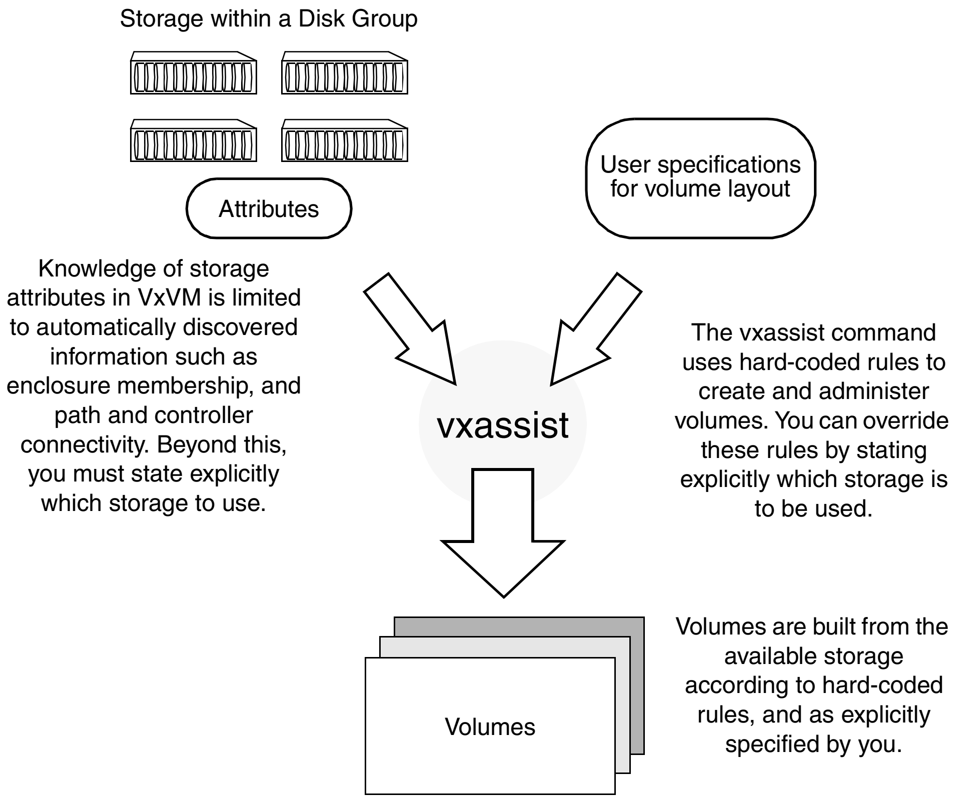
The intent of a volume is a conceptualization of its purpose as defined by its characteristics and implemented by a template. ISP attempts to preserve the intent of a volume whenever the volume is reconfigured, resized, or relocated. Intent preservation automatically conserves capabilities such as reliability and performance, and observes additional rules such as allocating storage based on confinement and exclusion specifications.

The Benefits of ISP

When creating a volume in VERITAS Volume Manager in previous releases, you could specify the disk storage on which to lay out its various parts, subdisks, plexes, and so on. In specifying the storage to be used, you had to take into account the tolerance of a volume to failure of any component of the storage infrastructure, and how the specified layout affected I/O performance and reliability of service. For small installations with a few tens of disks in relatively low-specification arrays, you could either specify the storage layout manually to commands such as `vxassist`, or rely on `vxassist` to choose appropriate storage based on general layout specification, such as "mirror across controllers" and "mirror across enclosures," and using the set of heuristic rules that are hard-coded within `vxassist`.

The traditional model for allocating storage to volumes is shown in "Traditional Model for Creating and Administering Volumes in VERITAS Volume Manager" on page 13. This illustrates that, although some storage attributes are known to VxVM, you must do most of the work in deciding how to lay out the storage if you are to create a volume with the desired performance, reliability and fault tolerance.

Traditional Model for Creating and Administering Volumes in VERITAS Volume Manager

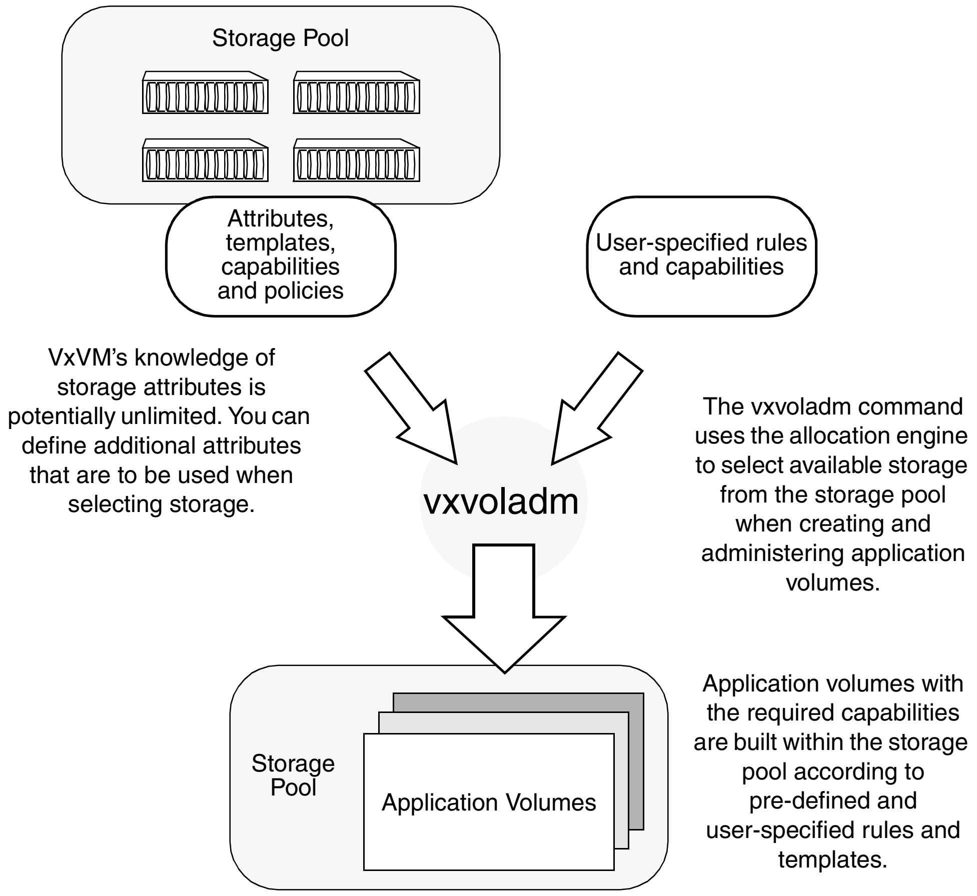

Storage within a Disk Group
Attributes
User specifications for volume layout
Knowledge of storage attributes in VxVM is limited to automatically discovered information such as enclosure membership, and path and controller connectivity. Beyond this, you must state explicitly which storage to use.
vxassist
The vxassist command uses hard-coded rules to create and administer volumes. You can override these rules by stating explicitly which storage is to be used.
Volumes
Volumes are built from the available storage according to hard-coded rules, and as explicitly specified by you.

When intelligent disk arrays are used, many sophisticated features, such as RAID capabilities, hardware snapshot facilities, and remote replication, are provided by logical unit storage devices, LUNs, that are exported by the disk array. Such devices may or may not have ways of making their attributes known to VxVM. In any case, you may be presented with hundreds or thousands of LUNs connected over a SAN.

Allocating storage to volumes when faced with a potentially large number of devices with widely varying and possibly hidden properties is a daunting task to perform manually. ISP aids you in managing large sets of storage by providing an allocation engine that chooses which storage to use based on the capabilities that you specify for the volumes to be created.

"How ISP Enhances Volume Management" on page 14 illustrates how ISP improves on the traditional model for creating volumes. The main differences are that the set of information about the available storage is potentially unlimited, and the set of rules that the allocation engine uses to choose storage is defined externally to commands such as `vxvoladm`.

How ISP Enhances Volume Management


Storage Pool
Attributes, templates, capabilities and policies
User-specified rules and capabilities
VxVM's knowledge of storage attributes is potentially unlimited. You can define additional attributes that are to be used when selecting storage.
vxvoladm
The vxvoladm command uses the allocation engine to select available storage from the storage pool when creating and administering application volumes.
Storage Pool
Application Volumes
Application volumes with the required capabilities are built within the storage pool according to pre-defined and user-specified rules and templates.

Summary of the Benefits of Using ISP

The following list summarizes the main benefits that VERITAS ISP provides over the existing storage allocation features in `vxassist`:

- Storage is automatically allocated based on abstract requirements such as the desired capabilities of a volume.
- Prefabricated capabilities that are provided by vendor-specific features of intelligent storage arrays can be encoded as storage attributes, and used to allocate storage.
- Volumes can be created or grown in batch mode safe in the knowledge that ISP will balance the requirements of all volumes.

- All ISP operations preserve the original intent of the volumes. There is no possibility that operations such as grow, evacuate, add mirror, or add column can accidentally degrade the reliability or performance capabilities of a volume.
- ISP is SAN-aware and understands SAN attributes. It is also capable of using VAIL to learn the capabilities of LUNs.
- The annotation service allows you to define attributes for LUNs that lie outside their discovered hardware characteristics, and to assign values to these attributes.

Limitations of ISP

The following features of `vxassist` are not currently supported in ISP:

- The `vxassist` utility includes a number of hard-coded rules that it uses when selecting storage. For example, `vxassist` may configure objects on separate controllers without being instructed to do so. ISP requires that the selection of storage is made explicit through rules, capabilities and templates.
- ISP supports space-optimized instant snapshots and full-sized instant snapshots that are created on pre-prepared volumes. It does not support third-mirror break-off snapshots.
- Disk group split and join is supported at the level of storage pools. A snapshot of an application volume should be created within a clone pool if it is to be moved between disk groups.
- Templates are not provided in the base product to support the special features of EMC Symmetrix arrays.

Administration Roles in ISP

The administration of ISP can seem overwhelming when compared with the traditional administration model in VERITAS Volume Manager. To simplify matters, it is useful to think in terms of three levels of administration based on level of knowledge of ISP, and frequency of application of this knowledge:

- Basic Administration Tasks
- Advanced Administration Tasks
- Expert Administration Tasks

Basic administration tasks are performed most often and require the least knowledge of ISP to perform. Expert storage administration tasks are performed least often and require the most knowledge of ISP to perform.

Basic Administration Tasks

Basic administration tasks include creating storage pools, and creating and administering volumes. This includes performing tasks such as adding or removing mirrors or columns from volumes, and resizing volumes.

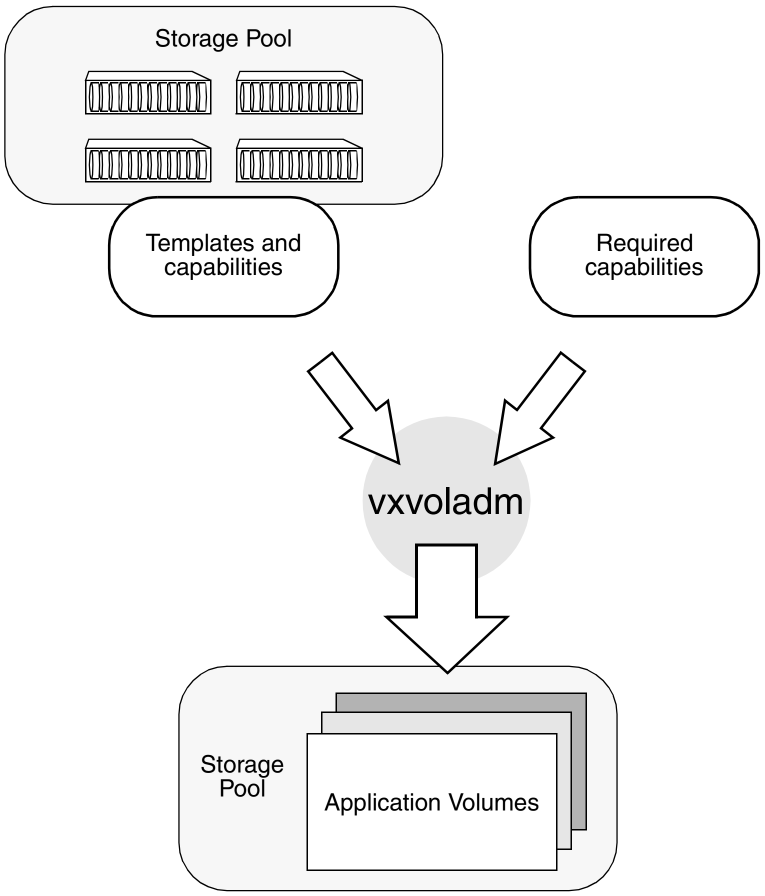
The system administrator's role requires the following knowledge of ISP:

- Familiarity with the meaning of the terms disk group, storage pool, template, user template, application volume, and capabilities such as reliability, performance and fault tolerance.
- What templates and user templates are available for use in creating volumes with the required capabilities.
- What templates and user templates are associated with the disk groups in which you will create volumes.
- How to use the VEA or the `vxvoladm` and `vxtemplate` commands to perform your tasks.

As a system administrator, you can use either the VEA or the `vxvoladm` and `vxtemplate` utilities to perform your tasks. The VEA graphical interface is most suitable for day-to-day administration. The `vxvoladm` utility is primarily intended for use in administration scripts. The `vxtemplate` utility allows you to find out which templates are associated with disk groups and with storage pools.

The use of `vxvoladm` to create application volumes is illustrated in "Creation of Application Volumes."

Creation of Application Volumes



System administration tasks are described in the following chapters:

- "Creating Application Volumes" on page 43
- "Administering Application Volumes" on page 55
- "Administering Instant Snapshots" on page 71

Advanced Administration Tasks

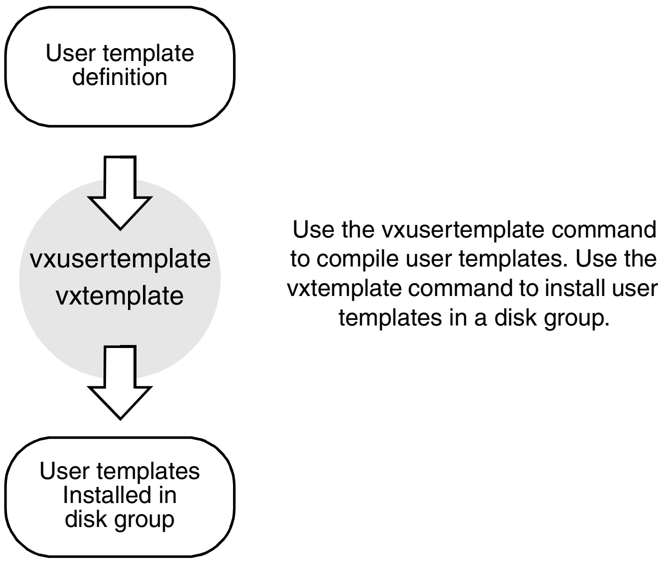
Advanced administration tasks include administering storage pools and user templates, and creating volumes with additionally specified rules.

The system administrator's role requires the following knowledge of ISP:

- Knowledge of basic administration tasks, see "Basic Administration Tasks" on page 16.
- Familiarity with the meaning of the terms LUN, attribute, policy, intent, and rules such as those for confining or excluding how storage is allocated to new volumes.
- How to create or modify user templates, and then associate these with disk groups and storage pools.
- How to use the VEA or the command-line utilities to perform your tasks.

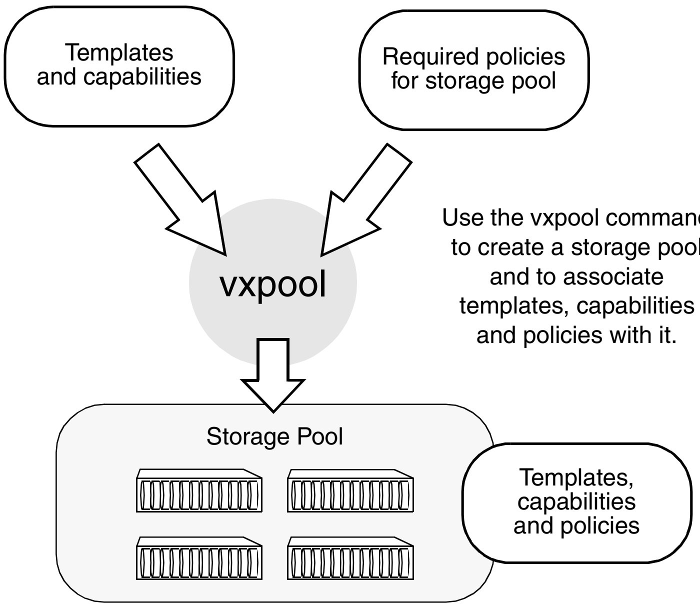
As a storage administrator, you can use either the VEA or command-line utilities to perform your tasks. The VEA interface is most suitable for day-to-day administration. The command-line utilities are primarily intended for use in administration scripts, but can also be used to compile and install user templates as illustrated in "Creation of User Templates."

Creation of User Templates


User template definition
vxusertemplate
vxtemplate
Use the vxusertemplate command to compile user templates. Use the vxtemplate command to install user templates in a disk group.
User templates Installed in disk group

"Creation of Storage Pools" illustrates that the `vxpool` command is used to create storage pools with associated policies, templates and capabilities.

Creation of Storage Pools


Templates and capabilities
Required policies for storage pool
vxpool
Use the vxpool command to create a storage pool and to associate templates, capabilities and policies with it.
Storage Pool
Templates, capabilities and policies

System administration tasks are described in the following chapters:

- "Creating and Administering Storage Pools" on page 31
- "Creating and Modifying User Templates" on page 99

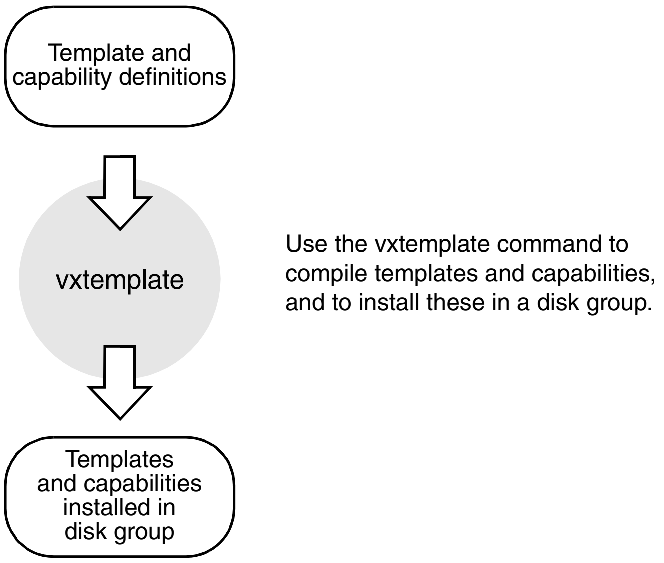
Expert Administration Tasks

Expert administration tasks include creating new attributes to describe storage features, and designing and creating new templates and capabilities.

The storage administrator's role requires the following knowledge of ISP:

- Knowledge of basic and advanced administration tasks, see "Basic Administration Tasks" on page 16 and "Advanced Administration Tasks" on page 18.
- Familiarity with the ISP rule specification language, and how to use it to write rules, capabilities and templates.
- How to use the VEA or the command-line utilities to perform your tasks. You can use any suitable text editor to create template definition files. The command-line utilities are primarily intended for use in administration scripts, but can also be used to compile and install templates and capabilities as illustrated in "Creating Templates and Capabilities."

Creating Templates and Capabilities


Template and capability definitions
vxtemplate
Templates and capabilities installed in disk group

Use the vxtemplate command to compile templates and capabilities, and to install these in a disk group.

Advanced storage administration tasks are described in the following chapters:

- "Administering Volume Templates and Other Configuration Elements" on page 93
- "Using Capabilities, Templates and Rules" on page 105
- "ISP Language Definition" on page 131

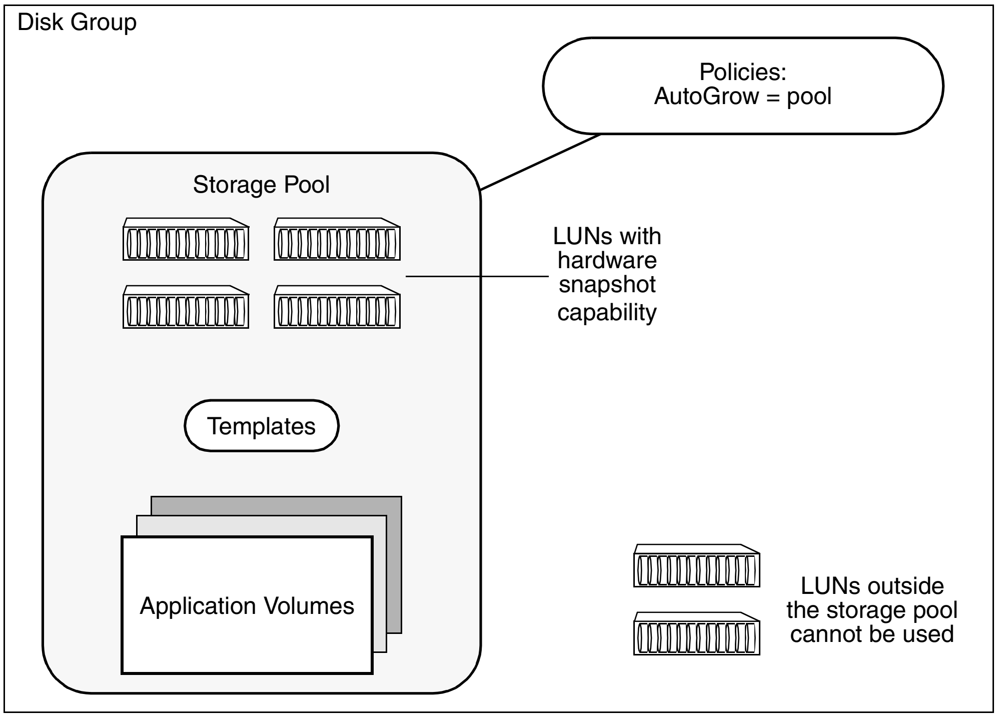
Sample ISP Deployments

This section contains high-level examples of how you can configure volume creation using ISP.

Using Storage Pool Policies

As described in "Policy" on page 5, a storage pool's policies affect how it allocates LUNs to create new volumes, and how it uses templates. By selecting which templates and LUNs are associated with a storage pool, and setting appropriate policies on the storage pool, you can control how storage is allocated to volumes. For example, a storage pool might be composed entirely of LUNs that have a hardware snapshot capability (for example, EMC Business Continuity Volumes). Setting the `AutoGrow` policy to `pool` ensures that the entire storage pool remains snapshot-capable as illustrated in "Effect of Setting the Value of the AutoGrow Policy to pool."

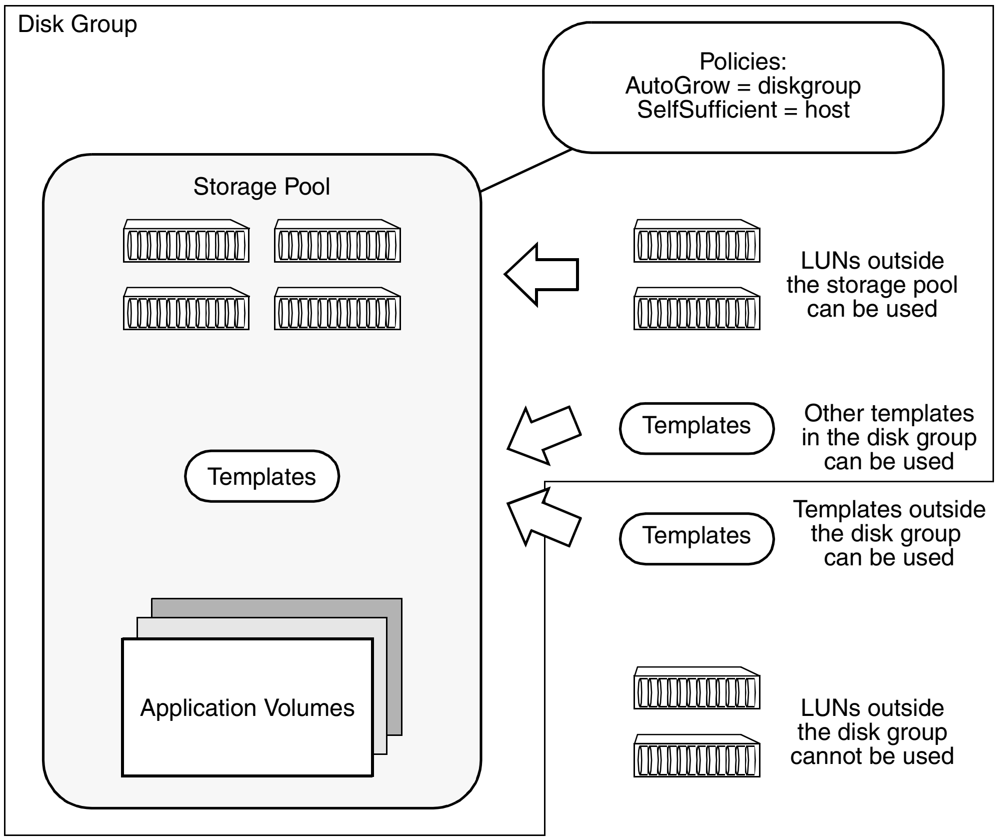
Effect of Setting the Value of the AutoGrow Policy to pool


Disk Group
Policies:
AutoGrow = pool
Storage Pool
LUNs with hardware snapshot capability
Templates
Application Volumes
LUNs outside the storage pool cannot be used

If the `AutoGrow` policy level were to remain set to the default value of `diskgroup`, this would allow the ISP to aggregate LUNs from the disk group.

"Effect of Setting Non-Default Storage Pool Policies" illustrates how setting the `AutoGrow` policy to `diskgroup` allows LUNs from the same disk group that are outside the storage pool to be used, and setting the `SelfSufficient` policy to `host` allows templates that provide the required capabilities to be imported from outside the storage pool or disk group.

Effect of Setting Non-Default Storage Pool Policies

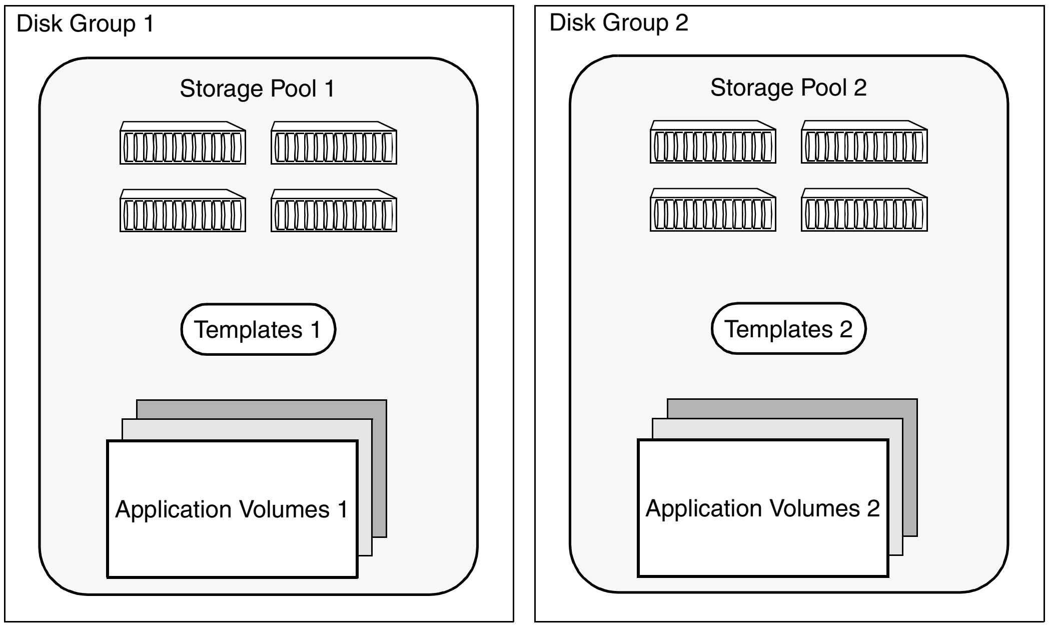

Disk Group
Policies:
AutoGrow = diskgroup
SelfSufficient = host
Storage Pool
Templates
Application Volumes
LUNs outside the storage pool can be used
Templates
Other templates in the disk group can be used
Templates
Templates outside the disk group can be used
LUNs outside the disk group cannot be used

Note Setting the storage pool policies away from their default values may not be desirable if you want to maintain close control over how a storage pool is used.

Arranging Storage by Volume Usage

The simplest way to arrange storage so that its use is restricted to certain applications is to divide it between storage pools as shown in "Arranging Storage by Volume Usage." This requires that each storage pool is configured in a separate disk group. Each storage pool can have its own set of policies and templates that are tailored to the requirements of the volumes that are created from its LUNs.

Arranging Storage by Volume Usage



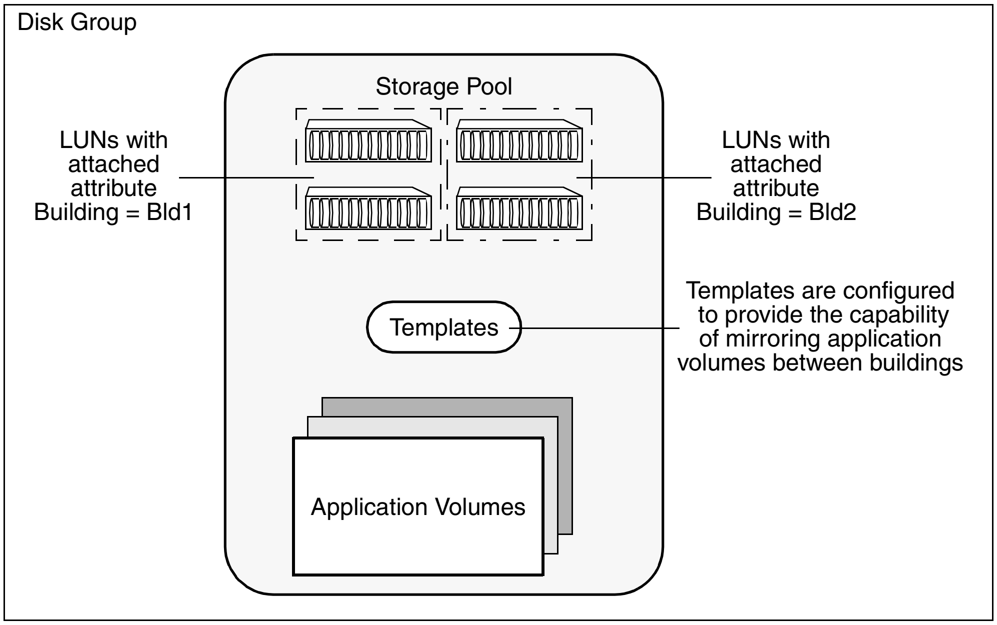
Although this is the simplest way of arranging storage and is expected to be the most common, it may not provide sufficient flexibility for some installations. See "Arranging Storage by Attributes" on page 24 for an example of using storage attributes for controlling how storage is allocated.

Arranging Storage by Attributes

You can use storage attributes to control how ISP assigns storage to application volumes. For example, you can use confinement rules to restrict some volumes to a subset of LUNs which share common attributes, such as caching to enhance I/O performance, or hardware RAID to provide redundancy and/or enhance performance.

As described in "Policy" on page 5, not all attributes of LUNs are capable of being discovered automatically. You can use the annotation service to manually attach such attributes to storage. An example of using attached attributes is shown in "Example Usage of Attached Attributes," where the templates can use the value of the `Building` attribute to provide the availability capability of mirroring volumes between different locations at a site.

Example Usage of Attached Attributes


Disk Group
Storage Pool
LUNs with attached attribute Building = Bld1
LUNs with attached attribute Building = Bld2
Templates
Templates are configured to provide the capability of mirroring application volumes between buildings
Application Volumes

Alternatively, you could specify appropriate separation rules to instruct ISP to mirror volumes between buildings.

Another example of using attached attributes would be to tag certain LUNs within a storage pool as having the best performance. You could then use confinement rules to ensure that certain volumes are only configured from this storage, while the remaining storage is used for other volumes with less critical performance requirements.

Frequently Asked Questions About ISP

- *What is the relationship between a storage pool and a volume template?*

  Storage pools contain disks, VxVM objects such as volumes, and a set of volume templates. A storage pool is defined by the volume templates that it contains. The ISP Configuration Database contains a number of storage pool definitions that you can use to create a storage pool object in VxVM. Each definition contains a list of volume templates and the default policy settings for the pool definition. When you create a storage pool object in a disk group from a storage pool definition, these volume templates and policies also get installed.

- *When do I need to specify a template set?*

  A storage pool contains volume templates that define its characteristics. A template set is simply a collection of related volume templates that you can associate with a storage pool.

- *When do I need to specify a storage pool set?*

  A disk group that you want to use with ISP must be configured to contain one data storage pool, and optionally one or more clone storage pools. You can use a storage pool set definition to organize a disk group so that it contains data and clone storage pools with well-defined characteristics.

- *If I create a storage pool using a storage pool definition, can I later create a volume in that pool using a volume template other than those that are associated with the pool?*

  The answer can be illustrated by an example. Suppose you create a storage pool using the `mirrored_volumes` pool definition. This installs volume templates that allow you to create mirrored volumes and volumes with similar characteristics in the pool. If you attempted to create a striped volume in the pool, the resulting volume is mirrored as well as striped. However, you are not constrained from creating volumes with other characteristics. You can use rules to bypass restrictions that are imposed by higher-level abstractions like volume templates and capabilities.

  Bear in mind that creating a storage pool from a storage pool definition does not uniquely determine the capabilities of volumes that you create in the pool. Only when you create a volume can you specify its capabilities and ensure consistency between the volumes in a pool.

- *What does "prefabricated" mean as used in volume templates?*

  The term *prefabricated* implies that the characteristics of a volume are implemented using hardware rather than software. For example, `PrefabricatedRaid5` implies the use of RAID-5 LUNs that have been set up in an array's hardware, rather than being implemented as a VxVM RAID-5 volume.

◆ *Can I use both hardware and software RAID volumes in a storage pool?*

  A storage pool is usually configured either for prefabricated RAID devices or for VxVM volumes that are created in software. This provides consistency in performance and failure tolerance within the pool. If you add both hardware and software RAID templates to a pool, ISP allocates templates that are appropriate to the capabilities of the volumes that you specify.

◆ *How does ISP discover LUN hardware characteristics?*

  ISP relies on the VERITAS Array Integration Layer (VAIL) to provide detailed information on LUN characteristics via array-specific modules.

◆ *How do I restrict allocation to storage from certain vendors, for example EMC BCV or Hitachi?*

  By default, ISP use LUNs with similar characteristics for allocating storage. If insufficient storage is available, it relaxes this constraint. You can make the constraint mandatory by specifying the capability `ArrayProductId` when creating a volume. This forces ISP to allocate storage on LUNS that share the same product identifier. Alternatively, you can use the capability `ConfineToSimilarStorage`. This makes ISP use LUNs from the same vendor, but allows the product identifiers of these LUNs to differ.

◆ *When I create a volume, ISP uses space on the same disks unless I choose other disks from the storage pool manually. Why doesn't ISP automatically spread the volumes across the other disks in the storage pool to enhance I/O performance?*

  ISP is tuned to use as few disks as possible. In any case, I/O performance depends on many factors: the way storage is connected to the system, the inherent capabilities of the storage, how volumes are configured and how they share storage, the type of I/O requests made by applications, and the amount of I/O from/to each volume. For example, allocating two volumes to a single disk array that has a large cache would probably provide better overall I/O performance than placing one volume on the disk array and the other on a JBOD. If necessary, you can configure smaller storage pools in separate disk groups to restrict the allocation of storage. Alternatively, you can explicitly specify the storage that can or cannot be allocated to a volume.

Examples of Using ISP from the Command Line

This section provides examples of using ISP from the command line and provides pointers to where more information can be found. You can also find summaries of the usage of commonly used commands in “Command Summary” on page 173. Further examples may be found in “Examples of Using ISP” on page 177 and in the manual page for each command.

Creating a Data Storage Pool

Assuming that you have created a disk group, `mydg`, that contains several disks that you have initialized for use with VxVM, the following command creates a data storage pool, `mypool`, containing several disks, and which supports the creation of striped-mirror volumes:

```
# vxpool -g mydg create mypool \
 dm=mydg01,mydg02,mydg03,mydg04,mydg04,mydg06 \
 pooldefinition=stripe_mirror_volumes
```

For more information, see “Creating a Storage Pool” on page 34.

Adding Disks to a Storage Pool

You can use the `vxpool adddisk` command to add initialized disks to a storage pool. For example, this command adds two disks to the storage pool, `mypool`:

```
# vxpool -g mydg adddisk mypool dm=mydg07,mydg08
```

For more information, see “Adding Disks to a Storage Pool” on page 37.

Creating an Application Volume

The following command creates a striped-mirror volume with three columns and two mirrors in the data storage pool, `mypool`, by specifying the capability `DataStripeMirror` together with the appropriate parameters:

```
# vxvoladm -g mydg -p mypool make stmrvol 2g \
 capability='DataStripeMirror(ncols=3,nmirs=2)' init=active
```

The `init=active` attribute makes the volume immediately available for use without performing any synchronization.

Having created the application volume, stmrvol, you can use the following command to prepare it for use with volume snapshots:

```
# vxvoladm -g mydg -p mypool add log stmrvol nlog=2 logtype=dco
```

This command associates a data change object (DCO) and DCO volume with the volume. The attribute nlog is used to specify that the DCO volume has the same redundancy as the original volume. Alternatively, you can use the vxsnap prepare command to set up the volume for snapshots:

```
# vxsnap -g mydg prepare stmrvol ndcomirs=2
```

For more information, see "Creating Application Volumes" on page 43 and "Creating Instant Snapshots" on page 79.

Resizing an Application Volume

If the application volume, stmrvol, that you have just created is not large enough for your needs, you can increase its size using this command:

```
# vxvoladm -g mydg -p mypool growto stmrvol 4g
```

Any file system or other application storage layout that you have created on the volume can be resized after you have grown the volume.

For more information, see "Resizing Volumes Online" on page 55.

Creating a Clone Storage Pool

Assuming that you also want to create full-sized snapshots of application volumes in mypool that can be moved into different disk groups (potentially for offhost processing), the following command creates a clone storage pool, myclpool, in the same disk group as mypool:

```
# vxpool -g mydg create myclpool dm=mydg09,mydg10,mydg11,mydg12 \
  autogrow=pool pooldefinition=mirrored_volumes
```

This pool supports the creation of mirrored volumes. It also has a non-default autogrow policy that prevents it aggregating disks from the disk group outside the pool.

For more information, see "Preparing Storage Pools for Full-Sized Instant Snapshots" on page 73.

Preparing a Full-Sized Snapshot Volume

Before you can take a full-sized snapshot of an application volume, you must prepare the empty volume that is to become the snapshot volume as shown here:

```
# vxvoladm -g mydg -p myclpool make mysnpvol 2g type=snapshot\
 init=active
```

This command automatically associates a data change object (DCO) and DCO volume with the volume. For more information, see "Creating a Volume for Use as a Full-Sized Instant Snapshot" on page 74.

Taking a Full-Sized Snapshot of an Application Volume

Having prepared an empty volume, you can take a snapshot of the application volume:

```
# vxsnap -g mydg make source=stmrvol/snapvol=mysnpvol/syncing=on
```

The following command starts a full synchronization of the snapshot volume, and blocks until this is complete:

```
# vxsnap -g mydg syncwait mysnpvol
```

For more information, see "Creating Instant Snapshots" on page 79.

Creating a Cache Volume for Space-Optimized Snapshots

If you want to use space-optimized snapshots, you must prepare a storage cache where the snapshots can be created. This command sets up a 1GB cache volume, `mycache`, in the clone pool, `myclpool`:

```
# vxvoladm -g mydg -p myclpool make mycache 1g type=cachevolume
```

For more information, see "Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots" on page 75.

Preparing a Space-Optimized Snapshot

Having created a cache volume, you now need to prepare the space-optimized snapshots that you require. This command sets up a space-optimized snapshot, `mysovol`, using the cache volume, `mycache`:

```
# vxvoladm -g mydg -p myclpool make mysovol 2g type=snapshot \
  cachevolume=mycache init=active
```

Note The argument `2g` is the same as the length of the original source volume for which the snapshot is being prepared. This value defines the logical size of the snapshot. The actual amount of storage that the snapshot requires is less than this, and is limited by the size of the cache volume.

For more information, see "Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots" on page 75.

Taking a Space-Optimized Snapshot of an Application Volume

Having prepared a cache volume and one or more empty space-optimized snapshots, you are ready to take a snapshot of the application volume:

```
# vxsnap -g mydg make source=stmrvol/snapvol=mysovol
```

For more information, see "Creating Instant Snapshots" on page 79.

Creating and Administering Storage Pools 2

VERITAS Intelligent Storage Provisioning (ISP) allows you to group storage with similar characteristics for creating volumes. A storage pool is a named collection of volumes and the LUNs with which they are associated.

The storage policies and rules that are associated with a storage pool determine its characteristics. Each storage pool represents a collection of volumes that are created according to these policies and rules. For example, a pool may be configured to allow allocation of LUNs from outside the pool, and to use only templates that are associated with the pool by specifying the appropriate `autogrow` and `selfsufficient` policies.

For more information on the rules that are supported for storage pools, refer to “Rules” on page 113.

This chapter describes how to use the `vxpool` utility to create and administer storage pools. For full information about this command, see the `vxpool`(1M) manual page.

Reserving and Unreserving Disks for Use with ISP

When you initialize a disk for use with VxVM, for example, by running the `vxdiskadm` command, both ISP and non-ISP utilities have access to the space on the disk. You can reserve a disk for use with either set of utilities by setting the values of the `allocator_reserved` and `allocator_nouse` flags for the disk.

To reserve disks for exclusive use with ISP, and prevent non-ISP utilities such as `vxassist` from using these disks, select the menu item `23 Mark a disk as ISP-reserved for a disk group` from the main menu of the `vxdiskadm` command. Alternatively, you can use the following command to reserve a disk specified by its disk media name for use with ISP:

```
# vxedit [-g diskgroup] set "allocator_reserved=on" diskname
```

Note A disk that is to be reserved for ISP must not contain any existing VxVM subdisks.

To remove the reservation flag from disks, select menu item `24 Turn off the allocator-reserved flag on a disk` from the main menu of the `vxdiskadm` command. Alternatively, you can use the following command to remove ISP reservation from a disk specified by its disk media name:

```
# vxedit [-g diskgroup] set "allocator_reserved=off" diskname
```

To prevent a disk from being used by ISP, enter the following command:

```
# vxedit [-g diskgroup] set "allocator_nouse=on" diskname
```

The following command removes the restriction on ISP using a disk:

```
# vxedit [-g diskgroup] set "allocator_nouse=off" diskname
```

Note The flags `allocator_reserved` and `allocator_nouse` are mutually exclusive. Their values cannot both be set to `on` for a disk.

You can use the `vxdisk list` and `vxprint` commands to tell whether a disk has been reserved for ISP, as shown in the following examples:

```
# vxdisk list
DEVICE      TYPE           DISK       GROUP     STATUS
c0t8d0s2    auto:cdsdisk   mydg1      mydg      online allocrsvd

# vxprint -g mydg mydg1
TY  NAME   ASSOC     KSTATE LENGTH   PLOFFS  STATE     TUTIL0  PUTIL0
dm  mydg1  c0t8d0s2  -      35365968-        ALLOC_RES -       -
```

The `allocrsvd` status flag and the `ALLOC_RES` state indicate that a disk is reserved for use with ISP.

Organizing Storage Pools in a Disk Group

Before you can use ISP to create volumes in a disk group, you must first create any storage pools that you require in that disk group. A storage pool has associated disks, templates and policies. These policies control how the disks and templates are used when allocating storage from the pool to volumes.

The `vxpool organize` command simplifies the initial creation of one or more pools in a disk group by using a storage pool set definition. You can use this command to create a set of pools with policies and templates that are designed for a variety of different applications. A storage pool set consists of one data pool definition and one or more clone pool definitions. Each of these pool definition typically consists of the pool type, the templates that the pool contains, and the pool policies. See "Listing Storage Pool Sets" and "Displaying Storage Pool Set Definitions" on page 33 for details of how to find out what storage pool sets are available for use. See "Using Disk Group Split and Join with Storage Pools" on page 36 for details of how data and clone pools are typically used with the disk group split and join feature of VxVM.

For example, if you want your data volumes to be mirrored for redundancy, and your snapshot volumes to be striped for performance, you can choose a storage pool set definition where the data pool has associated templates that relate to mirroring, and the clone pool has associated templates that relate to striping. A suitable choice would be the `mirrored_data_striped_clones` storage pool set described on page 167. To create these storage pools within a disk group, you would use the following command:

```
# vxpool -g diskgroup organize mirrored_data_striped_clones
```

The section, "Creating a Storage Pool" on page 34, describes the alternate way of creating storage pools in a disk group.

Listing Storage Pool Sets

A storage pool set defines the storage pool types for a data storage pool and for the clone storage pools that are used to hold snapshots of the data storage pool's volumes.

To list all the available storage pool sets, use the following command:

```
# vxpool listpoolsets
```

For a list of supported storage pool sets, see "Storage Pool Sets" on page 167.

Displaying Storage Pool Set Definitions

To display the definition of a storage pool set, use the following command;

```
# vxpool printpoolsets storage_pool_set [storage_pool_set ...]
```

For example, the following command displays the definition of the storage pool set, `mirrored_data_stripe_clones`:

```
# vxpool printpoolsets mirrored_data_stripe_clones
storage_pool_set mirrored_data_striped_clones {
   description "The data volumes have multiple copies of data.
   Snapshot volumes have I/Os spread across multiple columns."
   descriptionid "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 139
   display_name "Mirrored Data and Striped Snapshots"
   display_name_id "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 138
   data mirrored_volumes
   clone striped_volumes
};
```

See "Displaying Storage Pool Definitions" on page 35 for information on how to display definitions for storage pool types such as `mirrored_volumes` and `striped_volumes`.

Creating a Storage Pool

As a alternative to the `vxpool organize` command described in "Organizing Storage Pools in a Disk Group" on page 32, you can use the `vxpool create` command to define and create a storage pool, as shown here:

```
# vxpool [-g diskgroup] create storage_pool [dm=dm1[,dm2...] \
  [description="description"] [autogrow={1|pool}|{2|diskgroup}] \
  [selfsufficient={1|pool}|{2|diskgroup}|{3|host}] \
  [rules=rule [ rule ...]] [pooldefinition=storage_pool_definition]
```

For example, the following command creates the storage pool, `mypool`, that contains disks `mydg02` and `mydg03`, and associates it with the disk group, `mydg`.

```
# vxpool -g mydg create mypool dm=mydg02,mydg03 \
  autogrow=diskgroup selfsufficient=pool
```

The `autogrow` policy level is set to `diskgroup` so the pool can use any storage within the disk group. The `selfsufficient` policy level of `pool` only allows the use of templates that have been manually assigned to the storage pool.

To simplify pool creation, you can also create a storage pool from a storage pool definition that is known to the system, as shown here:

```
# vxpool -g mydg create mypool pooldefinition=mirrored_volumes
```

Such definitions standardize storage pool policies and the templates that are to be associated with storage pools. See "Listing Available Storage Pool Definitions" on page 35 for details of how to find out the storage pool definitions that are known to the system, and "Displaying Storage Pool Definitions" on page 35 for information on how to display a storage pool definition.

See "Storage Pools" on page 163 for a list of pre-defined storage pool types. These definitions include default policy values, and a set of volume templates that are installed. You can add disks to such a storage pool as described in "Adding Disks to a Storage Pool."

Note The disks that you assign to a storage pool must have already been initialized for use, and must belong to the disk group in which you are creating the storage pool.

The first storage pool that you create in a disk group is a data storage pool that contains application volumes. Any storage pools that you subsequently create in the disk group are clone storage pools that can be used to hold full-sized instant snapshots of the volumes in the data storage pool. You need only place such snapshots in a separate clone storage pool if they need to be created using different templates from their parent volumes, or if they are to be moved into a different disk group.

See "Administering Instant Snapshots" on page 71 for more information about creating and using full-sized instant snapshots with clone storage pools.

Listing Available Storage Pool Definitions

To list all the available storage pool definitions, use the following command:

```
# vxpool listpooldefinitions
```

For a list of supported storage pool definitions, see "Storage Pools" on page 163.

To display the details of a storage pool definition, see "Displaying Storage Pool Definitions" on page 35.

Displaying Storage Pool Definitions

To display the details of one or more storage pool definitions, use the following command:

```
# vxpool printpooldefinitions [storage_pool_definition] ...
```

If no storage pool definitions are named, the definitions for all storage pools are displayed.

For example, the following command displays the definition of the storage pool, `mirrored_volumes`:

```
# vxpool printpooldefinitions mirrored_volumes
storage_pool mirrored_volumes {
   description "Volume has multiple copies of data."
   descriptionid "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 117
   display_name "Data Mirroring"
   display_name_id "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 116
   volume_templates ArrayProductId, ConfineLogsToSimilarStorage,
   ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage,
   ConfineToSpecificStorage, DCOLogMirroring, DCOLogStriping,
   DataMirroring, ExcludeSpecificStorage,
   InstantSnapshottable, LogsOnSeparateComponents,
   MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths
   autogrow 2
   selfsufficient 1
};
```

Using Disk Group Split and Join with Storage Pools

Storage pools form the smallest unit that can participate in disk group split and join operations (see the section “Reorganizing the Contents of Disk Groups” in the “Creating and Administering Disk Groups” chapter of the *VERITAS Volume Manager Administrator’s Guide* for details).

Note Only clone storage pools can be moved between disk groups; data pools must remain in the disk group in which they were created.

The following command is used to split one or more clone pools from a source disk group to a newly created target disk group:

```
# vxdg split sourcedg targetdg clonepool ...
```

All volumes (including instant snapshots) within the specified clone pools are moved to clone pools within the target disk group.

Note Any disk group that contains a clone pool must also contain a data pool. If a clone pool is split from a disk group, an empty data pool is also created in the newly created target disk group.

The following command is used to join two disk groups by merging the contents of the source disk group with the target disk group and then removing the source disk group:

```
# vxdg join sourcedg targetdg
```

All volumes (including full-sized instant snapshots) within the clone pool in the source disk group are moved to a clone pool of the same name within the target disk group.

Note When two disk groups containing storage pools are joined, only one of the data pools may contain any disks, and the set of templates that are associated with one data pool must be a subset (including the null set) of the templates that are associated with the other data pool. The join operation fails if both data pools contain disks, if the sets of templates are overlapping or disjoint. At the end of the join operation, the data pool that contains the most templates is retained and the other data pool is deleted.

You can use the following command to move a clone pool between disk groups:

```
# vxdg move sourcedg targetdg clonepool ...
```

As for the split operation, a data pool is created in the target disk group if no data pool currently exists there.

Adding Disks to a Storage Pool

To add one or more initialized disks to the storage pool, use the following command:

```
# vxpool [-g diskgroup] adddisk storage_pool dm=dm1[,dm2,...]
```

The following example shows two disks, `mydg04` and `mydg05`, being added to the storage pool, `mypool`:

```
# vxpool -g mydg adddisk mypool dm=mydg04,mydg05
```

Note Any disks that you add to a storage pool must have already been initialized for use, and must belong to the same disk group as the storage pool.

If a storage pool's autogrow policy is set to `diskgroup`, ISP automatically brings additional disks from the disk group into the storage pool as required.

Removing Disks from a Storage Pool

To remove one or more disks from the storage pool, use the following command:

```
# vxpool [-g diskgroup] rmdisk storage_pool dm=dm1[,dm2...]
```

In the following example, the disks, `mydg01` and `mydg04`, are removed from the storage pool, `ReliablePool`, for use elsewhere:

```
# vxpool -g mydg rmdisk ReliablePool dm=mydg01,mydg04
```

Note You cannot remove a disk from a storage pool if any volumes are configured on that disk. To remove such a disk, first use the `vxvoladm evacute` command to move the volumes away from the disk. When you have done this, you can then remove the disk from the storage pool.

Associating Templates with a Storage Pool

To associate one or more volume templates with a storage pool, use the `vxpool assoctemplate` command as shown here:

```
# vxpool [-g diskgroup] assoctemplate storage_pool \
  template=t1[,t2,...]
```

For example, the following command associates the templates `Mirroring` and `Striping` with the storage pool, `ReliablePool`:

```
# vxpool -g mydg assoctemplate ReliablePool \
  template=Mirroring,Striping
```

Note If the value of the `selfsufficient` policy is `diskgroup` or `host`, ISP first looks for storage that complies with the templates that are associated with the storage pool, and if no suitable templates are found, it then examines templates outside the pool.

For a list of supported templates, see "Volume Templates" on page 153.

Associating Template Sets with a Storage Pool

To associate one or more template sets, including all the templates that they contain, with a storage pool, use the `vxpool assoctemplateset` command as shown here:

```
# vxpool [-g diskgroup] assoctemplateset storage_pool \
  template_set=ts1[,ts2,...]
```

For example, the following command associates the template set, `DataMirroring`, with the storage pool, `ReliablePool`:

```
# vxpool -g mydg assoctemplateset ReliablePool \
  template_set=DataMirroring
```

Note If the value of the `selfsufficient` policy is `diskgroup` or `host`, ISP first looks for storage that complies with the templates that are associated with the storage pool, and if no suitable templates are found, it then examines templates outside the pool.

For a list of supported template sets, see "Template Sets" on page 148.

Dissociating Templates from a Storage Pool

To dissociate a template from the storage pool, use the following command:

```
# vxpool [-g diskgroup] distemplate storage_pool \
  template=t1[,t2,...]
```

In the following example, the `PrefabricatedRaid5` template is disassociated from the storage pool, `ReliablePool`:

```
# vxpool -g mydg distemplate ReliablePool \
  template=PrefabricatedRaid5
```

After a template has been dissociated, Storage Allocator does not refer to the rules and capabilities in that template unless this is permitted by the `selfsufficient` policy that is set on a storage pool.

Displaying Information About Storage Pools

To display information about one or more storage pools, use the following command:

```
# vxpool [-g diskgroup] print storage_pool [storage_pool ...]
```

For example, the following command displays information about the storage pool, `ReliablePool`:

```
# vxpool -g mydg print ReliablePool
TY   NAME           AUTOGROW    SELFSUFFICIENT   DESCRIPTION
st   ReliablePool   2           2                 -
dm   disk04         -           -                 -
dm   disk02         -           -                 -
dm   disk01         -           -                 -
```

The command displays the policies and description for each specified storage pool, together with a list of the disks that are associated with the storage pool.

Note The `vxpool` command displays only disks that are in a pool, and which have at least one path available. Use the `vxprint` command to list full information about disks and their states.

Displaying Storage Pool Policies

To display the policies that are set on a storage pool, use the `vxpool getpolicy` command as shown here:

```
# vxpool [-g diskgroup] getpolicy storage_pool
```

In the following example, this command is used to display the policies for the storage pool, `ReliablePool`:

```
# vxpool -g mydg getpolicy ReliablePool
Autogrow      Selfsufficient
2             1
```

Changing the Policies on a Storage Pool

By default, Storage Allocator sets the values of the `autogrow` policy to `diskgroup`, and the `selfsufficient` policy to `pool`. To change the policies that are set on a storage pool, use the `vxpool setpolicy` command:

```
# vxpool [-g diskgroup] setpolicy storage_pool \
  [autogrow={1|pool}|{2|diskgroup}] \
  [selfsufficient={1|pool}|{2|diskgroup}|{3|host}]
```

The existing pool policies are overwritten by the new levels that you set.

In the following example, the policies on the storage pool, `mypool`, are changed to disallow the use of storage resources from outside the storage pool, and to allow all available templates to be considered for use when creating volumes:

```
# vxpool -g mydg setpolicy mypool autogrow=pool \
  selfsufficient=host
```

Listing Storage Pools Within a Disk Group

To display a list of all storage pools within a disk group, use the vxpool `list` command as shown here:

```
# vxpool [-g diskgroup] list
```

For example, the following command lists all the storage pools within the disk group, `mydg`:

```
# vxpool -g mydg list
```

Renaming a Storage Pool

To rename a storage pool, use the following command:

```
# vxpool [-g diskgroup] rename storage_pool new_name
```

For example, to rename the storage pool, `mypool`, as `ReliablePool`, you would use the following command:

```
# vxpool -g mydg rename mypool ReliablePool
```

Deleting a Storage Pool

To delete a storage pool, use the following command:

```
# vxpool [-g diskgroup] [-r] delete storage_pool
```

The `-r` option must be specified to dissociate all disks from the storage pool and then deletes the storage pool as shown in this example:

```
# vxpool -g mydg -r delete ReliablePool
```

Note If any volumes are present in the storage pool, you must delete these before the storage pool can be deleted.

Creating Application Volumes 3

Volumes created by VERITAS Intelligent Storage Provisioning (ISP) are similar to traditional volumes created by `vxassist`, but have the advantage that their intent is preserved and cannot accidentally be degraded. Volumes that are created by ISP can be managed by using commands such as `vxvoladm`, or by using the VEA client graphical user interface. For information on using VEA to create volumes, refer to the VEA online help. This chapter describes how to use the `vxvoladm` command to create volumes.

Note To create application volumes successfully, the appropriate licenses must be present on your system. For example, you need a full VERITAS Volume Manager license and a VERITAS FlashSnap™ or FastResync license to use the instant snapshot feature. Vendors of disk arrays may also provide capabilities that require special licenses for certain features of their hardware.

Overview of the vxvoladm Command

You can use the `vxvoladm` command to create and manage volumes. ISP optimally assigns storage resources as defined and constrained by any parameter values, rules, capabilities and templates that you specify as arguments to the command. Capabilities provide the highest, most abstract way of specifying volumes. Rules provide the lowest, most direct means of specification. This gives you great freedom to create volumes that meet your requirements.

The `vxvoladm` command takes the general form:

```
# vxvoladm [options] keyword volume [additional_arguments] \
  [storage_specification] [attribute=value ...]
```

The *`keyword`* denotes the action that `vxvoladm` is to perform on the named volume. The storage specification defines the storage that can or cannot be used with an operation. This consists of a comma-separated list of disk media names and other storage attributes, such as `Controller:`*`controller_name`* to indicate all disks on a controller. Excluded storage is indicated by a ! prefix. Finally, attributes and their values can be used to specify further constraints on the operation.

Each invocation of vxvoladm is applied to only a single storage pool that has been configured within a disk group. The default disk group is that aliased by the setting of `defaultdg`. You can specify an alternate disk group by using the `-g` *`diskgroup`* option.

Note Refer to the `vxvoladm`(1M) manual page for full details on using the `vxvoladm` command.

Setting Default Values for vxvoladm

You can define default values for `vxvoladm` in the file `/etc/default/allocator`, or in an alternate defaults file that you specify using the `-d` option. The defaults listed in this file are used unless they are overridden by a value specified on the command line. If a value is not defined in a defaults file or on the command line, `vxvoladm` uses a built-in default value.

Tip The file, `/etc/default/allocator_readme`, contains a copy of the defaults file as it is shipped and first installed.

By default, the attribute settings in the installed `/etc/default/allocator` file are commented out. If required, you can uncomment the entries, and edit their values. If you do this, you should first make a backup copy of the original unedited file to keep for reference.

The following entry for `default_rules` in the `/etc/default/allocator` file is commented out by default:

```
# default_rules=desired confineto "ProductId"
```

If enabled, this rule changes the default behavior of ISP so that it attempts to confine volumes to disks with the same product ID. The rule may also prevent hot-relocation or volume transformation taking place if disks with the same product ID are not available.

For a single invocation of the `vxvoladm` command, you can override the default values of attributes that are defined in the `/etc/default/allocator` file, or that are built into `vxvoladm`, by specifying them as comma-separated arguments to the `-o` option.

Determining the Maximum Size of a Volume

Before creating a volume, you may wish to check whether there is sufficient storage available. You can use the following command to determine the maximum size of a volume with a given capability that you can create in the data storage pool of a disk group:

```
# vxvoladm [-g diskgroup] [-p storage_pool] [-b] maxsize \
[storage_specification] [attribute=value ...]
```

Specify the `-b` option if you want to run this command in the background. Otherwise, it will block until it has completed its calculation of the maximum volume size.

Note The storage that is available for allocation is based on the setting of the `AutoGrow` policy on a storage pool. If the value of this policy is set to `diskgroup` and not to `pool`, all suitable disks in the disk group are used in the calculation. You can use the `-p` option to specify that only storage from the specified pool is to be considered.

For example, the following command returns the maximum possible size of a mirrored volume with 3 mirrors that can be created in the disk group, `mydg`, from all the available free storage using the `DataMirroring` capability:

```
# vxvoladm -g mydg maxsize capability='DataMirroring(nmirs=3)'
```

The next example checks for the maximum volume size that can be created using prefabricated mirrors of a specified vendor type:

```
# vxvoladm -g peakdg maxsize \
  volume_template=PrefabricatedDataMirroring \
  rules='confineto "VendorName"="ACME"'
```

Creating Volumes

To create a volume with a specified length, specify the `make` keyword to `vxvoladm` as shown here:

```
# vxvoladm [options] make volume length [storage_specification] \
  [attribute=value ...]
```

It is possible to specify a combination of capabilities, templates and rules to this command. Recall that:

- A rule specifies a criterion for choosing and allocating storage.
- A template is a meaningful collection of rules that define a capability.
- A capability is a high-level description of what a volume can do.

The properties of the volume that is created are further determined by any parameters and other attributes that you specify. Rules, capabilities and templates may be combined as follows:

- If you specify rules along with capabilities, ISP creates volumes that comply to the rules that are defined in the capabilities, and also to those rules that you specify as arguments to `vxvoladm`.
- If you specify rules along with templates, ISP creates volumes that comply to the rules in the templates, and also to those rules that are specified as arguments to `vxvoladm`.
- If you specify capabilities along with templates, ISP selects the appropriate templates from those specified that conform to the desired capabilities.
- If you specify rules, capabilities and templates, ISP selects the appropriate templates from those specified that conform to the desired capabilities, and that adhere to the specified rules in addition to the rules in those templates.

Refer to "Using Capabilities, Templates and Rules" on page 105 for more information.

Finally, you can create volumes by specifying user templates that you have set up with the required redundancy, fault tolerance, or performance capabilities for the applications that you run at your site. See "Creating and Modifying User Templates" on page 99 for more information.

Creating Volumes by Specifying Capabilities

A capability is a high-level description of a volume, for example, `DataMirroring`, `Striping` or `PrefabricatedRaid5`. ISP automatically selects a suitable template from those that provide the desired capability. As such, this is the most abstract way of creating volumes using `vxvoladm` as it requires the least specification by you. You can customize a capability by specifying values for any variable parameters that it defines.

For a list of predefined capabilities that are supported, see "Capabilities" on page 157. The following sections provide some examples of creating volumes with these capabilities.

Creating a Mirrored Volume

The following command creates a 1-gigabyte volume with the default number of 2 mirrors:

```
# vxvoladm -g mydg make mir2vol 1g capability='DataMirroring' \
  init=active
```

The `init=active` attribute makes the volume immediately available for use without attempting to synchronize its empty plexes.

The following command creates a 1-gigabyte volume with 3 mirrors:

```
# vxvoladm -g mydg make mir3vol 1g \
  capability='DataMirroring(nmirs=3)' init=active
```

Creating a Mirrored Volume with Mirrors on Separate Enclosures

The following command creates a 2-gigabyte mirrored volume with 2 mirrors, and with the mirrors located on separate enclosures:

```
# vxvoladm -g mydg make strpvol 2g capability='DataMirroring,\
MirrorsOnSeparateComponents'
```

Such a volume tolerates the failure of one enclosure and provides greater reliability. Such a capability can be combined with multipathing to provide resilience against the failure of one of the paths to an enclosure:

```
# vxvoladm -g mydg make strpvol 2g capability='DataMirroring,\
MirrorsOnSeparateComponents,MultipathingThroughMultiplePaths'
```

Creating a Striped Volume

The following command creates a 2-gigabyte striped volume with 10 columns:

```
# vxvoladm -g mydg make strpvol 2g capability='Striping(ncols=10)'
```

Creating a Mirrored-Stripe Volume with Mirrors on Separate Controllers

The following command creates a 2-gigabyte mirrored-stripe volume with 8 columns, and with the mirrors located on separate controllers:

```
# vxvoladm -g mydg make strpvol 2g \
  capability='DataMirrorStripe(ncols=8),\
  MirrorsOnSeparateComponents(component="Controller")'
```

Creating a Striped-Mirror Volume from Prefabricated Mirrors

The following command creates a 10-gigabyte striped-mirror volume with 8 columns, and which uses prefabricated mirrors that are exported by an array to form each column:

```
# vxvoladm -g mydg make strpvol 2g capability='Striping(ncols=8),\
  PrefabricatedDataMirroring'
```

Creating a RAID-5 Volume with a RAID-5 Log

The following command creates a 2-gigabyte RAID-5 volume with 8 data columns and a RAID-5 log that has 2 redundant copies:

```
# vxvoladm -g mydg make r5vol 2g \
  capability='Raid5Capability(ncols=8),Raid5LogMirroring(nlogs=2)'
```

Creating Volumes by Specifying Capabilities and Rules

You can specify storage selection and layout rules in addition to capabilities when creating volumes. This allows you to select explicitly which storage can and cannot be used for certain volumes. For example, you might do this to ensure that volumes are created on storage with certain performance or reliability that is implemented in an array's hardware.

Refer to "Rules" on page 113 for details of the different types of rule and their usage.

Creating a RAID-5 Volume on Prefabricated Storage

The following command creates a 10-gigabyte volume on a prefabricated RAID-5 disk that is exported from an array made by a specified vendor:

```
# vxvoladm -g mydg make perfr5vol 10g \
  capability='PrefabricatedRaid5' \
  rules='confineto "VendorName"="ACME"'
```

Creating a Mirrored Volume on Enclosures in Separate Locations

The following command creates a mirrored volume that tolerates the failure of a single enclosure, where each enclosure is in a different room. This avoids single point of failure and ensures greater reliability.

```
# vxvoladm -g mydg make mirvol 10g capability='DataMirroring' \
  rules='separateby "Room","Enclosure"'
```

Note In this example, it is assumed that values for the user-defined attribute `Room` have been assigned to each enclosure.

Creating a Striped Volume Excluding Certain Disks

The following command creates a striped volume on storage other than that in `Room1` and certain disks in enclosure, `Enc1`:

```
# vxvoladm -g mydg make strvol 1g capability='Striping(ncols=4)' \
  rules='exclude allof("Room"="Room1","DeviceName"="Enc1_1",\
"DeviceName"="Enc1_2")'
```

Creating Volumes by Specifying Templates

Volumes can be created by specifying templates instead of capabilities. The following example demonstrates how to create a mirrored volume using a template:

```
# vxvoladm -g mydg make mirvol 1g volume_template=DataMirroring
```

Note If you specify templates when creating a volume, you must ensure that these templates are self-sufficient, and that they do not depend on templates that are not specified on the command line. This applies to all cases where templates are named by themselves, or in combination with a mixture of capabilities and rules.

A template can refer to other templates in following ways:

- It can be an extension of another template.
- It can apply another template.
- It can require or inherit a capability that is provided by another template.

If one or more of these conditions apply, ISP may not be able to use the given templates and volume creation may fail. To view the details of a template, use the following command:

```
# vxtemplate [-g diskgroup] print template=template_name
```

Examine the definitions of the `extends`, `inherits`, `requires` and `apply` fields to see the other templates on which the specified template depends. See "Volume Templates" on page 108 for more information about these fields.

For example, the following command fails because of a template dependency:

```
# vxvoladm -g mydg make myvol 1g volume_template=PrefabricatedRaid5
VxVM vxvoladm ERROR V-61-49872-28 Template PrefabricatedRaid5 is
not valid for the operation. Either the template itself is invalid
or one or more of the related templates/capabilities are not in the
scope.
```

The `vxtemplate` command is then run to examine the definition of the `PrefabricatedRaid5` volume template:

```
# vxtemplate -g mydg print template=PrefabricatedRaid5
volume_template PrefabricatedRaid5 {
    provides PrefabricatedRaid5
    rules {
        apply ArrayProductId
        confineto "Parity" ="1"
    }
};
```

The apply rule in the listing shows that the PrefabricatedRaid5 template depends on the ArrayProductId template. If the ArrayProductId template does not depend on any other templates, the vxvoladm make command should be modified to list ArrayProductId in addition to PrefabricatedRaid5:

```
# vxvoladm -g mydg make myvol 1g \
 volume_template=PrefabricatedRaid5,ArrayProductId
```

Creating Volumes by Specifying Templates and Rules

The following command creates a striped volume using a template, and specifies a rule to ensure that storage is allocated only from a single enclosure in a specified location:

```
# vxvoladm -g mydg make strvol 1g \
 volume_template='Striping' \
 rules='confineto eachof("Enclosure","Room"="Room2")'
```

Note If you use a volume template to create a volume, and do not specify any capabilities, the values of all the variables that are used in the volume template are taken from the default values defined in the capability. An error is returned if such a variable does not have a default value.

Creating Volumes by Specifying Templates and Capabilities

If you specify templates in addition to capabilities when creating a volume, this restricts ISP to choosing from the specified templates.

The following example shows how to specify both capabilities and templates:

```
# vxvoladm [-g diskgroup] make volume length \
 capability='capability[,capability...]' \
 volume_template=template[,template...]
```

If you specify rules in addition to capabilities and templates, these rules are applied after ISP has selected the templates that satisfy the required capabilities.

Creating Volumes by Specifying User Templates

Once you have set them up, user templates provide the simplest way of creating volumes for use with the applications that you run. For example, you can configure user templates that ensure that volumes that you create to store database tables all share the same reliability and performance capabilities, and that they are allocated from a restricted set of storage. The following example shows how you might use a user template to create a volume for a database table:

```
# vxvoladm -g dbdg make Customers 15g user_template=DBTable
```

Creating Multiple Volumes as a Volume Group

If you choose to create volumes individually, allocation may eventually fail when the available storage is exhausted. The -M option to the `vxvoladm` command allows you to create several volumes at the same time while making the most efficient use of the available storage resources. ISP automatically chooses the best way to allocate storage to the volumes. A set of multiple volumes that are created by this method is referred to as a *volume group*.

For convenience, it is easiest to define one or more volume groups in a definition file, and have `vxvoladm` read this file to create the volumes as shown here:

```
# vxvoladm -M make < filename
```

For a description of the syntax of a volume group definition, see “Volume Group Definition Syntax” on page 169.

A sample definition might contain the following `volumegroup` entry:

```
volumegroup {
  diskgroup "mydg"
  rules {
    separateby "Enclosure"
    exclude "Enclosure"="ENC1"
  }
  volume "mirvol1" 10g {
    capability 'DataMirroring(nmirs=2)'
  }
  volume "mirvol2" 10g {
    capability 'DataMirroring(nmirs=2)'
  }
  volume "mirvol3" 10g {
    capability 'DataMirroring(nmirs=2)'
  }
};
```

This specifies three 10-gigabyte mirrored volumes in the disk group, `mydg`, with the data mirrors placed on separate enclosures, but excluding enclosure, `ENC1`.

The next sample definition specifies a prefabricated striped volume on storage that is restricted to the location `Room1`, and a volume that is mirrored across controllers in the disk group `testdg`. In addition, the rules for the volume group specify that the volumes are to be created on separate enclosures, and that storage may only be allocated on disks from a given vendor.

```
volumegroup {
  diskgroup "testdg"
  rules {
    separateby "Enclosure"
    confineto "VendorName"="ACME"
  }
  volume "strpvol" 10g {
    rules {
      confineto "Room=Room1"
    }
    capability 'PrefabricatedStriping'
  }
  volume "mirdvol" 1g {
    rules {
      separateby "Controller"
    }
    capability 'DataMirroring(nmirs=2)'
  }
};
```

Creating a Volume for Use with Snapshots and DRL

If the dirty region logging (DRL) or instant snapshot features are going to be used with an application volume, a version 20 data change object (DCO) and DCO volume must be associated with the volume.

If you want to create a volume of which you can take instant snapshots, the `InstantSnapShottable` capability or template must be specified (unless this capability is already implied by another capability or template):

```
# vxvoladm -g mydg make mir3vol 1g \
  capability='DataMirroring(nmirs=3),InstantSnapshottable' \
  init=active
```

By default, a data change object (DCO) and DCO volume with a single plex are associated with a volume to enable the instant snapshot capability. To increase the redundancy of the DCO volume, specify the `DCOLogMirroring` capability as shown here:

```
# vxvoladm -g mydg make mir3vol 1g \
  capability='DataMirroring(nmirs=3),InstantSnapshottable,\
  DCOLogMirroring(nlogs=3)' init=active
```

In this example, the same degree of redundancy is created for the DCO volume as for the data volume.

The DCO and DCO volume that are added by the `InstantSnapShottable` capability also provide the dirty region logging (DRL) capability that speeds recovery of mirrored volumes after a system crash. To enable DRL, specify either the attribute `drl=on` for full DRL, or `drl=sequential` for sequential DRL (used with volumes containing database replay logs). By default, DRL is disabled (`drl=off`). For example, the following command enables DRL for the volume, `mir3vol`, that is being created:

```
# vxvoladm -g mydg make mir3vol 1g \
 capability='DataMirroring(nmirs=3),InstantSnapshottable' \
 drl=on init=active
```

Note For information about using traditional DRL with an ISP volume, see "Adding Logs to a Volume" on page 65. Such logs are implemented using a dedicated plex for each log copy, rather than using a DCO volume, and are supported for mirrored volume layouts only.

Administering Application Volumes 4

This chapter describes how to perform maintenance tasks on volumes that you have created using VERITAS Intelligent Storage Provisioning (ISP). This includes resizing and changing the capabilities of volumes without taking them offline.

The operations in this chapter use the `vxvoladm` command. For full details, see the vxvoladm(1M) manual page.

For details of how to display information about volumes, monitor and control tasks, and using the `vxresize` command to resize a volume and an underlying file system, see the "Administering Volumes" chapter of the *VERITAS Volume Manager Administrator's Guide*.

Resizing Volumes Online

Increasing or decreasing the size of a volume is an operation that can be performed while a volume is online. The following `vxvoladm` operations are available for resizing a volume:

- `growto` — Increase volume size to a specified length.
- `growby` — Increase volume size by a specified length.
- `shrinkto` — Reduce volume size to a specified length.
- `shrinkby` — Reduce volume size by a specified length.

You can specify the length argument in sectors, kilobytes, megabytes, gigabytes or as a percentage by adding the unit of measure as a suffix (`s`, `m`, `k`, `g`, `%`) to the length value. If no unit is specified, sectors are assumed.

Caution If you use `vxvoladm` to resize a volume, do not shrink it below the size of the file system that is located on it. If you do not shrink the file system first, you risk unrecoverable data loss. If you have a VxFS file system, shrink the file system first, and then shrink the volume. Other file systems may require you to back up your data so that you can later recreate the file system and restore its data.

Alternatively, you can use the `vxresize` command to resize both the volume and its file system where this is supported.. See the `vxresize`(1M) manual page for more information.

Note If you use the `vxvoladm` command to resize application volumes of type `fsgen` or `raid5`, you must specify the `-f` (force) option to the command. You must also specify the `-f` option if growing a volume would violate any rules.

Determining the Maximum Size of a Volume

You can use the following command to determine by how much you can grow a volume using the available storage:

```
# vxvoladm [-g diskgroup] maxgrow volume [attributes...]
```

You can use storage specification attributes with this command to restrict the storage that is taken into consideration by the calculation. For example, the following command specifies that any JBOD storage may be used to resize volume, `vol02`:

```
# vxvoladm -g mydg maxgrow vol02 \
 use_storage='allof("Enclosure"="Disk")'
```

Increasing the Size of a Volume to a Specified Length

The following command grows a volume to a specified length:

```
# vxvoladm [-g diskgroup] [-f] growto volume length [attributes...]
```

You can use storage specification attributes with this command to restrict the storage that is used to grow a volume. For example, the following command expands the volume `vol1` to 10 gigabytes, but excludes storage on controller `c1` from being allocated:

```
# vxvoladm -g mydg growto vol1 10g \
 use_storage='noneof("Controller"="c1")'
```

This operation fails if the new length specified is smaller that the current size of the volume.

Increasing the Size of a Volume by a Specified Amount

The following command grows a volume by a specified amount:

```
# vxvoladm [-g diskgroup] [-f] growby volume length [attributes...]
```

For example, the following command grows the volume `vol1` by 1 gigabyte by allocating contiguous storage:

```
# vxvoladm -g mydg growby vol1 1g layout=contig
```

The setting `layout=contig` allows only contiguous regions of disk to be used for plexes or columns. By default, the length of a volume is increased by first extending existing subdisks in the volume if possible, and then by adding and associating new subdisks. This default behavior corresponds to the attribute setting `layout=nocontig`.

Reducing the Size of a Volume to a Specified Length

The following command reduces the length of a volume:

```
# vxvoladm [-g diskgroup] [-f] shrinkto volume length \
  [attributes...]
```

For example, the following command shrinks the volume `vol1` to 5 gigabytes:

```
# vxvoladm -g mydg shrinkto vol1 5g
```

This operation fails if the new length specified is larger that the current size of the volume.

Reducing the Size of a Volume by a Specified Amount

The following command reduces the length of a volume by a specified amount:

```
# vxvoladm [-g diskgroup] [-f] shrinkby volume length \
  [attributes...]
```

For example, the following command shrinks the volume `vol01` by 500 megabytes:

```
# vxvoladm -g mydg shrinkby vol1 500m
```

Growing and Shrinking Multiple Volumes

If the `-M` option is specified to the `vxvoladm` command, multiple volumes can be resized in the same operation. For convenience, it is easiest to define the volumes that are to be resized in a file, and then have `vxvoladm` read this file to resize the volumes as shown in this example:

```
# vxvoladm -M growby < filename
```

Each line of input defines the disk group, volume and length parameters for the resize and has the following format:

```
diskgroup dgname volume volume_name length
```

When used in scripts, the input may conveniently be taken from a “here document” as shown in this example:

```
vxvoladm -M shrinkto <<!!
diskgroup mydg volume vol01 10g
diskgroup mydg volume vol02 12g
!!
```

Preparing a Volume for DRL and Snapshot Operations

To prepare an application volume for dirty region logging (DRL) and instant snapshot operations, a data change object (DCO) and DCO volume must be associated with the volume.

Note The procedure in this section describes how to add a version 20 DCO and DCO volume to an application volume that you previously created in a disk group with a version number of 110 or greater. If you are creating a new volume in a disk group with a version number of 110 or greater, you can specify the co-creation of a DCO and DCO volume and enable DRL as described in “Creating a Volume for Use with Snapshots and DRL” on page 52.

You may need an additional license to use the DRL and FastResync features.

For information about using traditional DRL with an ISP volume, see “Adding Logs to a Volume” on page 65.

Use the following command to add a version 20 DCO and DCO volume to an existing volume:

```
# vxvoladm [-g diskgroup] [-p storage_pool] add log volume \
 [nlog=number] logtype=dco [regionsize=size] \
 [drl=yes|no|sequential]
```

The `nlog` attribute specifies the number of DCO plexes that are created in the DCO volume. It is recommended that you configure as many DCO plexes as there are data plexes in the volume. For example, specify `nlog=3` for a volume with 3 data plexes.

The value of the `regionsize` attribute specifies the size of the tracked regions in the volume. A write to a region is tracked by setting a bit in the change map. The default value is `64k` (64KB). A smaller value requires more disk space for the change maps, but the finer granularity provides faster resynchronization.

To enable DRL logging on the volume, specify `drl=yes`. If sequential DRL is required, specify `drl=sequential`.

You can also specify `vxvoladm`-style storage attributes to define the disks that can and/or cannot be used for the plexes of the DCO volume.

Removing Support for DRL and Snapshots from a Volume

To remove support for DCO-based DRL and instant snapshots from a volume, use the following command to remove the DCO and DCO volume that are associated with the volume:

```
# vxvoladm [-g diskgroup] [-p storage_pool] removeall log volume \
  logtype=dco
```

Note This command fails if the volume is part of a snapshot hierarchy.

Evacuating a Volume

If you need to remove or disable a disk, you must first move any data off the disk by evacuating it. Similarly, if the whole or parts of a volume are configured on disks that are needed for other purposes, or which are not optimal or appropriate for use by the volume, you can evacuate these.

To evacuate certain disks on which a volume is configured, use either of the following commands to specify these:

```
# vxvoladm [-g diskgroup] [-b] evacuate disk volume \
  !dmname ... [use_storage=rule[,...]] [attributes...]
# vxvoladm [-g diskgroup] [-b] evacuate disk volume \
  evac_storage=rule[,...] [use_storage=rule[,...]] \
  [attributes...]
```

The disk media names of the disks that are to be evacuated are specified as `!`*dmname* where *dmname* is a disk media name. Alternatively, you can also use the storage specification attribute, `evac_storage`, to specify rules for evacuating currently used storage. The -b option may be specified to run the evacuation as a background task. ISP allocates suitable storage according the `autogrow` policy of the storage pool, or you can use the storage specification attribute, `use_storage`, to specify rules for allocating new storage.

For example, the following command evacuates disks mydg01 and mydg02 on which volume, vol01, is configured, and specifies disks mydg03 and mydg04 as destination disks:

```
# vxvoladm -g mydg evacuate disk vol01 !mydg01 !mydg02 \
 use_storage='allof("DM"="mydg03","DM"="mydg04")'
```

Not only disks can be evacuated. You can also specify subdisks, columns, logs, mirrors or entire volumes to be evacuated. In these cases, you can use the `evac_storage` attribute to specify which storage is to be evacuated. In the following example, all columns of the volume are evacuated that have disks on controller `c1`:

```
# vxvoladm -g mydg evacuate column vol01 \
 evac_storage='"Controller"="c1"'
```

The next example evacuates any disks in columns 0 or 1 that lie on controller `c2`:

```
# vxvoladm -g mydg evacuate column vol01 column=0,1 \
 evac_storage='"Controller"="c1"'
```

This command specifies that both columns 0 and 1 are to be evacuated to disks on controller c2:

```
# vxvoladm -g mydg evacuate column vol01 column=0,1 \
 use_storage='"Controller"="c2"'
```

In the final example, volume data is evacuated from subdisks that are connected to controller `c1` to disks on any other controller:

```
# vxvoladm -g mydg evacuate subdisk vol01 \
 evac_storage='allof("Controller"="c1")' \
 use_storage='noneof("Controller"="c1")'
```

If the specified volume is currently enabled, the data in enabled plexes and their component enabled plexes is moved without interrupting the availability of the volume and without changing its redundancy. Subdisks that are within detached plexes, disabled plexes, detached logs, or RAID-5 subdisks are moved without any attempt to recover the data.

If the specified volume is not currently enabled, stale or offline plexes are moved without recovery. The evacuation fails if a non-enabled volume contains other subdisks that need to be moved.

Removing a Volume

Once a volume is no longer required, you can use the following command to delete it and make its storage available for re-use:

```
# vxvoladm [-g diskgroup] remove volume volume
```

For example, the following command removes the volume, `vol1`:

```
# vxvoladm -g mydg remove volume vol1
```

Performing Online Relayout on a Volume

ISP does not support online relayout of an application volume in the same way as when the `vxassist relayout` command is used on a traditional volume. ISP can perform relayout internally if this is necessary to preserve the intent of a volume, or to support operations such as changing the number of mirrors, columns or logs that are associated with a volume. However, you should note that such operations may destroy the intent of a volume by changing its desired data redundancy or performance capabilities.

The nearest equivalent in ISP to the online relayout operation is capability transformation. This changes the capabilities of a volume in a controlled fashion, and preserves the size of the volume but not its intent. This operation is discussed in the following section. Subsequent sections describe how to add or remove mirrors, columns or logs to or from a volume, how to stop and reverse transformation and relayout operations, and how to verify that the intent of a volume has been preserved.

Transforming the Capabilities of a Volume Online

To change the capabilities of an existing volume online, use the `vxvoladm transform` command as shown here:

```
# vxvoladm [-g diskgroup] [-b] transform volume [attributes...]
```

If specified, the `-b` option performs the transformation in the background.

For example, the following command changes the capability of the volume, `vol02`, to DataMirroring with 4 mirrors:

```
# vxvoladm -g mydg -b transform vol02 \
  capability='DataMirroring (nmirs=4)'
```

The next example adds the InstantSnapShottable and DCOLogMirroring capabilities to enable the use of instant snapshots with a mirrored volume:

```
# vxvoladm -g mydg -b transform mir3vol \
  capability='DataMirroring(nmirs=3),InstantSnapShottable,\
DCOLogMirroring(nlogs=3)'
```

Adding Mirrors to a Volume

To add mirrors to an existing volume, use the following command:

```
# vxvoladm [-g diskgroup] [-b] add mirror volume \
  [nmirrors=number] [attributes...]
```

By default, one mirror is added. You can use the `nmirrors` attribute to specify the number of mirrors to add. If specified, the `-b` option performs the synchronization of the new mirrors in the background. You can also use storage attributes to specify the storage to be used for the mirrors. For example, the following command adds a mirror to the volume, `mirvol1`, using disk `mydg01`:

```
# vxvoladm -g mydg -b add mirror mirvol1 \
  use_storage='"DM"="mydg01"'
```

Removing Mirrors from a Volume

To remove mirrors from a volume, use the following command:

```
# vxvoladm [-g diskgroup] [-f] remove mirror volume \
  [nmirrors=number] [attributes...]
```

By default, one mirror is removed. You can use the `nmirrors` attribute to specify the number of mirrors to remove. You can use storage attributes to specify the storage to be removed. For example, the following example removes the mirror on the disk `mydg01`, from the volume `mirvol1`:

```
# vxvoladm -g mydg remove mirror mirvol1 \
  remove_storage='"DM"="mydg01"'
```

Note If you use the `vxvoladm` command to remove mirrors, you must specify the `-f` (force) option to the command if the operation would violate any rules. For example, the rules may imply that a volume must have minimum number of mirrors of a particular kind.

Adding Columns to a Volume

To add columns to a striped or RAID-5 volume, use the following command:

```
# vxvoladm [-g diskgroup] [-b] add column volume ncols=number \
  [tmplen=length] [attributes...]
```

The `ncols` attribute specifies the number of columns to add. You can use storage attributes to specify the storage to be used for the columns. If specified, the `-b` option adds the columns in the background.

Note This operation creates a temporary 2-way mirror volume that requires at least two disks, and therefore twice as much disk space as the size of the temporary volume. The size of the temporary volume is based on the size of the volume that is being changed. If required, you can use the `tmplen` attribute to specify the size of the temporary volume.

For example, the following command adds a column to the volume, `strpvol1`, using disk `enc1_5`:

```
# vxvoladm -g mydg -b add column strpvol1 ncols=1 \
  use_storage='"DeviceName"="enc1_5"'
```

Note If a UFS file system is configured on an ISP volume, do not specify `layout=grow` to the `vxvoladm` command when adding columns to the volume unless you first unmount the file system. This file system type can only be grown if it is first unmounted. This restriction does not apply to a VxFS file system, which can be grown while mounted. See the `vxresize` (1M) manual page for more information.

Removing Columns from a Volume

To remove columns from a striped or RAID-5 volume, use the following command:

```
# vxvoladm [-g diskgroup] [-b] [-f] remove column volume \
  [ncols=number] [tmplen=length]
```

The `ncols` attribute specifies the number of columns to remove. If specified, the `-b` option removes the columns in the background.

Note This operation creates a temporary 2-way mirror volume that requires at least two disks, and therefore twice as much disk space as the size of the temporary volume. The size of the temporary volume is based on the size of the volume that is being changed. If required, you can use the `tmplen` attribute to specify the size of the temporary volume.

For example, the following command removes a column from the volume, `strpvol1`:

```
# vxvoladm -g mydg -b remove column strpvol1 ncols=1
```

Note If you use the `vxvoladm` command to remove columns, you must specify the `-f` (force) option to the command if the operation would violate any rules. For example, the rules may imply that a volume must have minimum number of columns of a particular kind.

If a UFS file system is configured on an ISP volume, do not specify `layout=shrink` to the `vxvoladm` command when removing columns from the volume. This file system type cannot be shrunk. This restriction does not apply to a VxFS file system, which can be shrunk while mounted. See the `vxresize` (1M) manual page for more information.

Changing the Stripe Unit Size of Volumes

To change the stripe unit size of a striped or RAID-5 volume, use the following command:

```
# vxvoladm [-g diskgroup] [-b] setstwidth volume stripeunit=size \
  [tmplen=length] [attributes...]
```

If specified, the `-b` option changes the stripe width in the background.

Note This operation creates a temporary 2-way mirror volume that requires at least two disks, and therefore twice as much disk space as the size of the temporary volume. The size of the temporary volume is based on the size of the volume that is being changed. If required, you can use the `tmplen` attribute to specify the size of the temporary volume.

For example, the following command changes the stripe unit size of the volume `vol1` to 32KB:

```
# vxvoladm -g mydg -b setstwidth vol1 stripeunit=32k
```

Adding Logs to a Volume

To add logs to a volume, use the following command:

```
# vxvoladm [-g diskgroup] [-b] add log volume logtype=type \
  [nlogs=number] [loglen=length] [attributes...]
```

The supported log types are `dcm`, `dco`, `drl` and `raid5`.

Adding a data change object (DCO) and DCO plex to a volume also allows the use of instant snapshots and dirty region logging (DRL) with the volume.

Traditional DRL may be added by specifying `logtype=drl` instead of `logtype=dco`. Such logs are implemented using a dedicated plex for each log copy, rather than using a DCO volume, and are supported for mirrored volume layouts only.

Data change map (DCM) logs are used with VERITAS Volume Replicator (VVR) replicated volumes. This type of log is usually added automatically by VVR adminstration commands.

RAID-5 logs are supported for software RAID-5 volumes only.

By default, one log or a DCO with one plex is added. You can use the `nlogs` attribute to specify the number of logs or DCO plexes to add. The `loglen` attribute can be used to specify the size of a RAID-5 log or a DCO volume. If the volume already contains such a log or DCO volume, this attribute is ignored. For a DCO volume, ISP may round up the length to make room for the maps that are required. For a RAID-5 log, a minimum size of three times the full stripe width is imposed, and the length is rounded up to a integral multiple of the full stripe width.

You can use storage attributes to specify the storage to be used for the logs. For example, the following command adds a DCO plex to the volume, `mirvol1`, using disk `enc1_7`:

```
# vxvoladm -g mydg -b add log mirvol1 logtype=dco \
  use_storage='"DeviceName"="enc1_7"'
```

Removing Logs from a Volume

To remove logs from a volume, use the following command:

```
# vxvoladm [-g diskgroup] [-f] remove log volume [nlogs=number] \
  logtype=type [attributes...]
```

The supported log types are `dco` and `raid5`. By default, one RAID-5 log or one plex of a DCO volume is removed. You can use the `nlogs` attribute to specify the number of logs or DCO plexes to remove. You can use storage attributes to specify the storage to be removed. In the following example, a DCO plex on the disk `mydg11` is removed from the volume `mirvol1`:

```
# vxvoladm -g mydg remove log mirvol1 logtype=dco\
  remove_storage='"DM"="mydg11"'
```

To remove all logs of a particular type from a volume, use the following command:

```
# vxvoladm [-g diskgroup] removeall log volume logtype=type
```

Note If you use the `vxvoladm` command to remove logs, you must specify the `-f` (force) option to the command if the operation would violate any rules. For example, the rules may imply that a volume must have minimum number of logs of a particular kind. You must also specify the `-f` option when removing a DCO that is in use by DRL configured on a volume.

Data change map (DCM) logs are usually removed automatically as required by VVR adminstration commands.

Monitoring and Controlling ISP Tasks

ISP performs management of objects (such as subdisks, plexes, and volumes). Once these objects have been created, VxVM can start performing I/O with them.

The `vxvoladmtask` command is provided to allow you to manage tasks (*ISP tasks*) that are involved in the creation of objects by ISP. The traditional `vxtask` command allows you to manage tasks that involve VxVM performing I/O with volumes.

Note The online transformation of an ISP volume is not necessarily complete if the `vxtask` command shows that synchronization of the volume has finished. A small additional time is required to perform cleanup operations.

For example, if you create a 2-way mirrored volume in the background, ISP creates an allocation task whose progress you can monitor using the `vxvoladmtask monitor` command. When ISP has allocated storage for the volume, it lays out the volume on that storage and then starts the volume. At this point, VxVM takes over control of I/O, and it begins to initialize the volume by synchronizing its plexes. To view the progress of this synchronization, you would use the `vxtask monitor` command.

The following command lists all current ISP tasks:

```
# vxvoladmtask list
```

This command monitors the progress of an ISP task, specified by its task tag:

```
# vxvoladmtask monitor task_tag
```

If necessary, you can use this command to stop an ISP task:

```
# vxvoladmtask abort task_tag
```

For more information about the `vxvoladmtask` command, see the `vxvoladmtask`(1M) manual page.

For information about the `vxtask` command, see the “Monitoring and Controlling Tasks” section in the “Administering Volumes” chapter of the *VERITAS Volume Manager Administrator’s Guide*, and the `vxtask`(1M) manual page.

Reversing Volume Transformations

If a volume transformation, which was invoked using the `vxvoladm transform` command, is in progress, you can use the `vxvoladm transformreverse` command to stop and reverse the transformation:

```
# vxvoladm [-g diskgroup] transformreverse volume
```

This command can also be used to reverse the following operations on mirrored-stripe volumes:

- Adding a column to a mirrored-stripe volume (`vxvoladm add column`).
- Removing a column from a mirrored-stripe volume (`vxvoladm remove column`).
- Changing the stripe width of a mirrored-stripe volume (`vxvoladm setstwidth`).

For `add/remove column` and `setstwidth` operations on striped, striped-mirror and RAID-5 volumes, use the following procedure to stop and reverse the relayout:

1. Enter the following command to discover the task tag of the operation that you want to reverse:

   ```
   # vxtask list
   ```

2. Use the task tag with this form of the `vxtask` command to stop the operation:

   ```
   # vxtask abort task_tag
   ```

3. Finally, use the `vxrelayout` command to revert the volume to its former layout:

```
# vxrelayout [-g diskgroup] reverse volume
```

Note When mirrors are added or removed, ISP does not use the `relayout` or `transform` operations internally. After adding a mirror to a volume, VxVM starts synchronizing the new plexes from the existing plexes. In this case, the reverse operation can be performed by removing the newly added plexes. To reverse the removal of a mirror, a new plex must be added, and time allowed for it to be brought into synchronization with the volume.

Verifying the Intent of a Volume

To verify whether the application volumes in a disk group conform to the template rules, user-defined rules, volume group rules and storage pool rules that were used to create them, use the following command:

```
# vxvoladm -g diskgroup verify
```

To verify the intent of all application volumes in all disk groups, use this form of the command:

```
# vxvoladm -a verify
```

Displaying the Rules Associated with Objects

You can use the following command to display the rules that are associated with disk groups, storage pools, plexes and volumes:

```
# vxvoladm [-g diskgroup] printintent [object_name ...]
```

If no objects are named as arguments, the command displays the rules that are associated with the disk group.

Migrating Volumes to ISP

To make volumes that you previously created using `vxassist` manageable by ISP, you can use the following form of the `vxvoladm` command:

```
# vxvoladm [-g diskgroup] [-p storage_pool] [-I rules] \
  migrate volume ...
```

Note Volumes to be migrated must be CDS-compliant and have an alignment value of 8k.

After migration, you must use the `vxvoladm` command to administer the volumes instead of `vxassist`. It is not possible to perform a reverse migration.

The volumes to be migrated from a disk group may be specified on the command line, or in a definitions file that is read from the standard input if the `-M` option is specified:

```
# vxvoladm [-g diskgroup] -M migrate
```

The syntax of the definitions file is shown below:

```
diskgroup "dgname"
volume "volumename1" {
  pool "pool_name1"
  rules { volume1_rules }
};
volume "volumename2" {
  pool "pool_name2"
rules { volume2_rules }
};
.
.
.
```

The default intent that ISP applies to the volumes that are being migrated is to allocate plexes, logs and columns on separate disks. You can specify additional rules using the `-I` option on the command line, or by entries in the definitions file. You cannot include mirror, stripe or log rules. After the volumes have been migrated, their intent is preserved by ISP as for volumes that are created directly using the `vxvoladm` command.

Rules specified on the command line are applied to all the specified volumes. Using a definitions file allows you to apply different rules to each volume.

Volumes that are specified on the command line are also associated with the same storage pool. If a storage pool is not specified using the `-p` option, the volumes are placed in the data storage pool of the disk group. Using a definitions file allows the migrated volumes to be placed in different storage pools.

The following example demonstrates how to use a definitions file to migrate two volumes to separate data and clone storage pools:

```
vxvoladm -M migrate <<!!
diskgroup "mydg"
volume "myvol" {
 pool "mydatapool"
};
volume "snap_myvol" {
 pool "myclonepool"
};
!!
```

Note the following limitations of the migration operation:

- All volumes in a VVR replicated volume group (RVG) must be migrated together.
- All `vxassist`-created volumes that share a set of disks must be migrated in a single operation.
- Disks cannot be shared with any volumes that are not listed on the command line or in a definitions file.
- Volumes cannot share disks unless these disks are to be located in the same storage pool.
- Volumes with a usage type of root, such as those on a root disk that is under VxVM control, cannot be migrated.
- The disk group containing the volumes to be migrated must have a version number of 120 or greater.

Administering Instant Snapshots 5

VERITAS Volume Manager (VxVM) provides the capability for taking an image of a volume at a given point in time. Such an image is referred to as a *volume snapshot*.

Instant volume snapshots allow you to make backup copies of your volumes online with minimal interruption to users. You can then use the backup copies to restore data that has been lost due to disk failure, software errors or human mistakes, or to create replica volumes for the purposes of report generation, application development, or testing.

Two kinds of instant volume snapshots are supported for use with application volumes created by VERITAS Intelligent Storage Provisioning (ISP):

- Full-sized instant snapshots require an empty volume to be prepared for use as the snapshot volume as described in “Creating a Volume for Use as a Full-Sized Instant Snapshot” on page 74. The length of this volume must be the same as that of the volume whose snapshot is being taken. A snapshot volume can be created in either a data pool or in a clone pool. It must be created in a clone pool if you want to move it to a separate disk group. See “Preparing Storage Pools for Full-Sized Instant Snapshots” on page 73 for details.

- Space-optimized instant snapshots require less space than a full-sized instant snapshot but they cannot be dissociated from their original volume nor can they be moved into a different disk group. A space-optimized snapshot uses a storage pool or cache, which can be shared by one or more other space-optimized snapshots. You must set up the cache and the space-optimized snapshot volume in advance of creating any space-optimized snapshots, as described in “Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots” on page 75.

The creation and administration of instant snapshots is described in “Creating Instant Snapshots” on page 79 and in subsequent sections.

Note A volume snapshot represents the data that exists in a volume at a given point in time. As such, VxVM does not have any knowledge of data that is cached by the overlying file system, or by applications such as databases that have files open in the file system. If the `fsgen` volume usage type is set on a volume that contains a VERITAS File System (VxFS), intent logging of the file system metadata ensures the internal consistency of the file system that is backed up. For other file system types, depending on the intent logging capabilities of the file system, there may be inconsistencies between in-memory data and the data in the snapshot image.

For databases, a suitable mechanism must additionally be used to ensure the integrity of tablespace data when the volume snapshot is taken. The facility to temporarily suspend file system I/O is provided by most modern database software. For ordinary files in a file system, which may be open to a wide variety of different applications, there may be no way to ensure the complete integrity of the file data other than by shutting down the applications and temporarily unmounting the file system. In many cases, it may only be important to ensure the integrity of file data that is not in active use at the time that you take the snapshot.

Traditional third-mirror break-off snapshots cannot be taken of application volumes that have been created by ISP.

Most VxVM commands require superuser or equivalent privileges.

For more information about instant volume snapshot features, see the chapter "Understanding VERITAS Volume Manager" in the *VERITAS Volume Manager Administrator's Guide*.

Full details of how to recover from failures of instant snapshot commands may be found in the "Recovery from Failure of Instant Snapshot Operations" chapter of the *VERITAS Volume Manager Troubleshooting Guide*.

Preparing Storage Pools for Full-Sized Instant Snapshots

Assuming that you have already set up a data storage pool in a disk group using the procedure given in "Creating a Storage Pool" on page 34, you can create one or more clone storage pools in the same disk group by using the same procedure. You may choose to use different types of disks or templates with a clone storage pool than you set up for the data storage pool.

For example, the following commands set up a data and clone storage pool in the disk group, `ttdg`, from storage pool definitions:

```
# vxpool -g ttdg create ttdtpool \
  pooldefinition=prefab_mirrored_volumes
# vxpool -g ttdg create ttclpool pooldefinition=mirrored_volumes
```

The data storage pool, `ttdtpool`, is configured with templates that support the creation of volumes on mirrored disks that are prefabricated in hardware. The templates that are installed for the clone storage pool, `ttclpool`, support mirrored volumes that may be created using software. Having set up the storage pools, they can be populated with initialized disks as described in "Adding Disks to a Storage Pool" on page 37.

Several storage pool sets are provided (see "Storage Pool Sets" on page 167) for setting up data and clone storage pools within a disk group. To set up a data and clone storage pool using one of these defined sets, use the following command:

```
# vxpool [-g diskgroup] organize storage_pool_set
```

For example, to set up a data storage pool that supports mirrored volumes and a clone storage pool that supports striped snapshots in the disk group, `mydg`, you could use this command:

```
# vxpool -g mydg organize mirrored_data_striped_clones
```

This command assigns default names for the storage pools. These names are based on the definition names. If required you can rename these storage pools as described in "Renaming a Storage Pool" on page 40.

Creating a Volume for Use as a Full-Sized Instant Snapshot

If you want to create a full-sized instant snapshot for an original volume, you can use an empty volume with the required capability, and with the same length and region size as the original volume.

To create an empty volume for use by a full-sized instant snapshot:

1. Use the `vxprint` command on the original volume to find the required size for the snapshot volume.

   ```
   # LEN=‘vxprint [-g diskgroup] -F%len volume‘
   ```

   Note The command shown in this and subsequent steps assumes that you are using a Bourne-type shell such as `sh`, `ksh` or `bash`. You may need to modify the command for other shells such as `csh` or `tcsh`.

2. Use the `vxvoladm` command to create a volume, *snapvol*, of the required size and redundancy:

   ```
   # vxvoladm [-g diskgroup] [-p storage_pool] make snapvol $LEN \
     [storage_specification ...] [attribute ...] type=snapshot \
     [regionsize=size] init=active
   ```

   The attribute `regionsize` specifies the minimum size of each chunk (or region) of a volume whose contents are tracked for changes. The region size must be a power of 2, and be greater than or equal to 16KB. A smaller value requires more disk space for the change maps, but the finer granularity provides faster resynchronization. The default region size is 64k (64KB).

   Note If the region size of a space-optimized snapshot differs from the region size of the cache, this can degrade the system’s performance compared to the case where the region sizes are the same.

   The `init=active` attribute is specified to make the volume available immediately.

   The following example creates a 10-gigabyte mirrored volume, `ttsnpvol`, in the clone storage pool, `ttclpool`:

   ```
   # vxvoladm -g ttdg -p ttclpool make ttsnpvol 10g \
    capability=’DataMirroring(nmirs=2)’ type=snapshot init=active
   ```

Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots

If you need to create several space-optimized instant snapshots for the volumes in a disk group, you may find it more convenient to create a single shared cache volume in the disk group rather than a separate cache volume for each snapshot.

To create a shared cache volume and prepare any space-optimized snapshots:

1. Decide on the following characteristics that you want to allocate to the cache volume:

   - The size of the cache volume should be sufficient to record changes to the parent volumes during the interval between snapshot refreshes. A suggested value is 10% of the total size of the parent volumes for a refresh interval of 24 hours.
   - If redundancy is a desired characteristic of the cache volume, it should be mirrored. This increases the space required by the cache volume in proportion to the number of mirrors that it has.
   - If the cache volume is mirrored, space is required on at least as many disks as it has mirrors. These disks should not be shared with the disks used for the parent volumes. The disks should also be chosen to avoid impacting I/O performance for critical volumes, or hindering disk group split and join operations.

2. Having decided on its characteristics, use the `vxvoladm` command to create the cache volume:

   ```
   # vxvoladm [-g diskgroup] [-p storage_pool] make cachevol size \
     [storage_specification ...] [attribute ...] [regionsize size] \
     type=cachevolume
   ```

   The attribute `regionsize` specifies the minimum size of each chunk (or region) of a volume whose contents are tracked for changes. The region size must be a power of 2, and be greater than or equal to 16KB. A smaller value requires more disk space for the change maps, but the finer granularity provides faster resynchronization. The default region size is 64k (64KB).

   The following example creates a 1GB mirrored cache volume, `cachevol`, in the clone storage pool, `myclpool`, within the disk group, `mydg`:

   ```
   # vxvoladm -g mydg -p myclpool make mycache 1g \
     rules="mirror 2" type=cachevolume
   ```

3. Once the cache volume has been created, use the following command to prepare each space-optimized snapshot that uses the cache volume:

   ```
   # vxvoladm [-g diskgroup] [-p storage_pool] make sovol srcvol_len\
     [storage_specification ...] [attribute ...] type=snapshot \
     cachevolume=cachevol init=active
   ```

Note The *srcvol_len* argument specifies the length of the source volume for which the snapshot is being prepared. This value defines the logical size of the snapshot. The actual amount of storage that the snapshot requires is less than this, and is limited by the size of the cache volume.

For example, this command creates a space-optimized snapshot volume that uses the cache volume, `mycache`:

```
# vxvoladm -g mydg -p myclpool make mysovol 10g type=snapshot \
  cachevolume=mycache
```

Note The argument `10g` is the size of the source volume for which the snapshot `mysovol` is being prepared.

Once created, such a volume is ready for use to take a space-optimized instant snapshot.

Alternatively, you can use the following command to create a cache volume and prepare the space-optimized snapshot volumes in a single operation:

```
# vxvoladm -M make <<!!
  volumegroup {
      diskgroup "diskgroup"
      volume "cachevol" cache_size {
          type cachevolume
          [storage_specification]
          [regionsize size]
      }
      volume "sovol1" vol1_size {
          init active
          cachevolume "cachevol"
      }
      volume "sovol2" vol2_size {
          init active
          cachevolume "cachevol"
      }
.
.
.
};
!!
```

Note Because of its complexity, it is recommended that you run this command as a script.

For the examples given earlier in this section, the combined form of the command would be:

```
# vxvoladm -M make <<!!
  volumegroup {
     diskgroup "mydg"
     volume "mycache" 1g {
        type cachevolume
        capability 'DataMirroring(nmirs=2)'
     }
     volume "mysovol" 10g {
        init active
        cachevolume "cachevol"
     }
};
!!
```

Tuning the autogrow Attributes

The `highwatermark`, `autogrowby` and `maxautogrow` attributes determine how the VxVM cache daemon (`vxcached`) maintains the cache if the `autogrow` feature has been enabled and `vxcached` is running:

- When cache usage reaches the high watermark value, `highwatermark` (default value is 90 percent), `vxcached` grows the size of the cache volume by the value of `autogrowby` (default value is 20% of the size of the cache volume in blocks). The new required cache size cannot exceed the value of `maxautogrow` (default value is twice the size of the cache volume in blocks).
- When cache usage reaches the high watermark value, and the new required cache size would exceed the value of `maxautogrow`, `vxcached` deletes the oldest snapshot in the cache. If there are several snapshots with the same age, the largest of these is deleted.

If the `autogrow` feature has been disabled:

- When cache usage reaches the high watermark value, `vxcached` deletes the oldest snapshot in the cache. If there are several snapshots with the same age, the largest of these is deleted. If there is only a single snapshot, this snapshot is detached and marked as invalid.

Note The `vxcached` daemon does not remove snapshots that are currently open, and it does not remove the last or only snapshot in the cache.

If the cache space becomes exhausted, the snapshot is detached and marked as invalid. If this happens, the snapshot is unrecoverable and must be removed. Enabling the `autogrow` feature on the cache helps to avoid this situation occurring. However, for very small caches (of the order of a few megabytes), it is possible for the cache to become exhausted before the system has time to respond and grow the cache. In such cases, either increase the size of the cache manually as described in "Growing and Shrinking a Cache" on page 78, or use the `vxcache set` command to reduce the value of `highwatermark` for the cache object, as shown in this example:

```
# vxcache -g mydg set highwatermark=60 cobjmydg
```

You can use the `maxautogrow` attribute to limit the maximum size to which a cache can grow. To estimate this size, consider how much the contents of each source volume are likely to change between snapshot refreshes, and allow some additional space for contingency.

If necessary, you can use the `vxcache set` command to change other `autogrow` attribute values for a cache. See the `vxcache`(1M) manual page for details.

Caution Ensure that the cache is sufficiently large, and that the `autogrow` attributes are configured correctly for your needs.

Growing and Shrinking a Cache

You can use the `vxcache` command to increase the size of the cache volume that is associated with a cache object:

```
# vxcache [-g diskgroup] growcacheto cache_object size
```

For example, to increase the size of the cache volume associated with the cache, `mycache`, to 2GB, use the following command:

```
# vxcache -g mydg growcacheto mycache 2g
```

To grow a cache by a specified amount, use the following form of the command:

```
# vxcache [-g diskgroup] growcacheby cache_object size
```

For example, to increase the size of the cache, `mycache`, by 1GB, you would use the following command:

```
# vxcache -g mydg growcacheby mycache 1g
```

You can similarly use the `shrinkcacheby` and `shrinkcacheto` operations to reduce the size of a cache. See the `vxcache`(1M) manual page for more information.

Removing a Cache

To remove a cache completely, including the cache object, its cache volume and all space-optimized snapshots that use the cache:

1. Run the following command to find out the names of the top-level snapshot volumes that are configured on the cache object:

   ```
   # vxprint -g diskgroup -vne \
   "v_plex.pl_subdisk.sd_dm_name ~ /cache_object/"
   ```

   where *cache_object* is the name of the cache object.

2. Remove all the top-level snapshots and their dependent snapshots (this can be done with a single command):

   ```
   # vxedit -g diskgroup -r rm snapvol ...
   ```

   where *snapvol* is the name of a top-level snapshot volume.

3. Stop the cache object:

   ```
   # vxcache -g diskgroup stop cache_object
   ```

4. Finally, remove the cache object and its cache volume:

   ```
   # vxedit -g diskgroup -r rm cache_object
   ```

Creating Instant Snapshots

Note Instant snapshots of ISP application volumes in a disk group's data pool are best created in clone pools that are also associated with the same disk group. A snapshot of a snapshot does not have to be in the same clone pool as its parent.

Volume sets can be used in place of volumes with the following `vxsnap` operations on instant snapshots: `addmir`, `dis`, `make`, `prepare`, `reattach`, `refresh`, `restore`, `rmmir`, `split`, `syncpause`, `syncresume`, `syncstart`, `syncstop`, `syncwait`, and `unprepare`. A snapshot of a volume set must itself be a volume set. A full-sized instant snapshot of a volume set can be created using a prepared volume set. You cannot use the `nmirrors` or `plex` attributes to specify that existing plexes are to be broken off. See the chapter "Creating and Administering Volume Sets" in the *VERITAS Volume Manager Administrator's Guide* for more information on creating volume sets.

VxVM allows you to make instant snapshots of volumes by using the `vxsnap` command.

A plex in a full-sized instant snapshot requires as much space as the original volume. If you instead make a space-optimized instant snapshot of a volume, this only requires enough storage to record the original contents of the parent volume as they are changed during the life of the snapshot.

The recommended approach to performing volume backup from the command line, or from a script, is to use the `vxsnap` command. The `vxsnap prepare` and `make` tasks allow you to back up volumes online with minimal disruption to users.

The `vxsnap prepare` step creates a DCO and DCO volume and associates this with the volume. It also enables Persistent FastResync on the volume.

The `vxsnap make` step creates an instant snapshot that is immediately available for making a backup. After the snapshot has been taken, read requests for data in the original volume are satisfied by reading either from a non-updated region of the original volume, or from the copy of the original contents of an updated region that have been recorded by the snapshot.

Note Synchronization of a full-sized instant snapshot from the original volume is enabled by default. If you specify the `syncing=no` attribute to `vxsnap make`, this disables synchronization, and the contents of the instant snapshot are unlikely ever to become fully synchronized with the contents of the original volume at the point in time that the snapshot was taken. If you wish to turn an instant snapshot volume into an independent volume, you must ensure that it has been completely synchronized.

You can immediately retake a full-sized or space-optimized instant snapshot at any time by using the `vxsnap refresh` command. If a fully synchronized instant snapshot is required, you must wait for the new resynchronization to complete.

To back up a volume with the `vxsnap` command, use the following procedure:

1. If you intend to take a space-optimized instant snapshot of the volume, you must first set up a shared cache volume in the same disk group as the volume. This cache object for this cache volume can be maintained by using the `vxcache` command.

   For both full-sized and space-optimized instant snapshots, you must also create a volume for use as the snapshot volume. This volume must have the same region size as that of the volume for which the snapshot is being created. In addition, a volume that is created for use as a full-sized instant snapshot must be the same size as the volume for which the snapshot is being created.

   See "Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots" on page 75 for details of how to set up a shared cache volume, and how to prepare space-optimized snapshots that share this cache.

   See "Creating a Volume for Use as a Full-Sized Instant Snapshot" on page 74 for details of how to prepare a volume for use as a full-sized instant snapshot.

Note If you intend to split the clone pool that contains snapshots into separate disk groups, the clone pool must only contain fully synchronized full-sized instant snapshots (which do not require a cache volume). You cannot split off a clone pool that contains either a cache volume or space-optimized instant snapshots.

---

2. Use the following commands on the primary host to see if the volume is associated with a version 20 data change object (DCO) and DCO volume that allow instant snapshots and Persistent FastResync to be used with the volume, and to check that FastResync is enabled on the volume:

```
# vxprint -g volumedg -F%instant volume
# vxprint -g volumedg -F%fastresync volume
```

If both these command return a value of `on`, the volume can be used for instant snapshot operations.

To prepare a volume for instant snapshots, use the following command:

```
# vxsnap [-g diskgroup] prepare volume [regionsize=size] \
  [ndcomirs=number] [alloc=storage_attributes]
```

Note It is only necessary to run this command on a volume if it does not already have a version 20 DCO volume.

For example, to prepare the volume, my`vol`, in the disk group, `mydg`, use the following command:

```
# vxsnap -g mydg prepare myvol regionsize=128k ndcomirs=2
```

This example creates a DCO object and redundant DCO volume with two plexes, and associates them with `myvol`. The region size is also increased to 128KB from the default size of 64KB. The region size must be a power of 2, and be greater than or equal to 16KB. A smaller value requires more disk space for the change maps, but the finer granularity provides faster resynchronization.

Note If you intend to create space-optimized instant snapshots that share a cache volume, the region size that you specify for the volume must be greater than or equal to any region size that you specify for the cache volume. Creation of space-optimized snapshots that use a shared cache fails if the region size of the volume is smaller than the region size of the cache.

If the region size of a space-optimized snapshot differs from the region size of the cache, this can degrade the system's performance compared to the case where the region sizes are the same.

---

3. Use the vxsnap make step to create an instant snapshot that is immediately available for making a backup. If you specify a name or size for a storage cache, a space-optimized snapshot is created that requires less space than does a full-sized instant snapshot volume.

❖ To create a full-sized instant snapshot, *snapvol*, use one of the following forms of the vxsnap make command:

```
# vxsnap [-g diskgroup] make source=volume/snapvol=snapvol\
  [/syncing=off]
```

Note The attributes for a snapshot are specified as a tuple. The vxsnap make command accepts multiple tuples; one for each snapshot that is being created. A tuple for a full-sized instant snapshot must contain a source attribute and a snapvol attribute. Each element of a tuple is separated from the next by a slash character (/). Tuples are separated by white space.

This command specifies an existing volume, *snapvol*, that is to be used as the snapshot volume. See "Creating a Volume for Use as a Full-Sized Instant Snapshot" on page 74 for details.

Background synchronization of the snapshot volume from its parent volume is enabled by default (equivalent to specifying the syncing=on attribute). If you do not want to move the snapshot into a separate disk group, or turn it into an independent volume, specify the syncing=off attribute to disable synchronization. This avoids unnecessary system overhead.

For example, to use the prepared volume, snap1myvol, as the snapshot for the volume, myvol, in the disk group, mydg, use the following command:

```
# vxsnap -g mydg make source=myvol/snapvol=snap1myvol
```

If you want to move a snapshot into a separate disk group, or to turn it into an independent volume, you must wait for its contents to be synchronized with those of its parent volume.

For example, to use the prepared volume, snap2myvol, as the snapshot for the volume, myvol, in the disk group, mydg, on the volume, use the following command:

```
# vxsnap -g mydg make source=myvol/snapvol=snap2myvol
```

You can use the vxsnap syncwait command to wait for the synchronization of the snapshot volume to be completed, as shown here:

```
# vxsnap [-g diskgroup] syncwait snapvol
```

For example, you would use the following command to wait for synchronization to finish on the snapshot volume, snap2myvol:

```
# vxsnap -g mydg syncwait snap2myvol
```

This command exits (with a return code of zero) when synchronization of the snapshot volume is complete. The snapshot volume may then be moved to another disk group or turned into an independent volume.

If required, you can use the following command to verify whether the `V_PFLAG_INCOMPLETE` flag is set on a volume:

```
# vxprint [-g diskgroup] -F%incomplete snapvol
```

This command returns the value `off` if synchronization of the volume, *snapvol*, is complete; otherwise, it returns the value `on`.

See “Controlling Instant Snapshot Synchronization” on page 90 for more information.

❖ To create a space-optimized instant snapshot, *`snapvol`*, that uses a prepared space-optimized snapshot:

```
# vxsnap [-g diskgroup] make source=vol/snapvol=snapvol
```

For example, to create the space-optimized instant snapshot of the volume, `myvol`, in the disk group, `mydg`, and the prepared snapshot, `snap3myvol`, enter the following command:

```
# vxsnap -g mydg make source=myvol/snapvol=snap3myvol
```

For details of how to create a shared cache object and prepare a snapshot that uses this cache, see “Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots” on page 75.

4. Use `fsck` (or some utility appropriate for the application running on the volume) to clean the temporary volume’s contents. For example, you can use this command:

```
# fsck -F vxfs /dev/vx/rdsk/diskgroup/snapshot
```

5. If you require a backup of the data in the snapshot, use an appropriate utility or operating system command to copy the contents of the snapshot to tape, or to some other backup medium.

You have the following choices for what to do with an instant snapshot:

◆ Refresh the contents of the snapshot. This creates a new point-in-time image of the original volume ready for another backup. If synchronization was already in progress on the snapshot, this operation may result in large portions of the snapshot having to be resynchronized. See “Refreshing an Instant Snapshot (vxsnap refresh)” on page 86 for details.

◆ Restore the contents of the original volume from the snapshot volume. For full instant snapshot volumes, you can choose whether none, a subset, or all of the plexes of the snapshot volume are returned to the original volume as a result of the operation. A space-optimized instant snapshot always remains intact at the end of the operation. See "Restoring a Volume from an Instant Snapshot (vxsnap restore)" on page 87 for details.

- Dissociate the snapshot volume entirely from the original volume. This may be useful if you want to use the copy for other purposes such as testing or report generation. If desired, you can delete the dissociated volume. See "Dissociating an Instant Snapshot (vxsnap dis)" on page 88 for details.

Note For space-optimized instant snapshots, this operation is only useful if you then want to delete the snapshot altogether.

- If the snapshot is part of a snapshot hierarchy, you can also choose to split this hierarchy from its parent volumes. See "Splitting an Instant Snapshot Hierarchy (vxsnap split)" on page 89 for details.

Note This operation is not supported for space-optimized instant snapshots.

Creating Multiple Instant Snapshots

Note In these examples, all snapshot volumes and any cache volumes must be prepared in advance as described in "Creating a Volume for Use as a Full-Sized Instant Snapshot" on page 74 and "Creating a Shared Cache Volume and Preparing Space-Optimized Snapshots" on page 75.

To make it easier to create snapshots of several volumes at the same time, the vxsnap `make` command accepts multiple tuples that define the source and snapshot volumes names as their arguments. For example, to create three instant snapshots, each with the same redundancy, the following form of the command can be used:

```
# vxsnap [-g diskgroup] make \
  source=vol1/snapvol=snapvol1 \
  source=vol2/snapvol=snapvol2 \
  source=vol3/snapvol=snapvol3
```

The specified source volumes (*`vol1`*, *`vol2`* and so on) may be the same volume or different volumes.

The `vxsnap make` command allows the snapshots to be of different types as shown here:

```
# vxsnap [-g diskgroup] make \
  source=vol1/snapvol=snapvol1 \
  source=vol2/snapvol=snapvol2
```

In this example, `snapvol1` is a full-sized snapshot, and `snapvol2` is a space-optimized snapshot.

Adding a Snapshot to a Cascaded Snapshot Hierarchy

To create a snapshot and push it onto a snapshot hierarchy between the original volume and an existing snapshot volume, specify the name of the existing snapshot volume as the value of the `infrontof` attribute to the `vxsnap make` command. The following example, shows how to place the space-optimized snapshot, `thurs_bu`, of the volume, `dbvol`, in front of the earlier snapshot, `wed_bu`:

```
# vxsnap -g dbdg make source=dbvol/snapvol=thurs_bu/\
infrontof=wed_bu/cache=dbdgcache
```

Similarly, the next snapshot that is taken, `fri_bu`, is placed in front of `thurs_bu`:

```
# vxsnap -g dbdg make source=dbvol/snapvol=fri_bu/\
infrontof=thurs_bu/cache=dbdgcache
```

For more information on the application of cascaded snapshots, see the *VERITAS Volume Manager Administrator's Guide.*

Refreshing an Instant Snapshot (vxsnap refresh)

Refreshing an instant snapshot replaces it with another point-in-time copy of a parent volume. To refresh one or more snapshots and make them immediately available for use, use the following command:

```
# vxsnap [-g diskgroup] refresh snapvol [source=vol] \
  [[snapvol2 source=vol2]...] [sync=yes|no]
```

If the source volume is not specified, the immediate parent of the snapshot is used. For full-sized instant snapshots, resynchronization is started by default. To disable resynchronization, specify the `syncing=no` attribute. This attribute is not supported for space-optimized snapshots.

Note The snapshot being refreshed must not be open to any application. For example, any file system configured on the volume must first be unmounted.

It is possible to refresh a volume from an unrelated volume provided that their sizes are compatible.

You can use the `vxsnap syncwait` command to wait for the synchronization of the snapshot volume to be completed, as shown here:

```
# vxsnap [-g diskgroup] syncwait snapvol
```

See “Controlling Instant Snapshot Synchronization” on page 90 for more information.

Attaching Plexes of an Instant Snapshot (vxsnap reattach)

Note Although this operation is named `reattach`, the plexes of an ISP snapshot volume could never have belonged to the parent volume. For this reason, the description below refers to the *attachment*, rather than the *reattachment*, of snapshot plexes.

This operation is not supported for space-optimized instant snapshots.

Using the following command, some or all plexes of an instant snapshot may be attached to the specified source volume, or to a source volume in the snapshot hierarchy above the snapshot volume:

```
# vxsnap -f [-g diskgroup] reattach snapvol source=vol \
  [nmirror=number]
```

Caution This operation requires the specification of the `-f` (force) option as it violates the intent of the source volume. After the `reattach` operation completes, it may not be possible to perform other operations such as resizing the volume or transforming the layout of the volume. To restore the intent of the volume and allow such operations to be performed, use the `vxplex dis` *`plex`* command to dissociate the attached snapshot plexes.

By default, all the plexes are attached, which results in the removal of the snapshot. If required, the number of plexes to be attached may be specified as the value assigned to the `nmirror` attribute.

Note The snapshot being reattached must not be open to any application. For example, any file system configured on the snapshot volume must first be unmounted.

Only the plexes of a snapshot volume that was set up using ISP may be attached.

If the snapshot volume and the source volume lie in different storage pools, the underlying disks of the snapshot volume are moved to the source volume's storage pool. However, if other objects in the snapshot volume's storage pool are also configured on these disks, the `reattach` command fails.

For example the following command attaches one plex from the snapshot volume, `snapmyvol`, to the volume, `myvol`:

```
# vxsnap -g mydg -f reattach snapmyvol source=myvol nmirror=1
```

Restoring a Volume from an Instant Snapshot (vxsnap restore)

On occasion, it may be desirable to reinstate the contents of a volume from a backup or modified replica within a snapshot volume. The following command may be used to restore a volume:

```
# vxsnap [-g diskgroup] restore [nmirrors=number] vol \
  [source=snapvol] [destroy=yes|no]
```

For a full instant snapshot, some or all of its plexes may be reattached to the parent volume or to a specified source volume in the snapshot hierarchy above the snapshot volume. If `destroy=yes` is specified, all the plexes of the snapshot are reattached and the snapshot volume is removed.

For a space-optimized instant snapshot, the cached data is used to restore the contents of the specified volume. The snapshot itself remains unchanged by the operation.

Note For this operation to succeed, the volume that is being restored and the snapshot volume must not be open to any application. For example, any file systems that are configured on either volume must first be unmounted.

It is not possible to restore a volume from an unrelated volume.

The `destroy` and `nmirror` attributes are not supported for space-optimized instant snapshots.

The following example demonstrates how to restore the volume, `myvol`, from the space-optimized snapshot, `snap3myvol`.

```
# vxsnap -g mydg restore myvol source=snap3myvol
```

Dissociating an Instant Snapshot (vxsnap dis)

The following command breaks the association between a snapshot volume, *snapvol*, and its parent volume, so that the snapshot may be used as an independent volume:

```
# vxsnap [-f] [-g diskgroup] dis snapvol
```

This operation fails if the snapshot, *snapvol*, has a snapshot hierarchy below it that contains unsynchronized snapshots. If this happens, the dependent snapshots must be fully synchronized from *snapvol*. When no dependent snapshots remain, *snapvol* may be dissociated. The snapshot hierarchy is then adopted by *snapvol*'s parent volume.

Note To be usable after dissociation, the snapshot volume and any snapshots in the hierarchy must have been fully synchronized. See "Controlling Instant Snapshot Synchronization" on page 90 for more information. In addition, you cannot dissociate a snapshot if synchronization of any of the dependent snapshots in the hierarchy is incomplete. If an incomplete snapshot is dissociated, it is unusable and should be deleted as described in "Removing an Instant Snapshot" on page 89.

The following command dissociates the snapshot, `snap2myvol`, from its parent volume:

```
# vxsnap -g mydg dis snap2myvol
```

Note When applied to a volume set or to a component volume of a volume set, this operation can result in inconsistencies in the snapshot hierarchy in the case of a system crash or hardware failure. If the operation is applied to a volume set, the `-f` (force) option must be specified.

Removing an Instant Snapshot

When you have dissociated a full-sized instant snapshot, you can use the `vxvoladm` command to delete it altogether, as shown in this example:

```
# vxvoladm -g mydg remove volume snap2myvol
```

You can also use this command to remove a space-optimized instant snapshot from its cache. For details of how to remove a cache, see "Removing a Cache" on page 79.

Splitting an Instant Snapshot Hierarchy (vxsnap split)

Note This operation is not supported for space-optimized instant snapshots.

The following command breaks the association between a snapshot hierarchy that has the snapshot volume, *snapvol*, at its head, and its parent volume, so that the snapshot hierarchy may be used independently of the parent volume:

```
# vxsnap [-f] [-g diskgroup] split snapvol
```

Note The topmost snapshot volume in the hierarchy must have been fully synchronized for this command to succeed. Snapshots that are lower down in the hierarchy need not have been fully resynchronized. See "Controlling Instant Snapshot Synchronization" on page 90 for more information.

The following command splits the snapshot hierarchy under `snap2myvol` from its parent volume:

```
# vxsnap -g mydg split snap2myvol
```

Note When applied to a volume set or to a component volume of a volume set, this operation can result in inconsistencies in the snapshot hierarchy in the case of a system crash or hardware failure. If the operation is applied to a volume set, the `-f` (force) option must be specified.

Displaying Instant Snapshot Information (vxsnap print)

The `vxsnap print` command may be used to display information about the snapshots that are associated with a volume.

```
# vxsnap [-g diskgroup] print [vol]
```

This command shows the percentage progress of the synchronization of a snapshot or volume. If no volume is specified, information about the snapshots for all the volumes in a disk group is displayed.

The following example shows a volume, `vol1`, which has a full-sized snapshot, `snapvol1` whose contents have not been synchronized with `vol1`:

```
# vxsnap -g mydg print
NAME      SNAPOBJECT     TYPE    PARENT     SNAPSHOT   %DIRTY   %VALID

vol1      --             volume  --         --         --       100
          snapvol1_snp1  volume  --         snapvol1   1.30     --
snapvol1  vol1_snp1      volume  vol1       --         1.30     1.30
```

The `%DIRTY` value for `snapvol1` shows that its contents have changed by 1.30% when compared with the contents of `vol1`. As `snapvol1` has not been synchronized with `vol1`, the `%VALID` value is the same as the `%DIRTY` value. If the snapshot were partly synchronized, the `%VALID` value would lie between the `%DIRTY` value and 100%. If the snapshot were fully synchronized, the `%VALID` value would be 100%. The snapshot could then be made independent or moved into another disk group.

Controlling Instant Snapshot Synchronization

Note Synchronization of the contents of a snapshot with its original volume is not possible for space-optimized instant snapshots.

By default, synchronization is enabled for the `vxsnap refresh` and `restore` operation on instant snapshots. Otherwise, synchronization is disabled unless you specify the `sync=yes` attribute to the `vxsnap` command.

The following table shows the commands that are provided for controlling the synchronization manually.

Command	**Description**
`vxsnap [-g` *`diskgroup`*`] syncpause` *`vol`*	Pause synchronization of a volume.
`vxsnap [-g` *`diskgroup`*`] syncresume` *`vol`*	Resume synchronization of a volume.
`vxsnap [-b] [-g` *`diskgroup`*`] syncstart` *`vol`*	Start synchronization of a volume. The `-b` option puts the operation in the background.
`vxsnap [-g` *`diskgroup`*`] syncstop` *`vol`*	Stop synchronization of a volume.

Command	Description
`vxsnap [-g diskgroup] syncwait vol`	Exit when synchronization of a volume is complete. An error is returned if `vol` is invalid (for example, it is a space-optimized snapshot), or if `vol` is not being synchronized.

Improving the Performance of Snapshot Synchronization

Two optional arguments to the `-o` option are provided to help optimize the performance of synchronization when using the `make`, `refresh`, `restore` and `syncstart` operations:

`iosize=`*`size`*	Specifies the size of each I/O request that is used when synchronizing the regions of a volume. Specifying a larger size causes synchronization to complete sooner, but with greater impact on the performance of other processes that are accessing the volume. The default *size* of 1m (1MB) is suggested as the minimum value for high-performance array and controller hardware. The specified value is rounded to a multiple of the volume's region size.
`slow=`*`iodelay`*	Specifies the delay in milliseconds between synchronizing successive sets of regions as specified by the value of `iosize`. This can be used to change the impact of synchronization on system performance. The default value of iodelay is 0 milliseconds (no delay). Increasing this value slows down synchronization, and reduces the competition for I/O bandwidth with other processes that may be accessing the volume.

Options may be combined as shown in the following examples:

```
# vxsnap -g mydg -o iosize=2m,slow=100 make \
 source=myvol/snapvol=snap2myvol/syncing=on
```

```
# vxsnap -g mydg -o iosize=10m,slow=250 syncstart snap2myvol
```

Note These optional parameters only affect the synchronization of full-sized instant snapshots. They are not supported for space-optimized snapshots.

Administering Volume Templates and Other Configuration Elements 6

The VERITAS Intelligent Storage Provisioning (ISP) feature creates volumes with a set of rules or capabilities. A volume template (or template for short) is a collection of rules that provide capabilities. ISP refers to templates when creating a volume, and selects an appropriate set of templates to use based on the requested capabilities.

ISP follows certain rules when selecting templates to match a requested set of capabilities. See "Rules" on page 113 for more details. For a list of the standard templates that are provided by ISP, see "Volume Templates" on page 153.

The procedures in this chapter use the `vxtemplate` command. For full information about using this command, see the `vxtemplate`(1M) manual page.

Installing Configuration Elements into the ISP Database

Storage pool, storage pool set, template set, template and capability definitions are referred to as *configuration elements*. A standard set of configuration elements are included in the Configuration Database that is installed with the ISP package (see "ISP Configuration Elements" on page 147). These configuration elements cover a broad range of uses, and should be sufficient for most applications. To make additional configuration elements available for use, they must be installed in the Configuration Database.

To install additional elements that are defined in a file, use the following command:

```
# vxtemplate -C -d element_defs_file install
```

You can select only to install selected elements from a file by naming them explicitly as shown here:

```
# vxtemplate -r -C -d my_templates install template=Reliability
```

The `-r` (recursive) option ensures that all capabilities and templates that are referred to by the `Reliability` template are also installed.

Installing Configuration Elements into Storage Pools and Disk Groups

If you specify a template set, storage pool definition or a storage pool set definition when creating a storage pool, the required templates and capabilities are automatically associated with the storage pool and with its disk group. (See "Creating a Storage Pool" on page 34 for details.)

A storage pool's `selfsufficient` policy governs whether configuration elements can be installed automatically from the Configuration Database as required. If the policy is set to `host`, elements are available to the pool from the Configuration Database, from the disk group and from the pool itself. If the policy is set to `diskgroup`, the pool can install additional elements from the disk group, but not from the Configuration Database. A policy value of `pool` means that only elements that are installed in the pool can be used. If required, you can use the `vxtemplate` command to install templates, capabilities and template sets from the Configuration Database into disk groups and pools.

Template sets are convenient for installing many capabilities and templates in a single operation. The following example shows how to install all the capabilities and templates from the template set, `DataMirroring`, into a storage pool, `mypool`, and its disk group, `mydg`:

```
# vxtemplate -g mydg -p mypool install template_set=DataMirroring
```

This is equivalent to using this (very long) command:

```
# vxtemplate -r -g mydg -p mypool install \
template=DataMirroring,ArrayProductId,\
ConfineLogsToSimilarStorage,ConfineMirrorsToSimilarStorage,\
DCOLogMirroring,InstantSnapshottable,LogsOnSeparateComponents,\
MirrorsOnSeparateComponents
```

Listing and Printing Configuration Elements

Use the following command to list the templates and capabilities that are associated with a specified disk group and/or storage pool.

```
# vxtemplate [-g diskgroup] [-p pool] list
```

This command displays results similar to the following.

```
TY NAME                         STATE   AUTOINSTALL
vt Mirroring                    Active  0
vt MirroringStriping            Active  0
vt Raid5Template                Active  0
vt Striping                     Active  0
cp ParityReliable               -       -
cp PerformanceByStriping        -       -
cp Reliability                  -       -
```

Here the types `vt` and `cp` indicate volume template and capability definitions.

To print the details of these templates and capabilities, use this command:

```
# vxtemplate [-g diskgroup] [-p pool] print
```

You can print the details of only certain elements by specifying these as arguments to the command:

```
# vxtemplate [-g diskgroup] [-p pool] print [template=t1[,t2...]] \
  [capability=c1[,c2...]] [template_set=ts1[,ts2...]] \
  [storage_pool_set=ps1[,ps2...]] [pool_definition=pd1[,pd2...]]
```

For example, to print the definitions of the `Mirroring` and `Striping` volume templates that are associated with the storage pool, `mypool`, in the disk group, `mydg`, you would use this command:

```
# vxtemplate -g mydg -p mypool print template=Mirroring,Striping
```

The following command lists all the templates and capabilities that are available in the ISP Configuration Database on the system:

```
# vxtemplate -C list
```

The output from this command is similar to the following.

```
TY NAME                         STATE   AUTOINSTALL
vt DataMirroring                -       -
vt Raid5Volume                  -       -
vt Reliability                  -       -
vt Striping                     -       -
cp DataMirroring                -       -
cp DataRedundancy               -       -
cp Raid5LogMirroring            -       -
cp Raid5Capability              -       -
cp Reliability                  -       -
cp Striping                     -       -
ts Raid5Templates               -       -
pd raid5_volumes                -       -
ps mirrored_data_striped_clones -       -
.
.
.
```

Here the types `ts`, `pd` and `ps` indicate template set, storage pool and storage pool set definitions respectively.

To print the details of elements in the Configuration Database, use this command:

```
# vxtemplate -C print [template=t1[,t2...]] \
  [capability=c1[,c2...]] [template_set=ts1[,ts2...]] \
  [storage_pool_set=ps1[,ps2...]] [pool_definition=pd1[,pd2...]]
```

As for storage pools and disk groups, you can print the details of certain elements by specifying these as arguments to the command, for example:

```
# vxtemplate -C print template_set=DataMirroring,Raid5Templates
```

You can also use the `listcapabilities`, `listtemplates` and `listtemplatesets`, `listpooldefinitions`, and `listpoolsets` keywords of `vxtemplate` to list only the capabilities or templates that are associated with the specified disk group and/or storage pool. Similarly, the `printcapabilities`, `printtemplates` and `printtemplatesets`, `printpooldefinitions`, and `printpoolsets` keywords are used to print the element definitions in detail. For more information, see the `vxtemplate`(1M) manual page.

Deactivating and Reactivating Templates

By default, templates are activated when they are associated with a storage pool. You can run the `vxtemplate deactivate` command to prevent one or more templates from being used in the storage pool with which they have been associated:

```
# vxtemplate [-g diskgroup] [-p pool] deactivate \
  template=template[,template...]
```

If the template is currently in use, ISP displays an error message.

You can reactivate templates by using the `vxtemplate activate` command:

```
# vxtemplate [-g diskgroup] [-p pool] activate \
  template=template[,template...]
```

Renaming a Capability

To change the name of a capability, use the following command:

```
# vxtemplate [-C | -g diskgroup] renamecapability oldname newname
```

For example, you may want to change the name if you have modified the attributes of the capability for a particular disk group.

Renaming a Template

To change the name of a template, use the following command:

```
# vxtemplate [-C | -g diskgroup] renametemplate oldname newname
```

For example, you may want to change the name if you have modified a template for a particular disk group.

Removing Templates, Capabilities and Template Sets

To remove a template, capability or template set from a disk group and/or storage pool, or from the ISP Configuration Database, use the `vxtemplate uninstall` command. For example, the following command removes the definitions of the DataMirroring template and capability from the storage pool, `mypool`, in the disk group, `mydg`:

```
# vxtemplate -g mydg -p mypool uninstall template=DataMirroring \
  capability=DataMirroring
```

The following command similarly removes this template and capability from the ISP Configuration Database:

```
# vxtemplate -C uninstall template=DataMirroring \
  capability=DataMirroring
```

Note If a template is associated with any ISP volumes, you cannot dissociate the template from a storage pool, or uninstall the template from a disk group without first deleting the volumes. To display which templates are associated with ISP volumes, use the following command:

```
# vxvoladm -g diskgroup printintent volume ...
```

Creating and Modifying User Templates 7

When using VERITAS Intelligent Storage Provisioning (ISP) to create an application volume with a specified set of capabilities, you can usually enter values for the parameters that modify these capabilities. For example, you can select the degree of redundancy, fault tolerance, or performance that you require from the volume. For convenience in creating volumes, you can set up user templates to store commonly used sets of capabilities and parameter values. You can then specify the name of a user template instead of the name of a capability when using the `vxvoladm` command to create an application volume.

Format of User Templates

A user template consists of a list of capabilities and rules. Associated with each capability is a list of parameter-value pairs that define default parameter values for the capability. The format of a typical user template specification is shown here:

```
user_template usertmplt_tname {
  description "string"
  descriptionid id
  capability capability1 {
    attribute_name:type = default_value
    ...
  }
  capability capability2 {
    attribute_name = default_value
    ...
  }
  ...
  rules {
    rule1
    rule2
    ...
  }
};
```

This definition has the following important components:

`usertmplt_name`	Defines the name of the user template, for example, `MyReliableReplication`, and `MySWSnapshot`.
`description`	Describes a user template in English.
`descriptionid`	References the message catalog where localized versions of the description may be found, and provides an index number for the description in the catalog.
`capability`	Indicates the capabilities that are provided by volumes created from the user template.
`attribute_name`	Defines the name and value of a parameter.
`rules`	Specifies the start of the section that contains the rules for selecting and laying out storage, and which implement the capabilities that the user template provides. See "Rules" on page 113.

For a formal definition of `user_template` in the ISP language, see "User Template" on page 142.

For example, consider a capability named `HardwareReplication` that has two variable parameters that specify the source and the destination:

```
capability HardwareReplication {
  var source:string
  var destination:string
};
```

In addition, the capability named `Reliable`, provides reliability by creating a mirrored volume:

```
capability Reliable {
  var NMIRS:int
};
```

Rules can also be specified to user templates, as shown in these examples that could be used for creating application volumes for database tables and indexes:

```
user_template DB_Table {
  description "Makes mirrored volume for a database table"
  capability DataMirroring {
    NMIRS = 2
  }
  rules {
    confineto "VendorName"="EMC"
  }
};
```

```
user_template DB_Index {
  description "Makes high performance volume for a database index"
  capability Striping {
    NCOLS = 8
  }
  rules {
    confineto "VendorName"="EMC"
  }
};
```

The user template, `DB_Table`, can be used to create a mirrored volume with two plexes, but is restricted to using only EMC disks. Similarly, the user template, `DB_Index`, can be used to create a striped volume with eight columns, and is also restricted to using only EMC disks.

Creating User Templates

You can either create a user template by defining it directly from the command line, or by defining it in a configuration file. The first method is only suitable for very simple user templates. It is usually preferable to define your templates in a configuration file.

To create a user template directly from the command line, use the `vxusertemplate create` command as shown here:

```
# vxusertemplate create usertemplate_name \
  [description="string"] \
  [rules=rule1 [rule2 ]...] \
  [capability=capability1[(var1=value1[,var2=value2]...)]\
            [,capability2[(var1=value1[,var2=value2]...)]]...]
```

For example, the following command creates a user template named `RP_DB_Table` that has both `Reliable` and `HighPerformance` capabilities:

```
# vxusertemplate create RP_DB_Table \
  description="Makes reliable high performance volume \
  for database table"rules=confineto "VendorName"="EMC" \
  capability='DataMirroring(NMIRS=2),Striping(NCOLS=8)'
```

This command adds the user template to the global `usertemplates` file that is maintained by ISP.

Alternatively, you can create a configuration file that contains an equivalent user template, as shown in this sample listing:

```
user_template DB_Table {
  description "Makes mirrored volume for database table"
  capability DataMirroring {
    NMIRS = 2
  }
  rules {
    confineto "VendorName"="EMC"
  }
};

user_template DB_Index {
  description "Makes high performance volume for database index"
  capability Striping {
    NCOLS = 8
  }
  rules {
    confineto "VendorName"="EMC"
  }
};
```

You can then use the `-d` option with `vxusertemplate create` command to add the user template in the configuration file to the global `usertemplates` file, as shown here:

```
# vxusertemplate -d config_file create
```

Using a User Template to Create an Application Volume

You can create an application volume using a user template by specifying the name of the user template in place of the name of a capability to the `vxvoladm make` command. For example, to create a 10GB application volume in the storage pool, `mypool`, using the user template, `RP_DB_Table`, you would use the following command:

```
# vxvoladm -g mydg -p mypool make myDBvol 10g \
  user_template='RP_DB_Table'
```

Note Unlike volume templates, you cannot specify parameter values for user templates on the command line.

Listing Currently Defined User Templates

Use the following command to list all the user templates that are currently defined in the global `usertemplates` file:

```
# vxusertemplate list
```

Printing User Template Definitions

Use the following command to print detailed information about one or more user templates that are currently defined in the global `usertemplates` file:

```
# vxusertemplate print usertemplate1 [usertemplate2 ...]
```

Deleting User Templates

To remove a user template definition from the global `usertemplates` file, use the following command:

```
# vxusertemplate delete usertemplate
```

Using Capabilities, Templates and Rules 8

VERITAS Intelligent Storage Provisioning (ISP) provides a structured and flexible rule-based declarative language for expressing how an application volume with a given set of characteristics is to be configured from the available storage. The language can be used to specify rules for allocating storage to the individual parts of a volume, such as mirrors, columns, logs and snapshots, as well to as an entire volume.

See the following sections in this chapter for more information:

- Capabilities
- Volume Templates
- Rules
- Storage Selection Rules
- Storage Selection Rule Operators
- Storage Layout Rules
- Compound Rules
- Attribute Aliases
- Simplified Syntax for Rules on the Command Line

See "ISP Language Definition" on page 131 for full details of the syntax of capabilities, rules and templates. Also see "ISP Configuration Elements" on page 147 for details of the basic capabilities and templates that are provided for use.

Capabilities

A capability, as expressed in the ISP language, is a description of what a volume is capable of doing. Each template is associated with one or more capabilities so that ISP can choose those templates that are suitable for use in allocating storage to volumes. A capability is interpreted by ISP as a tag.

The format of a typical capability definition is shown here:

```
capability cap_name {
  extends capname1,capname2, ...
  description text
  descriptionid id
  display_name name
  display_name_id catalogid, index
  var varname1:type {
    defaultvalue value
    description description
    descriptionid catalogid, index
  }
  var varname2:type {
    defaultvalue value
    description text
    descriptionid catalogid, index
  }
  ...
};
```

This definition has the following important components:

cap_name	Indicates the nature of the capability, for example, `Reliable`, `Performant`, `Snapshot` and `EMCSnapshot`.
`extends`	Indicates that the capability is derived from other named capabilities. See "Inheritance of Capabilities" on page 107 for more information.
`description`	Describes a capability or one of its variable parameters in English.
`descriptionid`	References the message catalog where localized versions of the description may be found, and provides an index number for the description in the catalog.
`display_name`	Defines the English name of the capability that is displayed in the VEA.
`display_name_id`	References the message catalog where localized versions of the display name may be found, and provides an index number for the display name in the catalog.

`var`	Defines a variable that may be specified as a parameter and its value to a capability. A template can use the variables in its rules section to provide the requested capability. Permitted variable types are `int` or `string`.
`defaultvalue`	Defines the default value of a capability's parameter if no value is specified.

For a formal definition of `capability` in the ISP language, see "Capability" on page 134.

The following is a sample capability definition:

```
capability DataMirroring {
    display_name "Data Mirroring"
    display_name_id "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 3

    description "Volume has multiple copies of data."
    descriptionid "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 4

    extends DataRedundancy
    var nmirs:int {
        display_name "Number of data copies"
       display_name_id "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 5

        description "Specify the number of copies of data."
        descriptionid "{b84f1c64-1dd1-11b2-8b42-080020feef8b}", 6

        defaultvalue 2
    }
};
```

Inheritance of Capabilities

The `extends` keyword in a capability definition allows a capability to inherit some of the properties of one or more *base* capabilities. This implies that such a *derived* capability has an "is a" relationship with these base capabilities. The following rules are applied by the inheritance mechanism:

- A derived capability inherits variables from all its base capabilities.
- A derived capability cannot define variables with the same name as any of the variables in any of its base capabilities.
- If a capability is derived from more than one base capability, none of the variable names in any of its base capabilities should be the same as a variable name in any other base capability.

The following sample capability definitions show how the `DataMirrorStripe` capability is derived from the more general `DataMirroring` and `Striping` capabilities:

```
capability DataMirrorStripe {
    extends DataMirroring, Striping
};
```

`DataMirrorStripe` also inherits the variables `nmirs` and `ncols` from the two capabilities that it extends.

Volume Templates

A volume template (or template for short) is a meaningful collection of rules that provides capabilities for volumes as defined by those rules, or by reference to other capabilities. ISP refers to templates when creating an application volume. It chooses an appropriate template to use based on the capabilities that you request for the volume, and allocates storage by following the rules that the template contains.

The format of a typical template specification is shown here:

```
volume_template template_name {
  extends template1, template2, ...
  inherits capability5, capability6, ...
  provides capability1, capability2, ...
  requires capability3, capability4, ...
  description text
  descriptionid id
  group name
  rules {
    rule1
    rule2
    ...
  }
};
```

This definition has the following important components:

`template_name`	Indicates the nature of the volume that can be created by the template, for example, `DataMirroring`, `Raid5Volume` and `InstantSnapshottable`.
`extends`	Indicates that the template includes all the capabilities, rules and variables from the named templates. See “extends” on page 109 for more information.
`inherits`	Indicates that the template can inherit capabilities when required from those listed. See “inherits” on page 111 for more information.

`provides`	Indicates the capabilities that are provided by volumes created from the template. See "provides" on page 111 for more information.
`requires`	Indicates that the template can acquire rules when required from other templates that provide the specified capabilities. See "requires" on page 112 for more information.
`description`	Describes a template in English.
`descriptionid`	References the message catalog where localized versions of the description may be found, and provides an index number for the description in the catalog.
`group`	Indicates the name of the group to which application volumes created from this template belong.
`rules`	Specifies the start of the section that contains the rules for selecting and laying out storage, and which implement the capabilities that the template provides. The rules usually operate on the values that were specified for the arguments of the requested capabilities. See "Rules" on page 113 and "Compound Rules" on page 123 for more information.

The following sections describe the keywords in detail:

- `extends`
- `group`
- `inherits`
- `provides`
- `requires`

For a formal definition of `volume_template` in the ISP language, see "Volume Template" on page 135.

extends

A template can derive some of its properties by extending one or more base templates as shown in this example:

```
volume_template DerivedTemplate {
  extends BaseTemplate
  rules {
    ...
  }
};
```

By extending template `BaseTemplate`, the template `DerivedTemplate`:

- Provides all capabilities that `BaseTemplate` provides (see "provides" on page 111).
- Requires all capabilities that `BaseTemplate` requires (see "requires" on page 112).
- Inherits all capabilities that `BaseTemplate` inherits (see "inherits" on page 111).
- Obtains and applies all the rules of `BaseTemplate`.
- Can use variables of all the capabilities that `BaseTemplate` provides.

Note `BaseTemplate` and `DerivedTemplate` cannot use different capabilities that have variables with the same name.

The derived template has an "is a" relationship with its base templates. The derived template can be used instead of any of its base templates.

The following example demonstrates the application of the `extends` keyword:

- Extend `ReliablePerformant` into the template `MyReliablePerformant`:

```
volume_template MyReliablePerformant {
  extends ReliablePerformant
  rules {
    ...
  }
};
```

group

This keyword specifies that all volumes allocated using this template are in the specified group. Rules in the storage pool apply to all groups, and specify relationships between groups. For example, a storage pool rule might specify that all groups are to be separated by enclosures. This would mean that all templates with different group tags must be placed in separate non-overlapping sets of enclosures. This keyword can also appear within a log clause. In this case, the specified group overrides any group specified in the template.

inherits

If a template specifies that it can inherit a capability, it provides that capability when required. Inheriting a capability is equivalent to the combination of requiring and providing a capability (see “requires” and “provides” on page 111).

The following example demonstrates the application of the `inherits` keyword:

- The following template definition:

  ```
  volume_template ReliableSnapshot {
    requires Reliable
    provides Reliable, Snapshot
    rules {
      ...
    }
  };
  ```

  can be rewritten as:

  ```
  volume_template ReliableSnapshot {
    inherits Reliable
    provides Snapshot
    rules {
      ...
    }
  };
  ```

provides

A template provides one or more capabilities as defined by its rules, or by requiring capabilities (see “requires”). Any variables that are defined for the capability can be used by the template’s rules.

The following example demonstrates the application of the `provides` keyword:

- Define a template, `ReliableT`, that provides the `Reliable` capability, and which uses the `NMIRS` variable of the capability to set the number of mirrors:

  ```
  volume_template ReliableT {
    provides Reliable
    rules {
      mirror NMIRS {
        ...
      }
    }
  };
  ```

requires

If a template requires one or more capabilities, it can take the appropriate rules from any templates that provide those capabilities.

The `requires` keyword does not imply `provides` (see "provides"). Whenever, a template provides a capability by specifying that it requires it, it should be explicitly listed in a `provides` or `inherits` clause (see "inherits" on page 111).

The following example demonstrates the application of the `requires` keyword:

- Define a template, `MySnapshot`, that provides the SnapShot capability, and requires, but does not provide, the Reliable capability:

```
volume_template MySnapshot {
  requires Reliable
  provides Snapshot
  rules {
    ...
  }
};
```

  This template picks up any templates that provide the `Reliable` capability, and merges their rules with its own rules. If the template were also required to provide the `Reliable` capability, the `inherits` keyword should be used as shown here:

```
volume_template MyReliableSnapshot {
  inherits Reliable
  provides Snapshot
  rules {
    ...
  }
};
```

  This template provides the Snapshot capability through its own rules, and also provides the `Reliable` capability by using rules from other templates.

Note By allowing ISP to choose any template that provides the required capability, the `requires` keyword gives ISP more flexibility when allocating storage. This behavior is known as *dynamic inheritance*.

When choosing a template with a required capability, ISP gives preference to templates that provide only that capability. This behavior avoids giving unrelated capabilities to a volume.

When searching for a template with a required capability, ISP chooses only those templates that inherit or provide that capability.

When searching for a template with a required capability, ISP recursively chooses templates that provide all the required capabilities.

Rules

Rules specify the criteria for allocating storage, the criteria for laying out VxVM objects on storage, and the relationship between these objects. Rules can be classified as storage selection rules that define how to choose storage, or as storage layout rules that define how storage is to be used.

You can optionally precede any rule with the keyword `desired`. This modifier means that ISP tries to honor this rule, but it can discard it if the rule would cause the allocation to fail. An optional integer after the `desired` keyword specifies the preference order value for the rule. If specified, this number must be greater than or equal to 1. If no preference order value is specified for a rule, a value of 1 is assumed. Rules with low preference order values are preferred to be retained over rules with higher values. Rules with the same preference order are discarded together.

In the following example, the `stripe` rule can be dropped if there is insufficient storage to fulfill the storage allocation request:

```
mirror 2 {
  desired 10 confineto "enclosure"
  desired 15 stripe 15
}
```

Storage Selection Rules

The following sections describe storage selection rules:

- `affinity`
- `confineto`
- `exclude`
- `multipath`
- `select`
- `separateby`
- `strong separateby`

See "Compound Rules" on page 123 for details of how to limit the scope of interpretation of rules to the components of an application volume, such as its plexes, columns and logs.

Multiple arguments to the `confineto`, `exclude` and `select` storage selection rules can be combined using the operators listed in "Storage Selection Rule Operators" on page 120. If an operator is not specified, ISP uses the default operator for the rule.

Note The `=`, `!=`, `<`, `<=`, `>` and `>=` comparative operators can be used with the `confineto`, `exclude` and `select` storage selection rules. However, the operand arguments to the `<`, `<=`, `>` and `>=` operators must be signed or unsigned integers that are capable of being represented by 64 or fewer bits. If the operands are character strings, real numbers, or are integers longer than 64 bits, the result of the comparison may be incorrect.

affinity

An `affinity` rule expresses attraction between VxVM objects. Objects that conform to this rule share as many attribute values as possible.

Note The `affinity` rule does not take any rule operators.

The following example demonstrates the application of `affinity` rules:

- Allocate storage from as few enclosures as possible:

```
desired affinity "Enclosure"
```

confineto

A `confineto` rule restricts a VxVM object, such as volume or mirror, to being configured from a specific set of LUNs. The scope of the rule determines the VxVM object for which the restrictions apply. When a `confineto` rule is used at the top level, it usually applies to the volume. Refer to "Compound Rules" on page 123 for details on confining a mirror, column or log to a set of LUNs.

Note Expressions involving `confineto` can use the `allof`, `anyof`, `eachof`, `noneof` and `oneof` operators to combine multiple arguments. By default, ISP applies the `eachof` operator. See "Storage Selection Rule Operators" on page 120 for more information.

The expression argument of a `confineto` rule usually consists of one or more LUN attributes that can be specified either with or without an accompanying value. The LUN attributes can be auto-discovered or user-defined. A value that is not quoted is interpreted as the name of a variable whose value is to be determined when a VxVM object is created.

The following examples demonstrate the application of `confineto` rules:

- Use storage having the same value for the user-defined attribute, `Room`:

  ```
  confineto "Room"
  ```

- By default, the `eachof` operator is assumed for a `confineto` rule. The following rules, which specify that storage is only to be assigned from EMC LUNs or from LUNs that share the same value for the `Room` attribute, are equivalent:

  ```
  confineto "Room", "VendorName"="EMC"
  confineto eachof("Room", "VendorName"="EMC")
  ```

- Use only EMC LUNs that have their `Room` attribute set to the value `Room1`:

  ```
  confineto eachof("VendorName"="EMC", "Room"="Room1")
  ```

- Use only storage with `VendorName` set to the value of the variable `VENDOR_NAME`, and with `Room` set to the value of the variable `ROOM_NAME`:

  ```
  confineto eachof("VendorName"=VENDOR_NAME, "Room"=ROOM_NAME)
  ```

  Note `VENDOR_NAME` and `ROOM_NAME` are variables that are defined in a capability. Their values are resolved when you enter values for the capability during the creation of a VxVM object.

- Create a volume using one or more LUNs from either or both of the enclosures `EMC1` and `EMC2`, and not from anywhere else:

  ```
  confineto anyof("Enclosure"="EMC1", "Enclosure"="EMC2")
  ```

Note When the `anyof` operator is used, ISP takes storage from the operands in the order that they are specified. In this example, ISP first attempts to select LUNs from the enclosure `EMC1`, and if this is not possible, it selects LUNs from the enclosure `EMC2`. If this also is not possible, ISP selects LUNs from both `EMC1` and `EMC2`.

- Use LUNs that originate either only from EMC or only from Hitachi:

```
confineto oneof("VendorName"="EMC", "VendorName"="Hitachi")
```

Note When the `oneof` operator is used, ISP takes storage from the operands in the order that they are specified. In this example, ISP first attempts to select EMC LUNs, and if this is not possible, it selects Hitachi LUNs.

- Confine storage to be allocated from either `Room1` or from `Room2`. If storage is selected from `Room1`, Hitachi LUNs cannot be used. Similarly, if storage is selected from `Room2`, EMC LUNs cannot be used.

```
confineto
oneof(eachof("Room"="Room1",noneof("VendorName"="Hitachi")), \
      eachof("Room"="Room2", noneof("VendorName"="EMC")))
```

Note In this example, ISP first attempts to select LUNs from `Room1`, and if this is not possible, it selects LUNs from `Room2`.

- Do not use LUNs from `Room1` or LUNs from vendor EMC:

```
confineto noneof("VendorName"="EMC", "Room"="Room1")
```

Note The `noneof` operator implies the logical union of its operands.

- Allocate storage from LUNs in `Room1` and `Room2`:

```
confineto allof("Room"="Room1", "Room"="Room2")
```

Note In the absence of a specified operator, the `eachof` operator is assumed.

- Do not mix EMC LUNs with LUNs from other vendors when allocating storage:

```
confineto oneof("VendorName"="EMC", noneof("VendorName"="EMC"))
```

- Allocate storage only from LUNs that have a `Columns` attribute value greater than 1, and a `Parity` attribute value of 0:

```
confineto eachof("Columns">"1", "Parity"="0"))
```

exclude

An `exclude` rule omits a set of LUNs from being allocated to a VxVM object.

Note Expressions involving `exclude` can only use the `allof` and `eachof` operators to combine multiple arguments. By default, ISP applies the `allof` operator. See "Storage Selection Rule Operators" on page 120 for more information.

The following examples demonstrate the application of `exclude` rules:

- The following rules, which prevent storage being assigned from EMC or Hitachi disks, are equivalent:

```
exclude "VendorName"="EMC", "VendorName"="Hitachi"
exclude allof("VendorName"="EMC", "VendorName"="Hitachi")
```

- Do not use EMC LUNs from `Room1`:

```
exclude eachof("VendorName"="EMC", "Room"="Room1")
```

- Do not use disks with `VendorName` set to the value of the variable `VENDOR_NAME`:

```
exclude "VendorName"=VENDOR_NAME
```

Note `VENDOR_NAME` is a variable that is defined in a capability. Its value is resolved when the VxVM object is created.

- Exclude certain LUNs from the enclosure Enclr1:

```
exclude allof("DeviceName"="Enclr1_1", "DeviceName"="Enclr1_2")
```

multipath

A `multipath` rule specifies how tolerant a VxVM object is to the failure of a number of specified components. The rule defines how many paths a VxVM object should have available through each component.

Note The `multipath` rule does not take any rule operators.

The following examples demonstrate the application of `multipath` rules:

- Tolerate the failure of one controller:

```
multipath 2 "Controller"
```

- Tolerate the failure of one controller *and* one switch:

```
multipath 2 "Controller", 2 "Switch"
```

select

A select rule specifies which storage to use for creating VxVM objects. When used outside of a sub clause, this rule is applied to an entire volume.

Note Expressions involving `select` can use the `allof`, `anyof`, `eachof`, `noneof` and `oneof` operators to combine multiple arguments. By default, ISP applies the `anyof` operator. See "Storage Selection Rule Operators" on page 120 for more information.

The following examples demonstrate the application of `select` rules:

- The following rules, which try to allocate LUNs first from `Room1`, then from `Room2` if unsuccessful, and then from both locations, are equivalent:

  ```
  select "Room"="Room1", "Room"="Room2"
  select anyof("Room"="Room1", "Room"="Room2")
  ```

  Note When the `anyof` operator is used, ISP takes storage from the operands in the order that they are specified.

- Use only EMC LUNs from `Room1`:

  ```
  select eachof("VendorName"="EMC", "Room"="Room1")
  ```

  Note Here the `eachof` operator is used rather than the `allof` operator. The `eachof` operator implies the logical intersection of its operands. The `allof` operator implies the logical union of its operands.

- Use the specified LUNs from an enclosure:

  ```
  select "DeviceName"="Enclr1_1","DeviceName"="Enclr1_2"
  ```

separateby

A `separateby` rule is used to describe separation between VxVM objects. This is typically used to define failure domains to provide greater reliability by avoiding a single point of failure. For example, a `separateby` rule can be used to define that the mirrors of a volume should not share a controller. This makes the volume resilient to the failure of a controller.

Note The `separateby` rule does not take any rule operators.

The following examples demonstrate the application of `separateby` rules:

- Allocate VxVM objects on separate enclosures:

  ```
  separateby "Enclosure"
  ```

- Allocate VxVM objects so that each object tolerates the failure of one controller and also uses LUNs from different manufacturers:

  ```
  separateby "VendorName", "Controller"
  ```

strong separateby

The `strong separateby` rule is a more restrictive form of `separateby` rule, which does not permit any sharing of attributes for the storage that is assigned to VxVM objects.

Note The `strong separateby` rule does not take any rule operators.

The following example demonstrates the application of the `strong separateby` rule:

- Allocate VxVM objects so that each object is configured on a totally independent set of spindles.

  ```
  strong separateby "Spindles"
  ```

Storage Selection Rule Operators

The following table lists the operators that are provided for combining the `confineto`, `exclude` and `select` storage selection rules:

Operator	Description
`allof`	Select available storage that matches the union of all the operands.
`anyof`	Select available storage that matches any of the operands in the order that they are listed. The first match is chosen.
`eachof`	Select available storage that matches each of the operands.
`noneof`	Do not select storage that matches any of the operands.
`oneof`	Select available storage that matches one and only one of the operands. The first match is chosen.

See the description of the individual selection rules for details of the applicability of these operators.

Storage Layout Rules

The following sections describe storage layout rules:

- `apply`
- `parity`
- `striped`

See "Compound Rules" on page 123 for details of how to limit the scope of interpretation of rules to the components of an application volume, such as its plexes, columns and logs.

apply

The apply rule is used to apply rules from one or more specified templates in addition to the rules that appear in the current template. This rule acts recursively if the specified templates also use apply in their rules sections. The capabilities of any referenced templates are not used.

Expressions involving apply can specify the `eachof` or `oneof` operator. The default operator for this keyword is `eachof`.

The following examples demonstrate the application of the `apply` rule:

- Apply the rules but not the capabilities from the template `ArrayProductId` to a compound rule within the template `PrefabricatedDataMirroring`:

  ```
  volume_template PrefabricatedDataMirroring {
    provides PrefabricatedDataMirroring
    rules {
      apply ArrayProductId
      confineto eachof ( "Redundancy" =nmirs , "Parity" ="0"  )
    }
  };

  volume_template ArrayProductId {
    provides ArrayProductId
    rules {
      confineto "ProductId"
    }
  };
  ```

- Typically, you would use the apply keyword when you want to get the rules of a template without its associated capabilities. In the example, the template `MyReliableSnapshot` is defined so that the application of `Snapshot` to one mirror results in the whole volume getting the associated `Snapshot` capability, whereas the application of `EMCStorage` to one mirror does not result in the whole volume getting the `EMCStorage` capability:

  ```
  volume_template MyReliableSnapshot {
    provides Snapshot, Reliable
    rules {
      separateby "Enclosure"
      mirror 1 {
        apply Snapshot, EMCStorage
        confineto "Enclosure"
      }
      mirror 1 {
        confineto "Enclosure"
      }
    }
  };
  ```

parity

The `parity` rule defines whether redundancy should be parity based (that is, RAID-5) as implemented in either hardware or software. The value can be `true` or `false`.

The following example demonstrates the application of the `parity` rule:

- Define a template for providing reliability using software RAID-5:

```
volume_template Raid5Volume {
  provides Raid5Capability, Raid5LogMirroring
  rules {
    parity true
    stripe ncols - nmaxcols
    log nlogs {
      type raid5
    }
  }
};
```

striped

The striped rule indicates whether a volume or mirror is to be striped.

If `striped` is set to `true`, the number of columns is not necessarily greater than one as striping can be implemented in hardware as well as software.

The following example demonstrates the application of the `striped` rule:

- Define a template for providing reliability using mirrors, but where striping is not allowed:

```
volume_template ReliableConcat {
  provides Reliable, Concat
  rules {
    mirror NMIRS
    striped false
  }
};
```

Compound Rules

Whether a rule applies to a volume, mirror, column or log depends on the scope in which the rule is applied. Compound rules are composed of several other rules, and are used to specify the scope of rules at a level below that of an entire volume. A compound rule can apply to one or more mirrors, columns or logs of a volume. It can also define how redundancy and separation are to be implemented for a volume.

Note No more than two levels of nesting of compound rules may be specified.

The following sections describe the various types of compound rule:

- `mirror`
- `mirror_group`
- `stripe`
- `log`

mirror

The `mirror` rule is used to describe one or more mirrors of a volume. All the basic rules except `striped` and `parity`, and a restricted form of the `stripe` rule, can be used within a `mirror` rule. Rules that are specified within a `mirror` rule apply only to those mirrors that are constructed from this rule.

The following examples demonstrate the application of the `mirror` rule:

- Confine each mirror within an enclosure so that no mirror spans more than one enclosure:

```
mirror all {
  confineto "Enclosure"
}
```

- Configure two mirrors of a volume with the `EMCSnapshot` feature:

```
mirror 2 {
  apply EMCSnapshot
}
```

- Use `confineto` rules to force one mirror to be created on each of four separate enclosures:

```
mirror 1 {
  confineto "Enclosure"="enclr1"
}
mirror 1 {
  confineto "Enclosure"="enclr2"
}
mirror 1 {
  confineto "Enclosure"="enclr3"
}
mirror 1 {
  confineto "Enclosure"="enclr4"
}
```

mirror_group

The `mirror_group` rule groups together different mirrors of a volume. It should be used when there are groups of mirrors with several things that are common to each group, or when such groups need to have a `separateby` rule between them. Merging of mirrors can only take place within mirror groups.

The following example demonstrates the application of the `mirror_group` rule:

- Configure two mirror groups, `A` with two striped mirrors, and `B` with two concatenated mirrors, where the mirrors in each group lie within different enclosures:

```
mirror_group A {
  mirror 2 {
    confineto "Enclosure"
  }
  stripe 4
}

mirror_group B {
  mirror 2 {
    confineto "Enclosure"
  }
  striped false
}

mirror_group A,B {
  separateby "Enclosure"
}
```

stripe

The `stripe` rule describes one or more columns of a volume. All basic rules and some restricted form-related or mirror-related rules can be specified within a `stripe` rule. ISP merges multiple `stripe` rules to form a single `stripe` rule whose rules are the union of the separate `stripe` rules.

The following examples demonstrate the application of the `stripe` rule:

- Stripe a VxVM object over 5 columns:

  ```
  stripe 5
  ```

- Use `confineto` rules to force a column to be created on separate enclosures, but which are attached to the same controller, `ctlr1`:

  ```
  stripe 6-2 {
    confineto "Controller"="ctlr1"
    separateby "Enclosure"
  }
  ```

  Six columns are created by preference. If this is not possible, ISP attempts to create fewer columns down to a minimum of two.

log

The `log` rule describes a volume's logs. The argument of the rule specifies how many mirrors the log should have. Compound rules can include storage selection rules, stripe rules, and define the log type. The following log types may be defined:

`dco`	Version 20 data change object (DCO) that can be used for both DRL and FastResync.
`raid5`	RAID-5 log.

The following examples demonstrate the application of the `log` rule:

- Create a striped RAID-5 log with 4 columns, and a DCO log, each of which are confined to LUNs from a single (but possibly separate) enclosure:

  ```
  parity true
  log 1{
    type raid5
    confineto "Enclosure"
    stripe 4
  }
  log 1{
    type dco
    confineto "Enclosure"
  }
  ```

- Create a mirrored new-style DCO log, with each plex configured on a separate controller.

```
mirror 2
log 2{
  type dco
  separateby "Controller"
}
```

Attribute Aliases

The following aliases are supported for attributes:

Attribute	Aliases	Description
`Controller`	`c, controller, cntrl, ctlr, ctrl`	The name of a controller, for example: `"Controller"="c1"`
`DA`	`d, da, daname, devicename`	A disk access name, for example: `"DA"="c0t4d0s2"`
`DM`	`disk, dm`	A disk media name, for example: `"DM"="mydg01"`
`Enclosure`	`enclosure, enclr`	The name of an enclosure, for example: `"Enclosure"="enc0"`
`ProductId`	`pid, productid`	The product identifier for an array, for example: `"ProductId"="GR710"`
`RPM`	`diskrpm, rpm`	Disk rotation speed in revolutions per minute, for example: `"RPM"="7200"`
`VendorName`	`vendor, vendorname`	The vendor identifier for an array, for example: `"VendorName"="FUJITSU"`

Simplified Syntax for Rules on the Command Line

For convenience, rules may be expressed in the following simplified form on the command line for the `vxvoladm` command:

```
rule_name=attribute_name[=value][,...]
```

The following examples of rule expressions:

```
confineto eachof("VendorName"="EMC","Room"="Room1","Building")
select anyof("Room"="Room1","Room"="Room2","Building")
exclude allof("VendorName"="EMC","VendorName"="Hitachi")
affinity "Enclosure"
separateby "Controller"
strong separateby "Spindles"
```

may be expressed by equivalent simplified rule expressions:

```
confineto=VendorName=EMC,Room=Room1,Building
select=Room=Room1,Room=Room2,Building
exclude=VendorName=EMC,VendorName=Hitachi
affinity=Enclosure
separateby=Controller
strong separateby=Spindles
```

The default storage selection rules are assumed, and cannot be substituted using the simplified form of the rule syntax.

Changing the Allocation Behavior of ISP A

The behavior that ISP exhibits when allocating storage can be controlled by setting the value of the `allocation_priority_order` attribute. For example, this attribute determines if growing the storage pool is preferred to dropping the desired rules when there is insufficient storage to create a volume. The default behavior can be changed by editing the definition of the attribute in the `/etc/default/allocator` file, or, for a single invocation of the `vxvoladm` command, by specifying the `-o allocation_priority=`*`value`* option as a command-line argument. The *`value`* argument can take an integer value from 1 to 12, as shown in the following table:

Value	Precedence Order
1	S < T < A < D
2	S < T < D < A
3	S < A < T < D
4	S < D < T < A
5	S < A < D < T
6	S < D < A < T
7	A < S < T < D (default behavior)
8	D < S < T < A
9	A < S < D < T
10	D < S < A < T
11	A < D < S < T
12	D < A < S < T

In the table, the precedence order symbols have the following meaning:

Symbol	Description
`A`	Autogrow: If permitted by the value of the `AutoGrow` setting, the storage pool may be grown to increase the available storage.
`D`	Desired Rules: Rules may be dropped if insufficient storage is available.
`S`	Self-Sufficient: If permitted by the value of the `SelfSufficent` setting, templates may be added to the storage pool if insufficient storage is available.
`T`	Template Combination: Different template combinations may be used if insufficient storage is available.
`<`	Indicates the precedence in choosing an action when attempting to allocate storage. "X < Y" means that Y is chosen in preference to X. The rightmost items in the list are chosen before those to the left.

For example, the default behavior of ISP (equivalent to setting `allocation_policy_order=7`), A < S < T < D, means:

`T < D`	First, drop desired rules in preference to using a different template combination.
`S < T`	Secondly, use a different template combination in preference to adding more templates to the storage pool.
`A < S`	Finally, add more templates to the storage pool in preference to growing the storage pool.

If a set of capabilities are specified for a volume during creation, ISP may find that there are multiple sets of templates that provide the same set of capabilities. These sets are referred to as *template combinations*. Some of the available template combinations may provide additional capabilities (*extraneous capabilities*) to those that were requested for the volume. By preferring not to select a different template combination, you can avoid implicitly specifying the extraneous capabilities. This assumes that you would request these capabilities explicitly if you required them.

The templates that are associated with a storage pool define the characteristics of the volumes that can be created in that pool. The `selfsufficient` policy of the storage pool allows you to control whether ISP can redefine the pool definition automatically, and, if so, to what extent.

ISP Language Definition B

You can define the following objects using the VERITAS Intelligent Storage Provisioning (ISP) specification language:

- Capability
- Volume Template
- User Template
- Storage Pool
- Template Set
- Storage Pool Set
- Volume Group

Note the following points with regard to the syntax of the language:

- Each object category, such as capability, template, user template and storage pool and capability has its own name space. This means that a capability and a template can have the same name, but two capabilities cannot have the same name.
- All keywords are case insensitive.
- The primitive types are:

boolean	Possible values are **true** or **false**.
guid_string	String identifier for a GUI element.
int	Short signed integer.
long	Long signed integer.
quoted_string	String enclosed in double quotes.
string	String.
uint32	Unsigned 32-bit integer.

Syntax Conventions

The following typographic conventions are used in the syntax description:

Typeface	Usage	Examples
`monospace (bold)`	Indicates a keyword.	**`capability`**

`monospace (italic)`	Indicates an irreducible term such as an identifier, and its type.
	A value is expected if only a type is specified.
		`c_name``:`*`string`*
		`uint32`

`monospace`	Indicates a reducible term.	`capability_list`

Symbol	Usage	Examples
[]	Indicates an optional syntax component.	`[` **`extends`** `capability_list ]`
|	Separates mutually exclusive syntax components.	**`dco`** | **`drl`** | **`raid5`** | **`srl`**

Reserved Keywords

The following keywords are reserved. They may not be used as identifiers for names of capabilities, templates and so on.

all	defaultvalue	int	selfsufficient
allof	description	log	separateby
affinity	descriptionid	mirror	server_plugin_id
aggregatable	desired	mirror_group	storage_pool
aggregate	display_name	multipath	storage_pool_set
anyof	display_name_id	none	string
application_template	dg	noneof	template
application_templates	domain	oneof	templates
apply	dontcare	parity	template_set
autogrow	eachof	pool	true
capabilities	exclude	pools	type
capability	extends	provides	user_template
clone	false	raid5	user_templates
column	feature	range	var
confineto	features	required	volume_template
const	group	requires	volume_templates
data	host	rules	widget_plugin_id
dcm	hosts	select	
dco	implements	stripe	
drl	inherits	strong	

Capability

```
capability c_name:string [ {
  [ extends string_list ]
  [ description quoted_string ]
  [ descriptionid msgcat_id:quoted_string, msg_id:int ]
  [ display_name quoted_string ]
  [ display_name_id msgcat_id:quoted_string, msg_id:int ]
  [ variable_list ]
} ] ;
```

See "Capabilities" on page 106 for more information about the elements of a capability specification.

string_list

```
string | string_list, string
```

variable_list

```
variable | variable_list variable
```

variable

```
var var_name:string : int | string [ {
  [ defaultvalue value:int | quoted_string ]
  [ description quoted_string ]
  [ descriptionid msgcat_id:quoted_string, msg_id:int ]
} ]
```

Volume Template

```
volume_template vt_name:string {
  [ provides string_list ]
  [ requires string_list ]
  [ inherits string_list ]
  [ extends string_list ]
  [ description quoted_string ]
  [ descriptionid msgcat_id:quoted_string, msg_id:int ]
  [ group quoted_string ]
  [ rules [ {
       template_rules
  } ] ]
} ;
```

See "Volume Templates" on page 108 for more information about the elements of a volume template specification.

template_rules

```
[ [ desired [ pref_order ] ] confineto confineto_expr ] |
[ [ desired [ pref_order ] ] exclude exclude_expr ] |
[ [ desired [ pref_order ] ] select select_expr ] |
[ [ desired [ pref_order ] ] separateby string_list ] |
[ [ desired [ pref_order ] ] strong separateby string_list ] |
[ [ desired [ pref_order ] ] affinity string_list ] |
[ [ desired [ pref_order ] ] multipath multipath_expr ] |
[ [ desired [ pref_order ] ] striped boolean ] |
[ [ desired [ pref_order ] ] parity boolean ] |
[ [ desired [ pref_order ] ] apply string_list ] |
[ [ desired [ pref_order ] ] mirror int [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] striped boolean ]
  [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
  } ] ]
} ] ] |

[ [ desired [ pref_order ] ] mirror [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] striped boolean ]
  [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
  } ] ]
} ] ] |
[ [ desired [ pref_order ] ] mirror all [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] striped boolean ]
  [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
  } ] ]
} ] ] |

[ [ desired [ pref_order ] ] stripe from:int - to:int [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] mirror int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
  } ] ]
    [ [ desired [ pref_order ] ] mirror [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
  } ] ]
} ] ] |
[ [ desired [ pref_order ] ] mirror_group mg_name:string [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] mirror int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
    [ [ desired [ pref_order ] ] striped boolean ]
    [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
      [ [ desired [ pref_order ] ] confineto confineto_expr ]
      [ [ desired [ pref_order ] ] exclude exclude_expr ]
      [ [ desired [ pref_order ] ] select select_expr ]
      [ [ desired [ pref_order ] ] separateby string_list ]
      [ [ desired [ pref_order ] ] strong separateby string_list ]
      [ [ desired [ pref_order ] ] affinity string_list ]
    } ] ]
  } ] ]
  [ [ desired [ pref_order ] ] mirror [ {
    [ provides string_list ]
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
    [ [ desired [ pref_order ] ] striped boolean ]
    [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
      [ [ desired [ pref_order ] ] confineto confineto_expr ]
      [ [ desired [ pref_order ] ] exclude exclude_expr ]
      [ [ desired [ pref_order ] ] select select_expr ]
      [ [ desired [ pref_order ] ] separateby string_list ]
      [ [ desired [ pref_order ] ] strong separateby string_list ]
      [ [ desired [ pref_order ] ] affinity string_list ]
    } ] ]
  } ] ]
} ] ]
```

```
[ [ desired [ pref_order ] ] stripe all [ {
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
} ] ] |

[ [ desired [ pref_order ] ] log int [ {
  [ type dcm |dco | drl | raid5 ]
  [ group quoted_string ]
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] striped boolean ]
  [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
  } ] ]
} ] ] |
[ [ desired [ pref_order ] ] log all {
  type dcm |dco | drl | raid5
  [ [ desired [ pref_order ] ] confineto confineto_expr ]
  [ [ desired [ pref_order ] ] exclude exclude_expr ]
  [ [ desired [ pref_order ] ] select select_expr ]
  [ [ desired [ pref_order ] ] separateby string_list ]
  [ [ desired [ pref_order ] ] strong separateby string_list ]
  [ [ desired [ pref_order ] ] affinity string_list ]
  [ [ desired [ pref_order ] ] multipath multipath_expr ]
  [ [ desired [ pref_order ] ] striped boolean ]
  [ [ desired [ pref_order ] ] stripe from:int - to:int [ {
    [ [ desired [ pref_order ] ] confineto confineto_expr ]
    [ [ desired [ pref_order ] ] exclude exclude_expr ]
    [ [ desired [ pref_order ] ] select select_expr ]
    [ [ desired [ pref_order ] ] separateby string_list ]
    [ [ desired [ pref_order ] ] strong separateby string_list ]
    [ [ desired [ pref_order ] ] affinity string_list ]
    [ [ desired [ pref_order ] ] multipath multipath_expr ]
 } ] ]
 [ [ desired [ pref_order ] ] stripe all [ {
   [ [ desired [ pref_order ] ] confineto confineto_expr ]
   [ [ desired [ pref_order ] ] exclude exclude_expr ]
   [ [ desired [ pref_order ] ] select select_expr ]
   [ [ desired [ pref_order ] ] separateby string_list ]
   [ [ desired [ pref_order ] ] strong separateby string_list ]
   [ [ desired [ pref_order ] ] affinity string_list ]
   [ [ desired [ pref_order ] ] multipath multipath_expr ]
 } ] ]
} ] ]
```

confineto_expr

```
name:string |
name:string operator value:string |
name:quoted_string |
name:quoted_string operator value:quoted_string |
eachof(confineto_expr) |
anyof(confineto_expr) |
allof(confineto_expr) |
oneof(confineto_expr) |
noneof(confineto_expr) |
confineto_expr, confineto_expr
```

exclude_expr

```
name:string operator value:string |
name:quoted_string operator value:quoted_string |
allof(exclude_expr) |
exclude_expr, exclude_expr
```

multipath_expr

```
from:int [ - to:int ] name:string |
from:int [ - to:int ] name:quoted_string |
multipath_expr, multipath_expr
```

select_expr

```
confineto_expr
```

operator

```
<= | < | = | > | >= | !=
```

pref_order

```
int
```

User Template

```
user_template ut_name:string [ {
  [ description quoted_string ]
  [ descriptionid descriptionid ]
  [ capability capabilities_expr ]
  [ rules [ {
    [ rules ]
  } ] ]
} ] ;
```

See "Creating and Modifying User Templates" on page 99 for more information about the elements of a user template specification.

capabilities_expr

```
c_name:string [ {
 parameter_list
} ]
| capabilities_expr, capabilities_expr
```

parameter_list

```
[ const ] attribute:string = value_expr
| parameter_list, parameter_list
```

value_expr

```
string | int
```

Storage Pool

```
storage_pool sp_name:string [ {
  [ volume_templates vt_name_list ]
  [ description quoted_string ]
  [ descriptionid descriptionid ]
  [ autogrow boolean ]
  [ selfsufficient boolean ]
  [ rules [ {
    [ sp_rules ]
  } ] ]
} ] ;
```

sp_rules

```
[ sp_rule ] | sp_rules sp_rule
```

sp_rule

```
[ [ desired [ pref_order ] ] exclude exclude_expr ]
[ [ desired [ pref_order ] ] separateby string_list ]
[ [ desired [ pref_order ] ] strong separateby string_list ]
[ [ desired [ pref_order ] ] affinity string_list ]
[ [ desired [ pref_order ] ] confineto sp_confineto_expr ]
[ [ desired [ pref_order ] ] select sp_confineto_expr ]
```

sp_confineto_expr

```
name:quoted_string |
name:quoted_string operator value:quoted_string |
eachof(sp_confineto_expr) |
anyof(sp_confineto_expr) |
allof(sp_confineto_expr) |
oneof(sp_confineto_expr) |
noneof(sp_confineto_expr)
```

Template Set

```
template_set sp_name:string [ {
  [ volume_templates vt_name_list ]
  [ description quoted_string ]
  [ descriptionid descriptionid ]
} ] ;
```

Storage Pool Set

```
storage_pool_set sp_name:string [ {
  [ storage_pools st_pool_list ]
  [ description quoted_string ]
  [ descriptionid descriptionid ]
} ] ;
```

st_pool_list

```
sp_name:string | st_pool_list, st_pool_list
```

Volume Group

vg_rules

```
[ vg_rule ] | vg_rules vg_rule
```

vg_rule

```
[[ desired [pref_order]] confineto confineto_expr] |
[[ desired [pref_order]] exclude exclude_expr] |
[[ desired [pref_order]] select select_expr] |
[[ desired [pref_order]] separateby string_list] |
[[ desired [pref_order]] strong separateby string_list] |
[[ desired [pref_order]] affinity string_list] |
[[ desired [pref_order]] multipath multipath_expr]
```

confineto_expr

```
quoted_string |
name:quoted_string operator value:quoted_string |
eachof(confineto_expr) |
anyof(confineto_expr) |
```

oneof(confineto_expr) |
noneof(confineto_expr) |
allof(confineto_expr) |
confineto_expr , confineto_expr

exclude_expr

name:*quoted_string* operator *value*:*quoted_string* |
allof(exclude_expr) |
eachof(exclude_expr) |
exclude_expr, exclude_expr

select_expr

quoted_string |
name:*quoted_string* operator *value*:*quoted_string* |
eachof(select_expr) |
allof(select_expr) |
noneof(select_expr) |
anyof(select_expr) |
oneof(select_expr) |
select_expr, select_expr

multipath_expr

from:*int* [- **to**: *int*] *name*:*quoted_string* |
from:*int* [- **to**: *int*] *name*:*string* |
multipath_expr, multipath_expr

operator

<= | **<** | **=** | **>** | **>=** | **!=**

pref_order

1 <= pref_order <= maxint

ISP Configuration Elements C

This appendix lists and describes the following types of pre-defined elements that are available for use with VERITAS Intelligent Storage Provisioning (ISP):

- Template Sets
- Volume Templates
- Capabilities
- Storage Pools
- Storage Pool Sets

These elements are defined in `/etc/vx/alloc/configuration_database.txt`. Before modifying this file, make a backup copy so that you can reverse any changes that you make.

Template Sets

ConfineVolume

Ensures that a volume is confined to specified storage.

Provides capabilities: ConfineToSimilarStorage, ConfineToSpecificStorage.

Uses templates: ConfineToSimilarStorage, ConfineToSpecificStorage.

DataMirroring

Ensures that a volume has multiple copies of its data.

Provides capabilities: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

Uses templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

DataMirroringPrefabricatedRaid5

Ensures that a volume has multiple copies of data on prefabricated RAID-5 disks that are exported by an array.

Provides capabilities: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, PrefabricatedRaid5.

Uses templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, PrefabricatedRaid5.

DataMirroringPrefabricatedStriping

Ensures that a volume has multiple copies of data on prefabricated striped disks that are exported by an array.

Provides capabilities: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, PrefabricatedStriping.

Uses templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, PrefabricatedStriping.

DataMirrorStripe

Ensures that I/O from and to a volume is spread across multiple columns within mirrors.

Provides capabilities: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirrorStripe, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

Uses templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataMirrorStripe, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

DataStripeMirror

Ensures that I/O from and to a volume is spread across multiple columns, where each column has multiple copies of the data.

Provides capabilities: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataStripeMirror, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

Uses templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, DataStripeMirror, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents.

InstantSnapshottable

Ensures that a volume supports dirty region logging (DRL) and instant snapshots.

Provides capabilities: ConfineLogsToSimilarStorage, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents.

Uses templates: ConfineLogsToSimilarStorage, DCOLogMirroring, DCOLogStriping, InstantSnapshottable, LogsOnSeparateComponents.

MultipathingThroughMirroring

Ensures that a volume can withstand the failure of a number of paths. The I/O from and to a volume can potentially be spread across all the paths.

Provides capability: DataMirroring, Multipathing.

Uses template: MultipathingThroughMirroring.

MultipathingThroughMultiplePaths

Ensures that a volume can withstand the failure of a specified number of paths. The I/O from and to the volume can potentially be spread across all these paths.

Provides capability: MultipathingThroughMultiplePaths.

Uses template: MultipathingThroughMultiplePaths.

PrefabricatedDataMirroring

Ensures that a volume uses prefabricated data mirroring configured within the disks exported by an array.

Provides capabilities: ArrayProductId, PrefabricatedDataMirroring.

Uses templates: ArrayProductId, PrefabricatedDataMirroring.

PrefabricatedRaid5

Ensures that a volume uses prefabricated RAID-5 disks that are exported by an array.

Provides capabilities: ArrayProductId, PrefabricatedRaid5.

Uses templates: ArrayProductId, PrefabricatedRaid5.

PrefabricatedStriping

Ensures that a volume uses prefabricated striped disks that are exported by an array.

Provides capabilities: ArrayProductId, PrefabricatedStriping.

Uses templates: ArrayProductId, PrefabricatedStriping.

Raid5Templates

Ensures that a volume uses parity to maintain redundant data.

Provides capabilities: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, LogsOnSeparateComponents, Raid5Capability, Raid5LogMirroring, Raid5LogStriping.

Uses templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, LogsOnSeparateComponents, Raid5LogStriping, Raid5Volume.

Striping

Ensures that I/O from and to a volume is spread across multiple columns.

Provides capabilities: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, Striping.

Uses templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, Striping.

StripingPrefabricatedDataMirroring

Ensures that I/O from and to a volume are spread across multiple columns, which are configured on prefabricated data mirror disks that are exported by an array.

Provides capabilities: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, PrefabricatedDataMirroring, Striping.

Uses templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, PrefabricatedDataMirroring, Striping.

Volume Templates

ArrayProductId

Provides capability: ArrayProductId.

ColumnsOnSeparateComponents

Provides capability: ColumnsOnSeparateComponents.

ConcatVolumes

Provides capability: ConcatVolumes.

ConfineColumnsToSimilarStorage

Provides capability: ConfineColumnsToSimilarStorage.

ConfineLogsToSimilarStorage

Provides capability: ConfineLogsToSimilarStorage.

ConfineMirrorsToSimilarStorage

Provides capability: ConfineMirrorsToSimilarStorage.

ConfineToSimilarStorage

Provides capability: ConfineToSimilarStorage.

ConfineToSpecificStorage

Provides capability: ConfineToSpecificStorage.

DataMirroring

Provides capability: DataMirroring.

Variable:	`nmirs`	Number of mirrors.

DataMirrorStripe

Provides capability: DataMirrorStripe.

Variables:	`ncols`	Minimum number of columns.
	`nmaxcols`	Maximum number of columns.
	`nmirs`	Number of mirrors.

DataStripeMirror

Provides capability: DataStripeMirror.

Variables:	`ncols`	Minimum number of columns.
	`nmaxcols`	Maximum number of columns.
	`nmirs`	Number of mirrors.

DCOLogMirroring

Provides capability: DCOLogMirroring.

DCOLogStriping

Provides capability: DCOLogStriping.

ExcludeSpecificStorage

Provides capability: ExcludeSpecificStorage.

InstantSnapshottable

Provides capability: InstantSnapshottable.

LogsOnSeparateComponents

Provides capability: LogsOnSeparateComponents.

MirrorsOnSeparateComponents

Provides capability: MirrorsOnSeparateComponents.

MultipathingThroughMirroring

Provides capabilities: DataMirroring, Multipathing.

Variable:	`nmirs`	Number of mirrors.

MultipathingThroughMultiplePaths

Provides capability: MultipathingThroughMultiplePaths.

PrefabricatedDataMirroring

Provides capability: PrefabricatedDataMirroring.

PrefabricatedRaid5

Provides capability: PrefabricatedRaid5.

PrefabricatedStriping

Provides capability: PrefabricatedStriping.

Raid5LogStriping

Provides capability: Raid5LogStriping.

Raid5Volume

Provides capabilities: Raid5Capability, Raid5LogMirroring.

Variables:	ncols	Minimum number of columns.

	`nlogs`	Number of logs.
	`nmaxcols`	Maximum number of columns.

Striping

Provides capability: Striping.

Variables:	`ncols`	Minimum number of columns.
	`nmaxcols`	Maximum number of columns.

Capabilities

ArrayProductId

A volume uses storage of the same type (`productid`).

Provided by volume template: ArrayProductId.

ColumnsOnSeparateComponents

The columns of a volume are separated at the specified component level, such as `"Controller"` or `"Enclosure"`.

Provided by volume template: ColumnsOnSeparateComponents.

Variable:	`component`	Name of component (default value is `"Controller"`).

ConcatVolumes

The volume is concatenated.

Provided by volume template: ConcatVolumes.

ConfineColumnsToSimilarStorage

Each column uses only storage that has the same value for a specified attribute.

Provided by volume template: ConfineColumnsToSimilarStorage.

Variable:	`name`	Name of storage attribute (default value is `"Enclosure"`).

ConfineLogsToSimilarStorage

Each log uses only storage that has the same value for a specified attribute.

Provided by volume template: ConfineLogsToSimilarStorage.

Variable:	`name`	Name of storage attribute (default value is `"Enclosure"`).

ConfineMirrorsToSimilarStorage

Each mirror uses only storage that has the same value for a specified attribute.

Provided by volume template: ConfineMirrorsToSimilarStorage.

Variable:	`name`	Name of storage attribute (default value is `"Enclosure"`).

ConfineToSimilarStorage

A volume uses only storage that has the same value for a specified attribute.

Provided by volume template: ConfineToSimilarStorage.

Variable:	`name`	Name of storage attribute (default value is `VendorName`).

ConfineToSpecificStorage

A volume uses only storage that has the specified value for a specified attribute name.

Provided by volume template: ConfineToSpecificStorage.

Variables:	`name`	Name of storage attribute (no default).
	`value`	Value of storage attribute (no default).

DataMirroring

A mirrored volume maintains multiple copies of its data. This capability extends the DataRedundancy capability.

Provided by volume template: DataMirroring.

Variable:	`nmirs`	Number of mirrors (default value is `2`).

DataMirrorStripe

A mirrored-stripe volume distributes I/O across multiple columns within mirrors. This capability extends the DataMirroring and Striping capabilities.

Provided by volume template: DataMirrorStripe.

Variables:	`ncols`	Minimum number of columns (default value is `8`).
	`nmaxcols`	Maximum number of columns (default value is `20`).
	`nmirs`	Number of mirrors (default value is `2`).

DataRedundancy

A volume that maintains redundant data.

Extended by capability: Raid5Capability.

Extended by capability: DataMirroring.

DataStripeMirror

A striped-mirror volume distributes I/O across multiple columns, where each column has multiple copies of data. This capability extends the DataMirroring and Striping capabilities.

Provided by volume template: DataStripeMirror.

Variables:	`ncols`	Minimum number of columns (default value is `8`).
	`nmaxcols`	Maximum number of columns (default value is `20`).
	`nmirs`	Number of mirrors (default value is `2`).

DCOLogMirroring

The number of DCO plexes (copies) to configure for a DCO volume.

Provided by volume template: DCOLogMirroring.

Variable:	`nlogs`	Number of DCO plexes (default value is `1`).

DCOLogStriping

The number of columns to configure for a striped DCO volume.

Provided by volume template: DCOLogStriping.

Variables:	`ndcocols`	Minimum number of columns (default value is `4`).
	`nmaxdcocols`	Maximum number of columns (default value is `10`).

ExcludeSpecificStorage

A volume does not use storage that has the specified value for a specified attribute name.

Provided by volume template: ExcludeSpecificStorage.

Variables:	`name`	Name of storage attribute (no default).
	`value`	Value of storage attribute (no default).

InstantSnapshottable

A volume supports instant snapshots (full-sized or space-optimized). This capability extends the Snapshottable capability.

Provided by volume template: InstantSnapshottable.

LogsOnSeparateComponents

The logs of a volume are separated at the specified component level, such as `"Controller"` or `"Enclosure"`.

Provided by volume template: LogsOnSeparateComponents.

Variable:	`component`	Name of component (default value is `"Enclosure"`).

MirrorsOnSeparateComponents

The mirrors of a volume are separated at the specified component level, such as `"Controller"` or `"Enclosure"`.

Provided by volume template: MirrorsOnSeparateComponents.

Variable:	`component`	Name of component (default value is `"Enclosure"`).

Multipathing

Multipathing allows a volume to withstand failure of a number of paths to the disks. The I/O from and to the volume can potentially be spread across all the paths.

Extended by capability: MultipathingThroughMultiplePaths.

MultipathingThroughMultiplePaths

Multipathing allows a volume to withstand failure of the specified number of paths to the disks. The I/O from and to the volume can potentially be spread across all the paths. This capability extends the Multipathing capability.

Provided by volume template: MultipathingThroughMultiplePaths.

Variable:	`npaths`	Number of paths that are allowed to fail (default value is `2`).

PrefabricatedDataMirroring

A volume uses prefabricated data mirroring that is configured on disks that are exported by an array. This capability extends the PrefabricatedDataRedundancy capability.

Provided by volume template: PrefabricatedDataMirroring.

Variable:	`nmirs`	Number of prefabricated mirrors to use (default value is `2`).

PrefabricatedDataRedundancy

A volume uses prefabricated redundant disks that are exported by an array.

Extended by capabilities: PrefabricatedDataMirroring, PrefabricatedRaid5.

PrefabricatedRaid5

A volume uses prefabricated RAID-5 disks that are exported by an array. This capability extends the PrefabricatedDataRedundancy capability.

Provided by volume template: PrefabricatedRaid5.

PrefabricatedStriping

A volume uses prefabricated striped disks that are exported by an array.

Provided by volume template: PrefabricatedStriping.

Raid5Capability

A RAID-5 volume uses parity to implement data redundancy. This capability extends the DataRedundancy capability.

Provided by volume template: Raid5Volume.

Variable:	`ncols`	Minimum number of data columns (default value is `8`).
	`nmaxcols`	Maximum number of data columns (default value is `20`).

Note An additional virtual column is always allocated to store parity information. This column is not included in the number of data columns that are specified.

Raid5LogMirroring

The number of RAID-5 log copies to configure for a RAID-5 volume.

Provided by volume template: Raid5Volume.

Variable:	nlogs	Number of RAID-5 log copies (default value is `1`).

Raid5LogStriping

The number of columns to configure for striped RAID-5 logs.

Provided by volume template: Raid5LogStriping.

Variables:	`nraid5cols`	Minimum number of columns (default value is `4`).
	`nmaxraid5cols`	Maximum number of columns (default value is `10`).

Snapshottable

Volume snapshots of a volume may be taken.

Extended by capability: InstantSnapshottable.

Striping

A striped volume distributes I/O across multiple columns.

Provided by volume template: Striping.

Variables:	`ncols`	Minimum number of columns (default value is `8`).
	`nmaxcols`	Maximum number of columns (default value is `20`).

Storage Pools

any_volume_type

Supports volumes using any template from the configuration database.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: none.

mirror_stripe_volumes

Supports distribution of I/O from and to volumes across multiple columns within mirrors.

Default policies: `autogrow=diskgroup`

`selfsufficient=1`

Associates volume templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DataMirrorStripe, DCOLogMirroring, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths.

mirrored_prefab_raid5_volumes

Supports use by volumes of multiple copies of data configured on prefabricated Raid-5 disks that are exported by an array.

Default policies: `autogrow=diskgroup`

`selfsufficient=1`

Associates volume templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths, PrefabricatedRaid5.

mirrored_prefab_striped_volumes

Supports use by volumes of multiple copies of data configured on prefabricated striped disks that are exported by an array.

Default policies: `autogrow=diskgroup`

`selfsufficient=1`

Associates volume templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths, PrefabricatedStriping.

mirrored_volumes

Supports volume with multiple copies of data.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: ArrayProductId, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DataMirroring, DCOLogMirroring, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths.

prefab_mirrored_volumes

Supports use by volumes of prefabricated data mirrors that are exported by an array.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: ArrayProductId, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, MultipathingThroughMultiplePaths, PrefabricatedDataMirroring.

prefab_raid5_volumes

Supports use by volumes of prefabricated RAID-5 disks that are exported by an array.

Default policies:	`autogrow=diskgroup`
	`selfsufficient=host`

Associates volume templates: ArrayProductId, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, MultipathingThroughMultiplePaths, PrefabricatedRaid5.

prefab_striped_volumes

Supports use by volumes of prefabricated striped disks that are exported by an array.

Default policies:	`autogrow=diskgroup`
	`selfsufficient=host`

Associates volume templates: ArrayProductId, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, MultipathingThroughMultiplePaths, PrefabricatedStriping.

raid5_volumes

Supports volumes which use parity to maintain redundant data.

Default policies:	`autogrow=diskgroup`
	`selfsufficient=host`

Associates volume templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, Raid5Volume, MultipathingThroughMultiplePaths.

stripe_mirror_volumes

Supports distribution of I/O from and to volumes across multiple columns, where each column has multiple copies of data.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineLogsToSimilarStorage, ConfineMirrorsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DataStripeMirror, DCOLogMirroring, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, LogsOnSeparateComponents, MirrorsOnSeparateComponents, MultipathingThroughMultiplePaths.

striped_prefab_mirrored_volumes

Supports distribution of I/O from and to volumes across multiple columns that are configured on prefabricated data mirrors exported by an array.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, MultipathingThroughMultiplePaths, PrefabricatedDataMirroring, Striping.

striped_volumes

Supports distribution of I/O from and to volumes across multiple columns.

Default policies: `autogrow=diskgroup`

`selfsufficient=host`

Associates volume templates: ArrayProductId, ColumnsOnSeparateComponents, ConfineColumnsToSimilarStorage, ConfineToSimilarStorage, ConfineToSpecificStorage, DCOLogStriping, ExcludeSpecificStorage, InstantSnapshottable, MultipathingThroughMultiplePaths, Striping.

Storage Pool Sets

mirrored_data_striped_clones

Supports data volumes with multiple copies of data, and snapshot volumes with I/O distributed across multiple columns.

Data storage pool type:	mirrored_volumes.
Clone storage pool type:	striped_volumes.

mirrored_prefab_raid5_data_mirrored_clones

Supports data volumes with multiple copies of data created from RAID-5 storage, and snapshot volumes with multiple copies of data.

Data storage pool type:	mirrored_prefab_raid5_volumes.
Clone storage pool type:	mirrored_volumes.

mirrored_prefab_stripe_data_striped_clones

Supports data volumes with multiple copies of data configured on prefabricated striped storage, and snapshot volumes with I/O distributed across multiple columns.

Data storage pool type:	mirrored_prefab_striped_volumes.
Clone storage pool type:	striped_volumes.

prefab_mirrored_data_prefab_striped_clones

Supports data volumes with multiple copies of data configured on prefabricated striped storage, and snapshot volumes with I/O distributed across multiple columns also configured on prefabricated striped storage.

Data storage pool type:	prefab_mirrored_volumes.
Clone storage pool type:	prefab_striped_volumes.

stripe_mirrored_data_striped_clones

Supports I/O from and to data volumes that are distributed across multiple columns, where each column has multiple copies of data, and snapshot volumes with I/O distributed across multiple columns.

Data storage pool type:	stripe_mirror_volumes.
Clone storage pool type:	striped_volumes.

striped_prefab_mirrored_data_striped_clones

Supports I/O from and to data volumes distributed across multiple columns constructed from mirrored storage, and snapshot volumes with I/O distributed across multiple columns.

Data storage pool type:	striped_prefab_mirrored_volumes.
Clone storage pool type:	striped_volumes.

Volume Group Definition Syntax D

This appendix describes the syntax of a volumegroup definition that may be used as input to the vxvoladm command. Volume groups are generally used to create several volumes at the same time within a storage pool and are given equal weighting by VERITAS Intelligent Storage Provisioning (ISP) when allocating storage resources.

The syntax of a volumegroup definition is shown here:

```
volumegroup {
  [diskgroup "dgname"]
  [rules { volume-group-rules } ]
  volume "name" length {
    [cachevolume "cachevol"]
    [capability 'capability[(name=value,...)][,capability...]']
    [comment "comment"]
    [dcologlen length]
    [dm dm1,[dm2,...]]
    [drl on|true|yes|sequential|off|false|no]
    [excl on|off|true|false|yes|no]
    [fmr on|off|true|false|yes|no]
    [fstype type]
    [group "group"]
    [init active|none|zero]
    [iodelay delay]
    [iosize size]
    [layout "layout-type"]
    [max_ncolumn number]
    [max_nraid5column number]
    [min_ncolumn number]
    [min_nraid5column number]
    [mode mode]
    [pool "poolname"]
    [raid5_stripeunit width]
    [raid5loglen length]
    [regionsize size]
    [rules { volume-rules } ]
    [spare yes|no|only]
    [stripe_stripeunit width]
```

```
        [tasktag "tag"]
        [type data|snapshot|cachevolume]
        [user "user"]
        [user_template "ut1"[,"ut2"...]]
        [usetype "volume-usage-type"]
        [volume_template "vt1"[,"vt2"...]]
        [vxvmtaskid taskid]
      }
      [volume "name" length { ...
      }]
    };
```

The `volumegroup` fields in this definition are:

`diskgroup` *dgname*	The name of the disk group in which the volumes are to be created.
`rules {` *volume-group-rules* `}`	The rules that are to be applied to all volumes in this volume group.
`volume "`*name*`"` *length*	The name of a volume to be created and its size.

The `volume` fields in the definition are:

`cachevolume "`*cachevol*`"`	The name of the cache volume on which a space-optimized snapshot volume is to be created.
`capability '`*capability*`[(`*name*`=`*value*`,...)][,`*capability*`...]'`	The capabilities that are desired for the volume.
`comment "`*comment*`"`	A description of the volume.
`dcologlen` *length*	The size of a DCO volume whose creation is implied by the specified capabilities or templates.
`dm` *dm1*,[*dm2*,...]	A list of disk media which can be allocated to a volume.
`drl on|true|yes|sequential|off|false|no`	Whether DRL, sequential DRL, or no DRL is enabled on a volume.
`excl on|off|true|false|yes|no`	Whether a volume in a cluster-shareable disk group can be opened by only one node at a time.
`fmr on|off|true|false|yes|no`	Whether FastResync is enabled on a volume.
`fstype` *type*	Specifies the file system type for a volume.

`group "`*`group`*`"`	The group ownership of a volume.
`init active|none|zero`	The type of initialization to perform on a volume.
`iodelay `*`delay`*	The delay in milliseconds between copy operations performed during recovery of a plex.
`iosize `*`size`*	The size of each region that is resynchronized during recovery of a plex.
`layout "`*`layout-type`*`"`	The plex layout that is to be created.
`max_ncolumn `*`number`*	The maximum number of columns in a striped volume.
`max_nraid5column `*`number`*	The maximum number of columns in a RAID-5 volume.
`min_ncolumn `*`number`*	The minimum number of columns in a striped volume.
`min_nraid5column `*`number`*	The minimum number of columns in a RAID-5 volume.
`mode `*`mode`*	The permissions to be applied to a volume, for example 644.
`pool "`*`poolname`*`"`	The name of the storage pool.
`raid5_stripeunit `*`width`*	The stripe unit width for a RAID-5 column.
`raid5loglen `*`length`*	The size of a RAID-5 log whose creation is implied by the specified capabilities or templates.
`regionsize `*`size`*	The size of each region that is tracked by a bit in the maps within a version 20 DCO volume. The value of *size* must be a power of 2 and be greater than or equal to 16k (16KB). The default value is 64k (64KB).
`rules { `*`volume-rules`*` }`	The rules that are to be applied during volume creation.
`spare yes|no|only`	Whether spare disks can be used for hot-relocation, or only spare disks are to be used.
`stripe_stripeunit `*`width`*	The stripe unit width.
`tasktag "`*`tag`*`"`	A tag that can be used to track the volume creation task.

`type data|snapshot|cachevolume`	Whether a volume is to be used for user data (such as a database or file system), as a full-sized instant snapshot volume, or as a cache volume for space-optimized instant snapshots.
`user "`*`user`*`"`	The user ownership of a volume.
`user_template` *`ut1`*[,*`ut2`*...]	The user templates that are to be used to create a volume.
`usetype "`*`volume-usage-type`*`"`	The usage type of a volume, such as `fsgen` or `raid5`.
`volume_template` *`vt1`*[,*`vt2`*...]	The templates that are to be used to create a volume.
`vxvmtaskid` *`taskid`*	VxVM task ID.

Multiple volumes may be defined within a volume group, and multiple volume groups may be defined in a definitions file.

Command Summary E

This appendix summarizes the usage and purpose of important commands for the VERITAS Intelligent Storage Provisioning (ISP) feature of VERITAS Volume Manager (VxVM).

- Creating and Administering Storage Pools
- Creating and Administering Application Volumes

References are included to longer descriptions in the remainder of this book. For detailed information about an individual command, refer to the appropriate manual page in the 1M section. Further examples can be found in "Examples of Using ISP" on page 177.

Creating and Administering Storage Pools

Command	Description
`vxpool [-g diskgroup] create \ storage_pool [dm=dm1[,dm2...] \ [description="description"] \ \[autogrow=1|2] \ [selfsufficient=1|2|3] \ [rules=rule[,rule ...]`	Creates a storage pool. See "Creating a Storage Pool" on page 34.
`vxpool [-g diskgroup] adddisk \ storage_pool dm=dm1[,dm2,...]`	Adds one or more disks to a storage pool. See "Adding Disks to a Storage Pool" on page 37.
`vxpool [-g diskgroup] rmdisk \ storage_pool dm=dm1[,dm2,...]`	Removes one or more disks from a storage pool. See "Removing Disks from a Storage Pool" on page 37.
`vxpool [-g diskgroup] assoctemplate\ storage_pool template=t1[,t2,...]`	Associates one or more templates with a storage pool. See "Associating Templates with a Storage Pool" on page 37.
`vxpool [-g diskgroup] \ assoctemplateset\ storage_pool \ template_set=ts1[,ts2,...]`	Associates one or more template sets with a storage pool. See "Associating Template Sets with a Storage Pool" on page 38.

Creating and Administering Storage Pools

Command	**Description**
`vxpool [-g diskgroup] distemplate\ storage_pool template=t1[,t2,...]`	Dissociates one or more templates from a storage pool. See “Dissociating Templates from a Storage Pool” on page 38.
`vxpool [-g diskgroup] print \ storage_pool [storage_pool ...]`	Displays information about storage pools. See “Displaying Information About Storage Pools” on page 39.
`vxpool [-g diskgroup] getpolicy \ storage_pool`	Displays policies for a storage pool. See “Displaying Storage Pool Policies” on page 39.
`vxpool [-g diskgroup] setpolicy storage_pool \ [autogrow={1|pool}|{2|diskgroup}] [selfsufficient={1|pool}|\ {2|diskgroup}|{3|host}]`	Sets policies on a storage pool. See “Changing the Policies on a Storage Pool” on page 40.
`vxpool [-g diskgroup] list`	Lists storage pools in a disk group. See “Listing Storage Pools Within a Disk Group” on page 40.
`vxpool [-g diskgroup] rename \ storage_pool new_name`	Renames a storage pool. See “Renaming a Storage Pool” on page 40.
`vxpool [-g diskgroup] [-r] delete \ storage_pool`	Deletes a storage pool. See “Deleting a Storage Pool” on page 41.

Creating and Administering Application Volumes

Command	**Description**
`vxvoladm [-g diskgroup] [-b] \` `maxsize [`*storage_specification*`] \` `[`*attribute=value* ...]	Determines the maximum volume size. See "Determining the Maximum Size of a Volume" on page 45.
`vxvoladm [-g diskgroup] [-b] make \` *`volume length`* `[`*storage_specification*`] \` `[`*attribute=value* ...]	Creates a volume. See "Creating Volumes" on page 45.
`vxvoladm [-g diskgroup] [-b] make \` *`volume length`* `\` `capability='DataMirroring' \` `init=active`	Creates a volume with 2 mirrors and makes it immediately available for use. See "Creating a Mirrored Volume" on page 46.
`vxvoladm [-g diskgroup] make \` *`volume length`* `\` `capability='Striping(ncols=`*`N`*`)'`	Creates a striped volume with *N* columns. See "Creating a Striped Volume" on page 47.
`vxvoladm [-g diskgroup] make \` *`volume length`* `\` `capability='PrefabricatedRaid5' \` `rules='confineto \` `"VendorName"="`*`Name`*`"'`	Creates a RAID-5 volume on a device that is exported by an array made by a specified vendor. See "Creating a RAID-5 Volume on Prefabricated Storage" on page 48.
`vxvoladm -M make <` *`filename`*	Creates multiple volumes from a specification file. See "Creating Multiple Volumes as a Volume Group" on page 51.
`vxvoladm [-g diskgroup] maxgrow \` *`volume`* `[`*storage_specification*`] \` `[`*attribute=value* ...]	Determines the maximum growable size of a volume. See "Determining the Maximum Size of a Volume" on page 56.
`vxvoladm [-g diskgroup] \` `{growby | growto}\` *`volume length`* `[`*storage_specification*`] \` `[`*attribute=value* ...]	Grows a volume. See "Increasing the Size of a Volume to a Specified Length" on page 56 and "Increasing the Size of a Volume by a Specified Amount" on page 57.
`vxvoladm [-g diskgroup] \` `{shrinkby | shrinkto}\` *`volume length`* `[`*storage_specification*`] \` `[`*attribute=value* ...]	Shrinks a volume. See "Reducing the Size of a Volume to a Specified Length" on page 57 and "Reducing the Size of a Volume by a Specified Amount" on page 57.
`vxvoladm [-g diskgroup] evacuate \` `disk` *`volume length`* `!dm:`*`dmname`* ...	Evacuates a volume from one or more specified disks. See "Evacuating a Volume" on page 59.

Command	Description
`vxvoladm [-g diskgroup] remove \ volume *volume*`	Deletes a volume. See "Removing a Volume" on page 61.
`vxvoladm [-g diskgroup] verify \ *volume*`	Verifies the intent of a volume. See "Verifying the Intent of a Volume" on page 68.

Examples of Using ISP F

This appendix lists examples of using the `vxvoladm` and other commands that are provided by the VERITAS Intelligent Storage Provisioning (ISP) feature.

Further examples are given in "Examples of Using ISP from the Command Line" on page 27, and on the `vxvoladm`(1M) manual page.

Creating Volumes

Create a 10-gigabyte concatenated volume:

```
# vxvoladm -g exdg make vol1 10g
```

Create a 2-way mirrored volume using rules:

```
# vxvoladm -g exdg make vol1 10g rules='mirror 2'
```

Create a 7-column striped volume using rules:

```
# vxvoladm -g exdg make vol1 10g rules='stripe 7'
```

Create a 2-way mirrored volume using the `DataMirroring` capability:

```
# vxvoladm -g exdg make vol1 10g \
  capability='DataMirroring(nmirs=2)'
```

Create a 2-way mirrored volume with each mirror on a separate enclosure:

```
# vxvoladm -g exdg make vol1 10g \
  capability='DataMirroring(nmirs=2),\
  MirrorsOnSeparateComponents(component="Enclosure")'
```

Create a 2-way mirror volume that is enabled for the creation of instant snapshots:

```
# vxvoladm -g exdg make vol1 10g \
  capability='DataMirroring(nmirs=2), InstantSnapshottable'
```

Create a volume using only disks from enclosure `e1`:

```
# vxvoladm -g exdg make vol1 10g rules='confineto "Enclosure"="e1"'
```

or alternatively:

```
# vxvoladm -g exdg make vol1 10g \
  capability='ConfineToSpecificStorage(name="Enclosure",\
  value="e1")'
```

Create a volume using disks on the same controller:

```
# vxvoladm -g exdg make vol1 10g rules='confineto "Controller"'
```

or alternatively:

```
# vxvoladm -g exdg make vol1 10g \
  capability='ConfineToSimilarStorage (name="Controller")'
```

Create a RAID-5 volume with a 2-way mirrored RAID-5 log and a 2-way mirrored DCO volume:

```
# vxvoladm -g exdg make vol1 10g capability='Raid5Capability,\
  Raid5LogMirroring(nlogs=2), DCOLogMirroring(nlogs=2)'
```

Create a volume using a RAID-5 device that has been implemented in hardware (such as a RAID-5 LUN in an EMC Symmetrix array):

```
# vxvoladm -g exdg make vol1 10g capability='PrefabricatedRaid5'
```

Create a striped volume with a minimum of 10 columns using mirrored LUNs from enclosure `e1`, and for which instant snapshots can be taken:

```
# vxvoladm -g exdg make vol1 10g \
  capability='PrefabricatedDataMirroring, Striping(ncols=10),\
  InstantSnapshottable' rules='confineto "Enclosure"="e1"'
```

or alternatively:

```
# vxvoladm -g exdg make vol1 10g \
  capability='PrefabricatedDataMirroring, Striping(ncols=10),\
  InstantSnapshottable,\
  ConfineToSpecificStorage(name="Enclosure",value="e1")'
```

Create a 4-way mirrored volume in which each mirror uses disks from the same enclosure, and for which instant snapshots can be taken:

```
# vxvoladm -g exdg make vol1 10g \
 capability='DataMirroring(nmirs=2),InstantSnapshottable,\
 ConfineMirrorsToSimilarStorage(name="Enclosure")'
```

Resizing a Volume

Note The following examples show how to resize volumes that do not contain file systems (volume type `gen`). If an application is using the volume to store data, use the appropriate utility to reduce the size of the data object before reducing the size of the volume, or to increase the size of the data object after increasing the size of the volume.

For volumes that contain volumes (volume type `fsgen`), use the `vxresize` command to change both the size of the file system and the volume.

Grow a volume by 5 gigabytes:

```
# vxvoladm -g exdg growby vol1 5g
```

Grow an existing 10-gigabyte volume to 15 gigabytes without using disks from the enclosure `e1`:

```
# vxvoladm -g exdg growto vol1 15g \
 use_storage='noneof("Enclosure"="e1")'
```

Shrink a volume by 10%:

```
# vxvoladm -g exdg growby vol1 10%
```

Shrink an existing 15-gigabyte volume to 10 gigabytes:

```
# vxvoladm -g exdg shrinkto vol1 10g
```

Adding or Removing Mirrors

Add a mirror to an existing volume:

```
# vxvoladm -g exdg add mirror vol1
```

Add two mirrors to a volume:

```
# vxvoladm -g exdg add mirror vol1 nmirror=2
```

Add a mirror to the volume `vol1`, where the new mirror is like the existing plex `p1`:

```
# vxvoladm -g exdg add mirror vol1 plexname=p1
```

Remove a mirror from a volume:

```
# vxvoladm -g exdg remove mirror vol1
```

Remove the plex `p1` from the volume `v1`:

```
# vxvoladm -g exdg remove mirror vol1 plexnames=p1
```

Adding or Removing Columns

Add a column to a volume, and grow the volume while doing this:

```
# vxvoladm -g exdg add column vol1 layout=grow
```

Add 4 columns to a volume, and grow the volume while doing this:

```
# vxvoladm -g exdg add column vol1 ncols=4 layout=grow
```

Add a column, but do not grow the volume:

```
# vxvoladm -g exdg add column vol1 layout=nogrow
```

Remove a column, and shrink the volume while doing this:

```
# vxvoladm -g exdg remove column vol1 layout=shrink
```

Remove a column, but do not shrink the volume:

```
# vxvoladm -g exdg remove column vol1 layout=noshrink
```

Adding or Removing Logs

Add a DCO log to a volume:

```
# vxvoladm -g exdg add log vol1 logtype=dco
```

Add a DCO log to volume `vol1`, and make the new log like the existing log `p1`:

```
# vxvoladm -g exdg add log vol1 lognames=p1 logtype=dco
```

Remove a RAID-5 log from a volume:

```
# vxvoladm -g exdg remove log vol1 logtype=raid5
```

Remove the RAID-5 log named `p1` from a volume:

```
# vxvoladm -g exdg remove log vol1 lognames=p1 logtype=raid5
```

Evacuating Data from a Volume

Evacuate subdisk `sd01` from the volume `vol1`:

```
# vxvoladm -g exdg evacuate subdisk vol1 sd=sd01
```

Evacuate subdisks `sd11` and `sd12` from volume `vol1`:

```
# vxvoladm -g exdg evacuate subdisk vol1 sd=sd11,sd12
```

Evacuate disks `disk01` and `disk01` from volume `vol1`:

```
# vxvoladm -g exdg evacuate disk vol1 \!disk01 \!disk02
```

Evacuate columns 4 and 7 of volume `vol1`:

```
# vxvoladm -g exdg evacuate column vol1 columnnames=4,7
```

Evacuate mirror `p1` of volume `vol1`:

```
# vxvoladm -g exdg evacuate mirror vol1 plexnames=p1
```

Evacuate columns 3 and 4 of mirror `p1` from volume `vol1`:

```
# vxvoladm -g exdg evacuate column vol1 columnnames=3,4 \
 plexnames=p1
```

Segregating Database Components

To achieve best performance, it is usual to place the components of a database, such as the redo log, table spaces and indexes, on different disks. Using ISP, this can be accomplished by using the Annotation Service feature, which allows you to define new characteristics and then assign these to your disks.

Note The Annotation Service is accessed by selecting a disk in the VERITAS Enterprise Administrator, and then selecting **Actions > Annotate Disks**. This feature is not available from the command line.

The Annotation Service can be used in conjunction with volume rules to reserve disks for particular volumes. By tagging disks with a suitable attribute name and value such as `reserved_for` and `redo_log`, you can use a `confineto` rule to ensure that the volume for a redo log is only allocated space from those disks:

```
confineto "reserved_for"="redo_log"
```

Conversely when creating volumes that are not to be used for the redo logs, you can specify an `exclude` rule:

```
exclude "reserved_for"="redo_log"
```

This technique allows you to share appropriately tagged disks among a set of volumes of the same type. For example, if you specify the same confinement rule when creating several redo log volumes in a storage pool, those volumes share the disks that are reserved for that purpose.

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